

**Demonstration of Steam Injection/Extraction Treatment  
of a DNAPL Source Zone at Launch Complex 34  
in Cape Canaveral Air Force Station**

**Final Innovative Technology Evaluation Report**

**Appendix D: Inorganic and Other Aquifer Parameters**

**Table D-1. Groundwater Field Parameters**

Well ID	pH				ORP (mV)				Conductivity (mS/cm)			
	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>												
PA-16S	8.15 <sup>3)</sup>	NA	NA	7.02	533.8	NA	NA	-95	1.208	NA	NA	0.15
PA-16I	9.12 (?)	NA	NA	6.59	-163.0	NA	NA	49	1.395	NA	NA	0.15
PA-16D	6.74	NA	NA	6.74	-159.7	NA	NA	113	12.01	NA	NA	0.16
PA-17S	6.96	NA	NA	8.72	-104.8	NA	NA	102	0.459	NA	NA	0.21
PA-17I	7.06	NA	NA	6.93	-151.9	NA	NA	89	4.236	NA	NA	0.19
PA-17D	7.07	NA	NA	7.09	-105.8	NA	NA	-231	3.925	NA	NA	0.55
<b>Steam Injection Perimeter Wells</b>												
BAT-5S	9.11 (?)	7.72	8.00	7.39	-177.3	-62	12.2	143	14.7	0.43	0.61	0.14
BAT-5I	7.67	7.59	8.13	7.44	-19.7	10	18.4	20	12.47	0.5	0.21	0.6
BAT-5D	7.32	7.52	7.90	7.04	-108.7	-24	11.5	111	14.55	0.62	0.7	0.63
PA-14S	7.59	7.03	8.30	6.64	-43.8	-44	-57	191	4.03	0.014	1.43	0.14
PA-14I	NA	7.18	8.23	6.72	NA	-136	-43	185	NA	0.02	2.25	0.12
PA-14D	6.76	7.07	9.26	6.84	-249.9	-213	-316	72	18.18	0.11	4.96	0.42
PA-18S	NA	6.71	8.41	6.38	NA	8	-128	175	NA	0.018	2.31	0.21
PA-18I	NA	7.38	8.09	6.66	NA	-32	-29	125	NA	0.011	1.12	0.15
PA-18D	NA	6.92	8.45	6.76	NA	18	-100	151	NA	0.013	1.41	0.13
PA-19S	NA	7.05	8.07	6.60	NA	34	-44	34	NA	0.12	0.475	33
PA-19I	NA	7.61	8.16	6.64	NA	-86	44	62	NA	-0.84	0.649	52
PA-19D	NA	8.17	8.84	5.81	NA	-155	-98	151	NA	0.2	1.62	0.12
<b>Distant Wells</b>												
PA-1S	7.35	7.74	8.44	6.81	-128.2	-65	-65	49	1.57	0.42	0.555	0.64
PA-1I	7.32	7.72	8.71	6.60	-234.9	-136	-148	35	1.296	0.43	0.596	0.5
PA-1D	6.94	7.08	8.38	6.82	-213.0	-182	-96	120	2.321	0.15	0.415	0.14

**Table D-1. Groundwater Field Parameters (Conitnued)**

Well ID	Temperature (°C)						DO (mg/L)			
	Pre-Demo	Aug 2001 <sup>1)</sup>	Aug 2001 <sup>2)</sup>	Nov 2001 <sup>1)</sup>	Nov 2001 <sup>2)</sup>	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>										
PA-16S	27.46	NA	NA	NA	NA	42.4	4.6 (?) <sup>3)</sup>	NA	NA	0.74
PA-16I	27.34	NA	NA	NA	NA	38.6	0.36	NA	NA	0.41
PA-16D	26.60	NA	NA	NA	NA	39.6	2.73	NA	NA	0.59
PA-17S	26.63	NA	NA	NA	NA	44.8	0.43	NA	NA	0.54
PA-17I	26.74	NA	NA	NA	NA	53.5	0.52	NA	NA	0.45
PA-17D	26.15	NA	NA	NA	NA	49.9	0.62	NA	NA	0.74
<b>Steam Injection Perimeter Wells</b>										
BAT-5S	27.67	28.9	NA	NA	25.5	26.5	1.06	0.50	0.97	0.50
BAT-5I	26.90	29.1	NA	NA	25.1	26.4	1.86	0.60	0.72	0.40
BAT-5D	27.04	29.1	NA	NA	25.6	25.1	1.73	0.50	0.42	0.51
PA-14S	41.19	36.2	38.1	29.6	33.9	27.0	0.60	0.90	0.65	0.87
PA-14I	NA	38	42.1	31.7	36.9	29.7	NA	0.50	0.77	0.78
PA-14D	31.59	39.5	38.2	32.9	34.0	31.1	0.87	0.40	0.90	0.52
PA-18S	NA	27.2	26.1	26.5	26.3	25.4	NA	0.50	0.63	0.32
PA-18I	NA	27	26.1	26.2	26.0	25.3	NA	0.40	0.63	0.55
PA-18D	NA	26.3	26.2	25.8	24.9	25.1	NA	0.50	0.60	0.77
PA-19S	NA	27.6	26.0	26.5	26.3	24.9	NA	0.60	0.79	0.69
PA-19I	NA	28.5	26.2	26.5	26.1	24.8	NA	0.70	0.74	0.76
PA-19D	NA	28.5	26.2	26.5	26.0	24.6	NA	0.40	0.93	0.76
<b>Distant Wells</b>										
PA-1S	25.91	28	25.6	26.4	26.1	25.0	0.51	0.60	0.73	1.20
PA-1I	25.92	27.8	25.7	26.3	26.4	24.7	0.41	0.80	0.70	0.49
PA-1D	25.64	26.9	25.5	26.4	26.2	25.0	0.50	0.60	0.49	1.21

1) Temperature was read from a flow-thru cell when the groundwater was being purged.

2) Temperature was read from a thermocouple directly dropped to the screen depth.

3) DO and pH values for the samples are suspect because of interference from high levels of permanganate in the water.

**Table D-2. Iron and Manganese Results**

Compound	Iron (mg/L)				Manganese (mg/L)			
	0.3 mg/L				0.05 mg/L			
SMCL	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
Well ID	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>								
PA-16S	<0.1	NA	NA	2.47	667	NA	NA	0.858
PA-16I	<0.1	NA	NA	0.296	5.3	NA	NA	0.100
PA-16D	0.28	NA	NA	0.813	1.3	NA	NA	0.826
PA-17S	3.9	NA	NA	<0.1	0.46	NA	NA	0.0134
PA-17I	3.4	NA	NA	<0.1	0.64	NA	NA	1.03 S
PA-17D	0.63	NA	NA	<0.1	0.18	NA	NA	0.0813
PA-17D-DUP	0.58	NA	NA	<0.1	0.18	NA	NA	0.0821
<b>Steam Injection Perimeter Wells</b>								
BAT-5S	0.055	0.25	NA	<0.1	0.38	0.98	NA	0.253
BAT-5S-DUP	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5I	0.058	0.22	NA	<0.1	1.2	1.9	NA	0.374
BAT-5D	<0.05	0.97	NA	2.24	4	2.1	NA	1.59
BAT-5D-DUP	NA	1.00	NA	NA	NA	2.10	NA	NA
PA-14S	<0.05	0.1	0.148	<0.1	<0.015	0.024	0.0239	0.0291
PA-14I	<0.05	0.021	0.141	<0.1	<0.015	0.021	0.0325	0.026
PA-14D	<0.05	0.058	0.185	<0.1	0.021	0.019	0.016	0.0184
PA-18S	NA	0.077	2.48	1.29	NA	0.077	0.409	0.0485
PA-18I	NA	0.036	0.438	0.554	NA	0.036	0.0218	0.034
PA-18D	NA	0.064	0.509	0.194	NA	0.064	0.0243	0.0203
PA-19S	NA	2.9	<0.100 S	<0.1	NA	0.11	0.012 S	<.010
PA-19I	NA	0.93	<0.100 S	<0.1	NA	0.084	0.0159 S	0.0332
PA-19D	NA	0.15	<0.100 S	0.18	NA	0.012	0.0105 S	0.0319
<b>Distant Wells</b>								
PA-1S	0.86	0.36	0.199 S	<0.1	0.052	0.02	0.0281 S	0.0223
PA-1I	0.7	0.42	0.54 S	0.296	0.13	0.058	0.0684 S	0.0529
PA-1D	0.48	1.7	<0.100 S	0.58	0.12	0.046	0.104 S	0.0887
<b>Confined Aquifer Wells</b>								
PA-20	NA	0.12	<0.100	<0.1	NA	0.031	0.022	<0.010
PA-21	NA	0.16	<0.100	<0.1	NA	0.078	0.0476	0.0443
PA-22	NA	0.13	<0.100	<0.1	NA	0.038	0.030	0.024
PA-22-DUP	NA	0.13	NA	NA	NA	0.038	NA	NA

NA: Not available.

<: The compound was analyzed but not detected at or above the specified reporting limit.

SMCL: Secondary Maximum Contaminant Level.

Shading denotes that the concentration exceeds or equals to the SMCL.

S: Spike recovery outside control limits

**Table D-3. Results of Chloride and Total Dissolved Solids**

SMCL	Chloride (mg/L)				TDS (mg/L)			
	250 mg/L				500 mg/L			
Well ID	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>								
PA-16S	<1,000	NA	NA	89	2,470	NA	NA	728
PA-16I	42.8	NA	NA	86	814	NA	NA	886
PA-16D	415	NA	NA	313	4,510	NA	NA	1,070
PA-17S	297	NA	NA	160	1,740	NA	NA	1,250
PA-17I	448	NA	NA	93	1,360	NA	NA	1,200
PA-17D	305	NA	NA	144	1,200	NA	NA	4,650
PA-17D-DUP	318	NA	NA	155	1,340	NA	NA	4,550
<b>Steam Injection Perimeter Wells</b>								
BAT-5S	436	330	NA	125	6,840	2,700	NA	925
BAT-5S-DUP	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5I	566	220	NA	23.6	5,380	1,500	NA	355
BAT-5I-DUP	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5D	752 J	570	NA	340	6,140	3,900	NA	5,000
BAT-5D-DUP	NA	550	NA	NA	NA	3,800	NA	NA
PA-14S	101	130	131	175	772	680	736	870
PA-14I	156	3,500	267	120	870	6,900	1,310	669
PA-14D	4,790	330	1,360	2,020	10,700	960	2,840	3,620
PA-18S	NA	170	239	221	NA	950	1,310	1,290
PA-18I	NA	70	95.3	181	NA	590	829	933
PA-18D	NA	72	167	165	NA	710	697	817
PA-19S	NA	79	27.7	175	NA	660	242	354
PA-19I	NA	130	42.6	NA	NA	590	257	NA
PA-19D	NA	430	383	237	NA	1,000	933	665
<b>Distant Wells</b>								
PA-1S	56.8	19	42.7	63.3	583	240	359	390
PA-1I	66.6	44	36.8	NA	496	260	187	NA
PA-1D	327	26	521	553	1,200	110	1,310	1,210
<b>Confined Aquifer Wells</b>								
PA-20	NA	680	698	209	NA	1,300	1,470	758
PA-21	NA	580	668	687	NA	1,300	1,450	1,350
PA-22	NA	670	683	800	NA	1,500	1,590	1,520
PA-22-DUP	NA	680	NA	NA	NA	1,400	NA	NA

NA: Not available.

SMCL: Secondary Maximum Contaminant Level.

J: Estimated but below the detection limit.

Shading denotes that the concentration exceeds the SMCL Level.

Table D-4. Other Parameter Results of Groundwater Samples

Well ID	Cations (mg/L)																							
	Calcium				Magnesium				Iron (0.3 mg/L)				Manganese (0.05mg/L)				Potassium				Sodium			
	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>																								
PA-16S	27.7	NA	NA	88	<2	NA	NA	17	<0.1	NA	NA	2.47	667	NA	NA	0.858	1,560	NA	NA	134	45.3	NA	NA	33.1
PA-16I	30.5	NA	NA	63.4	3.7	NA	NA	20.1	<0.1	NA	NA	0.296	5.3	NA	NA	0.1	511	NA	NA	242	42.4	NA	NA	31.3
PA-16D	111	NA	NA	86.8S	179	NA	NA	37.9S	0.28	NA	NA	0.813	1.3	NA	NA	0.826	1,600	NA	NA	92.4	72.4	NA	NA	184
PA-17S	108	NA	NA	5.3	73.6	NA	NA	1.51	3.9	NA	NA	<0.1	0.46	NA	NA	0.013	330	NA	NA	335	189	NA	NA	159
PA-17I	92.6	NA	NA	93.5S	101	NA	NA	15.7S	3.4	NA	NA	<0.1	0.64	NA	NA	1.03	32.6	NA	NA	217	213	NA	NA	67.8
PA-17D	90.7	NA	NA	47.6	100	NA	NA	19.9	0.63	NA	NA	<0.1	0.18	NA	NA	0.081	103	NA	NA	1,860	147	NA	NA	76
PA-17D-DUP	89.1	NA	NA	46.9	100	NA	NA	19.1	0.58	NA	NA	<0.1	0.18	NA	NA	0.082	109	NA	NA	1,770	144	NA	NA	72.8
<b>Steam Injection Perimeter Wells</b>																								
BAT-5S	4.5	21	NA	17.6	18.9	98	NA	18.8	0.055	0.25	NA	<0.1	0.38	0.98	NA	0.253	NA	920	NA	272	NA	NA	NA	81.2
BAT-5S-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5I	27.3	67	NA	15.2	30.6	130	NA	11.9	0.058	0.22	NA	<0.1	1.2	1.9	NA	0.374	NA	220	NA	115	NA	NA	NA	15
BAT-5D	66.1	71	NA	53.9	140.0	100	NA	69.7	<0.05	0.97	NA	2.24	4	2.1	NA	1.59	NA	1,300	NA	1,680	NA	NA	NA	85.2
BAT-5D-DUP	NA	73	NA	NA	NA	100	NA	NA	NA	NA	1	NA	NA	2.1	NA	NA	NA	1,300	NA	NA	NA	NA	NA	NA
PA-14S	55.3	96	124	154	10.6	26	29	22.3	<0.05	0.1	0.148	<0.1	<0.015	0.024	0.024	0.029	42.6	49	18.2	12.1	138	NA	NA	58
PA-14I	13.6	73	171	92.2	1.2	8	31.1	19.1	<0.05	0.086	0.185	<0.1	<0.015	0.021	0.033	0.026	14.2	28	63.8	31.4	258	NA	NA	69.4
PA-14D	662	420	161	182	30.2	30	21	33.9	<0.05	0.058	<0.10	<0.1	0.021	0.019	0.016	0.018	93.9	71	27	36.2	2,490	NA	NA	1,110
PA-18S	NA	220	160	130	NA	13	14.1	14.2	NA	4.4	2.48	1.29	NA	0.077	0.041	0.049	NA	92	329	357	NA	NA	NA	43.9
PA-18I	NA	86	112	138	NA	44	52.2	62.2	NA	0.89	0.438	0.554	NA	0.036	0.022	0.034	NA	11	14.7	12.7	NA	NA	NA	36.3
PA-18D	NA	120	133	94.9	NA	15	30.9	32.7	NA	0.77	0.509	0.194	NA	0.064	0.024	0.02	NA	140	70.2	59.6	NA	NA	NA	100
PA-19S	NA	150	48.5 S	48.2	NA	16	4.56 S	4.13	NA	2.9	<0.1	<0.1	NA	0.11	0.012	<0.01	NA	68	13.2	12.1	NA	NA	NA	19.1
PA-19I	NA	68	41.0 S	57	NA	53	19.1 S	43	NA	0.93	<0.1	<0.1	NA	0.084	0.016	0.033	NA	27	13.2	13.9	NA	NA	NA	42.5
PA-19D	NA	48	42.7 S	53.9	NA	49	46.3 S	27.8	NA	0.15	<0.1	0.18	NA	0.012	0.011	0.032	NA	44	19.3	18.7	NA	NA	NA	145
<b>Distant Wells</b>																								
PA-1S	128	65	85.8 S	110	8.8	3	4.7 S	5.21	0.86	0.36	0.199	<0.1	0.052	0.02	0.028	0.022	NA	2.4	2.43	3.03	NA	NA	NA	28.4
PA-1I	83.2	50	32.2 S	58.3	19.8	9.6	4.15 S	18.1	0.7	0.42	0.54	0.296	0.13	0.058	0.068	0.053	NA	13	22	18.5	NA	NA	NA	29.6
PA-1D	119	32	88.5 S	83	29.9	4	40.3 S	48	0.48	1.7	0.842	0.58	0.12	0.046	0.104	0.089	NA	3.5	12.3	135	NA	NA	NA	215
<b>Confined Aquifer Wells</b>																								
PA-20	NA	75	68.9	5.23	NA	64	69.1	1.27	NA	0.12	<0.1	<0.1	NA	0.031	0.022	<0.01	NA	16	14.3	122	NA	NA	NA	185
PA-21	NA	71	68.7	61.6	NA	59	65.9	55.4	NA	0.16	<0.1	<0.1	NA	0.078	0.048	0.044	NA	14	13.2	12	NA	NA	NA	329
PA-22	NA	90	86.3	74	NA	69	77.5	67.9	NA	0.13	<0.1	<0.1	NA	0.038	0.03	0.024	NA	19	16.4	12.9	NA	NA	NA	329
PA-22-DUP	NA	91	NA	NA	NA	69	NA	NA	NA	0.13	NA	NA	NA	0.038	NA	NA	NA	19	NA	NA	NA	NA	NA	NA

Table D-4. Other Parameter Results of Groundwater Samples (Continued)

Well ID	Anions (mg/L)												Others							
	Sulfate				Nitrate/Nitrite as N				Alkalinity				BOD				TOC			
	Pre-Demo	Aug 2001	Nov 2001	Feb 2002	Pre-Demo	Aug 2001	Nov 2001	Feb 2002	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo	Pre-Demo	Aug 2001	Nov 2001	Post-Demo
<b>Steam Injection Wells</b>																				
PA-16S	<1,000	NA	NA	95.6	NA	NA	NA	<0.5	661	NA	NA	361	<3.0	NA	NA	<6.0	1,680	NA	NA	61.5
PA-16I	104	NA	NA	90.9	<0.1	NA	NA	<0.5	380	NA	NA	468	13.8	NA	NA	<6.0	30.5	NA	NA	56
PA-16D	681	NA	NA	121	<0.1	NA	NA	<0.5	2,500	NA	NA	329	84	NA	NA	<6.0	134	NA	NA	73.5
PA-17S	293	NA	NA	360	<0.1	NA	NA	<1.0	1,430	NA	NA	248	70	NA	NA	6.8	74.2	NA	NA	26.8
PA-17I	120	NA	NA	466	<0.1	NA	NA	<1.0	422	NA	NA	193	7.4	NA	NA	4.2	2.1	NA	NA	29.2
PA-17D	202	NA	NA	1,960	<0.1	NA	NA	<1.0	479	NA	NA	441	24.6	NA	NA	13.8	19.6	NA	NA	69.2
PA-17D-DUP	208	NA	NA	1,940	<0.1	NA	NA	<1.0	459	NA	NA	445	22.8	NA	NA	16.6	19.5	NA	NA	79.5
<b>Steam Injection Perimeter Wells</b>																				
BAT-5S	NA	680	NA	NA	NA	NA	NA	NA	2,320	860	NA	408	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5S-DUP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5I	NA	460	NA	NA	NA	NA	NA	NA	1,720	490	NA	220	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5D	NA	1,200	NA	NA	NA	NA	NA	NA	1,700	810	NA	361	NA	NA	NA	NA	NA	NA	NA	NA
BAT-5D-DUP	NA	1,200	NA	NA	NA	NA	NA	NA	NA	810	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-14S	18.6	8.3	NA	NA	<0.1	NA	NA	NA	388	420	464	344	22.2	NA	NA	NA	18.7	NA	NA	NA
PA-14I	30	11	NA	NA	<0.1	NA	NA	NA	434	350	664	410	3.7	NA	NA	NA	8.9	NA	NA	NA
PA-14D	163	94	NA	NA	<0.1	NA	NA	NA	394	190	205	238	560	NA	NA	NA	100	NA	NA	NA
PA-18S	NA	99	NA	143	NA	NA	NA	NA	NA	450	508	566	NA	NA	NA	NA	NA	NA	NA	NA
PA-18I	NA	89	NA	97.8	NA	NA	NA	NA	NA	320	336	449	NA	NA	NA	NA	NA	NA	NA	NA
PA-18D	NA	97	NA	99.3	NA	NA	NA	NA	NA	420	346	366	NA	NA	NA	NA	NA	NA	NA	NA
PA-19S	NA	82	NA	NA	NA	NA	NA	NA	NA	390	123	12.7	NA	NA	NA	NA	NA	NA	NA	NA
PA-19I	NA	61	NA	NA	NA	NA	NA	NA	NA	300	126	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-19D	NA	58	NA	NA	NA	NA	NA	NA	NA	210	172	208	NA	NA	NA	NA	NA	NA	NA	NA
<b>Distant Wells</b>																				
PA-1S	NA	16	NA	NA	NA	NA	NA	NA	310	150	197	222	NA	NA	NA	NA	NA	NA	NA	NA
PA-1I	NA	15	NA	NA	NA	NA	NA	NA	255	150	70	NA	NA	NA	NA	NA	NA	NA	NA	NA
PA-1D	NA	2.8	NA	NA	NA	NA	NA	NA	230	44	176	189	NA	NA	NA	NA	NA	NA	NA	NA

NA: Not available.

Shading denotes that the concentration exceeds the MCL level listed.

### D-5. Surface Emission Results

Sample ID	Sample	TCE	Sample ID	Sample	TCE
	Date	ppb (v/v)		Date	ppb (v/v)
<b>Steam Injection Plot</b>			<b>Background</b>		
SI-SE-33	12/4/2000	1.2	DW-SE-36	12/6/2000	<0.40
SI-SE-34	12/5/2000	1.1	DW-SE-37	12/6/2000	0.49
SI-SE-35	12/5/2000	<0.40	DW-SE-38	12/7/2000	<0.40
SI-SE-1	8/27/2001	<37	DW-SE-40	11/5/2001	<0.060
SI-SE-2	8/27/2001	0.45	DW-SE-41	11/5/2001	<0.060
SI-SE-3	8/27/2001	<0.34	DW-SE-42	11/5/2001	<0.060
SI-SE-4	8/27/2001	<0.34	DW-SE-43	11/6/2001	0.26
SI-SE-5	8/28/2001	51	DW-SE-44	11/6/2001	0.26
SI-SE-6	8/28/2001	<49	DW-SE-45	11/6/2001	0.17
SI-SE-7	11/6/2001	<0.060	DW-SE-47	2/18/2002	<0.03
SI-SE-8	11/6/2001	<0.060	DW-SE-48	2/20/2002	<0.03
SI-SE-9	11/6/2001	<0.060	<b>Ambient Air at Shoulder Level</b>		
SI-SE-10	11/7/2001	<0.060	DW-SE-39	11/6/2001	<0.060
SI-SE-11	11/7/2001	<0.060	DW-SE-46	2/18/2002	<0.03
SI-SE-12	11/7/2001	<0.060	<b>Near Drainage Ditch Area</b>		
SI-SE-13	11/8/2001	40	SI-SE-7	8/28/2001	110
SI-SE-14	11/8/2001	45	SI-SE-8	8/28/2001	74
SI-SE-15	11/8/2001	21			
SI-SE-16	2/18/2002	33			
SI-SE-17	2/20/2002	15			
SI-SE-18	2/18/2002	280			
SI-SE-19	2/20/2002	180			

ppb (v/v): parts per billion by volume.



**Table D-6. TOC Results of Soil Samples**

Pre-Demo		Post-Demo		
Sample ID	SW9060 (mg/kg)	Sample ID	TOC by LECO (wt%-dry)	TOC by LECO (mg/kg)
SB-32-20	5,390	SB-236-10	0.036	360
SB-32-30	9,450	SB-236-30	0.065	650
SB-32-46	17,700	SB-236-38	0.068	680
SB-38-20	16,000	SB-234-18	0.024	240
SB-38-26	15,400	SB-234-30	0.216	2160
SB-38-39	47,800	SB-234-38	0.066	660

**Total Organic Carbon By  
 LECO Instrument**

Doc No.: 160-30.18  
 Date: January 14, 2002  
 Revision: 1  
 Supersedes: January 31, 2000

PREPARED BY: Mark Tipton DATE: 01/14/02  
 Mark Tipton, Quality Manager

APPROVED BY: Jeff Windschitl DATE: 01/14/02  
 Jeff Windschitl, Department Manager

APPROVED BY: Mark Tipton DATE: 01/14/02  
 Mark Tipton, Quality Manager

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## 1. OBJECTIVE

- 1.1 This procedure is for the determination of organic carbon in soil samples for analysis of soil, solids, or metal alloys using the LECO TOC instrument method.

## 2. SCOPE

- 2.1 In the LECO method, total organic carbon in soil samples is measured by detection of total carbon by reaction with oxygen and detection using IR analysis. Soils are first acid washed to remove inorganic carbon before being analyzed in the LECO instrument. In steel alloys, total carbon is the only portion analyzed.
- 2.2 For the LECO method the detection limit is 10 mg/kg for soil samples and 0.001% for metal alloy samples.
- 2.3 Metal alloy samples will give biased TOC results by the LECO method if oil or grease is present on the metal turnings or shavings. This is prevented by washing the turnings in acetone and drying prior to analysis.

## 3. REFERENCE

- 3.1 U.S. Environmental Protection Agency, Methods for Chemical Analysis of Soils and Sludges. EPA-600/2-78-054, Method 3.2.13, page 78.
- 3.2 U.S. Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, Method 415.1.
- 3.3 U.S. Environmental Protection Agency, Test Methods for Evaluating Solid Wastes. EPA-SW-846, Method 9060.

## 4. SAFETY

- 4.1 The use of eye protection and other personal protective laboratory attire is required.

## 5. APPARATUS & EQUIPMENT

- 5.1 LECO Total Organic Carbon Analysis System
- 5.1.1 Analytical balance unit interfaced with microprocessor
- 5.1.2 High-temperature reaction furnace
- 5.1.3 IR Detector

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### 5.1.4 Microprocessor

## 6. REAGENTS & STANDARDS

- 6.1 Copper Accelerator Reagent-LECO equivalent
- 6.2 TOC in Soil Standard and TOC in Steel Standard-LECO equivalent. A second source standard is required for the LECO method.
- 6.3 6N HCl-Carefully add 100 ml of concentrated HCl to 100 ml of DI water.

## 7. SAMPLE HANDLING & PRESERVATION

- 7.1 Soil samples for TOC analysis must be refrigerated prior to analysis. There is no established holding time and a 28 days internal holding time is recommended.
- 7.2 Metals samples for carbon content analysis are held at room temperature until analysis. There is no established holding time.

## 8. PROCEDURE

- 8.1 Analysis of Soil Samples
  - 8.1.1 For each soil sample, place about 5 grams of sample into an numbered planchet and dry at 103-105 °C overnight.
  - 8.1.2 Go through the maintenance checklist and perform all the instrument maintenance items and system checks. Record the completion of the checks by dating and initialling the checklist and placing a tic mark on the checklist for all items performed. Place a LECO crucible on the weighing pan and tare the balance. To prepare the blank (ICB), add approximately 0.25 gram of Ottawa sand to the crucible and store the weight in the data system. Add one scoop of copper accelerator to the ICB and carefully homogenize. Place the crucible on the sample holding tray in the first position.
  - 8.1.3 Place a LECO crucible on the weighing pan and tare the balance. Add approximately 0.25 gram of LECO carbon standard (ICV) to the crucible and store the weight in the data system. Add one scoop of copper accelerator to the standard and carefully homogenize. Place the crucible on the sample holding tray in the second position. Likewise, prepare a lab control standard (LCS) from a different standard.
  - 8.1.4 In a similar fashion weigh 0.25 grams of sample into a crucible, add accelerator, and place onto the holding tray. Complete this for every sample to be analyzed and for the spike sample and spike duplicate. The spike and spike duplicate must be prepared for each set of 10 samples or less. After the last sample is weighed, weigh another portion of standard in a crucible and a portion of Ottawa sand to use as the end of run calibration check and end of run blank.
  - 8.1.5 Bring all the crucibles to the vacuum filtration apparatus. Place the crucibles in order into the crucible holder and apply the vacuum. Rinse each sample and QC check with a portion of 6N hydrochloric acid to remove the

carbonates. After the liquid is removed, add another portion of HCl, and leave on the vacuum until the liquid is removed. Place the sample back into the holding tray. Dry for at least 4 hours at 103-105 °C.

8.1.6 Analyze the standards and samples. Open the induction furnace and put the crucible on the pedestal. Close the furnace and wait for the instrument green ready light to illuminate. Press the "ANALYZE" button. The analytical results will be stored in the data system and printed in the strip chart. Remove the crucible and discard after it has cooled.

8.1.7 Select a sample weight according to the following table:

<u>mg/kg TOC</u>	<u>Sample Weight</u>
10-5000	1.00g
2000-50,000	0.50g
20,000-100,000	0.20g

## 8.2 Analysis of Metal Samples

8.2.1 Go through the maintenance checklist and perform all the instrument maintenance items and system checks. Record the completion of the checks by dating and initialling the checklist and placing a tic mark on the checklist for all items performed. If samples are received in ingot or other solid form, the sample must be prepared in the lab. Clean the surface with acetone to remove any oil or grease and lock into place on the drilling surface. Using a sharp drill bit designed for drilling metals, drill into the surface and collect the shavings. If needed, move the sample to different position and collect more shavings. Keep the sample free from contamination during the preparation. If sample shavings are received from the client, the shavings must be washed with acetone and dried prior to analysis to remove residual grease and oil.

8.2.2 Place a LECO crucible on the weighing pan and tare the balance. Add approximately 0.5 gram of LECO carbon standard (ICV) to the crucible and store the weight in the data system. Add one scoop of copper accelerator to the standard and carefully homogenize.

8.2.3 Open the induction furnace and put the crucible on the pedestal. Close the furnace and wait for the instrument green ready light to illuminate. Press the "ANALYZE" button. The analytical results will be stored in the data system and printed in the strip chart. Remove the crucible and discard after it has cooled.

8.2.4 Repeat steps 8.3.2 and 8.3.3 for the second source standard (LCS), for the samples, for at least one sample duplicate for each 10 samples and analyze a standard at the end of run. See Section 10- Quality Control for the control limits for the standards and duplicates.

8.2.5 Select a sample weight according to the following table:

<u>Percent Carbon</u>	<u>Sample Weight</u>
0.001-1.00	1.00g
1.00-5.00	0.50g
5.00-10.00	0.20g

## 9. CALCULATIONS

The LECO instrument will report results directly in either mg/kg or percent depending on the computer set up. Because the sample is dried prior to analysis, the results will be on a dry weight basis for soils samples.

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## 10. QUALITY CONTROL

### 10.1 Initial Calibration Blank (ICB)

- 10.1.1 Frequency - Perform an ICB with each batch. The ICB is used to verify that no system contaminants are present.
- 10.1.2 Criteria - The results of the blank must be below the reporting level for TOC. If it is above this level, it indicates unusual contamination in the system and corrective actions must be taken to resolve the problem.

### 10.2 Initial Calibration Verification (ICV)

- 10.2.1 Frequency - The ICV is a standard reference material in soil or steel. The ICV is analyzed at the beginning of the run.
- 10.2.2 Criteria - The acceptance range for the ICV is either the limit posted on the standard, or if no limits are given, 90-110 percent recovery. If outside the range, perform corrective action to solve the source of the error, and then re-analyze the ICV.

### 10.3 Laboratory Control Standard (LCS)

- 10.3.1 Frequency - The LCS is prepared from a second source standard of TOC in soil or carbon in steel. It must be analyzed with each batch of samples, after the ICV standard for the LECO methods.
- 10.3.2 Criteria - The acceptance range for the LCS is either the limit posted on the standard, or if no limits are given, 80-120 percent recovery. If outside this range, stop the analysis and perform corrective action to solve the source of the error, and then re-analyze all samples.

### 10.4 Matrix Spike Sample

- 10.4.1 Frequency: Matrix spikes are analyzed for the LECO method at a frequency of one spike for each 10 or fewer samples.
- 10.4.2 Criteria - The acceptance range for the matrix spike is either the limit calculated from historical results, or if no limits have been calculated, 80-120 percent recovery. If outside this range, it is an indication of matrix interference and this must be reported with the results.

### 10.5 Duplicate Sample or Spike Duplicate

- 10.5.1 Frequency: Duplicates or spike duplicates will be analyzed on a frequency of one duplicate for each 10 samples analyzed. If fewer than 10 samples are in a batch, one duplicate will be analyzed.
- 10.5.2 Criteria: Acceptance limits are  $\pm 25\%$  RPD. If the duplicate results are outside the acceptance limits for relative percent difference, first determine if the cause is a system error; if so, correct the problem and repeat the duplicate. If still outside acceptance limits, the sample results should be flagged for matrix interference.

## 11. RECORDS

<b>STORK<sup>®</sup></b> <b>SwL</b> SOUTHWESTERN LABORATORIES	<b>Total Organic Carbon By  LECO Instrument</b>	DocNo.: 160-30.18 Date: January 14, 2002 Revision: 1 Supersedes: January 31, 2000
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11.1 The original instrument printout is kept on file. The printout is labeled with the date, analyst's name and sample labels.

## 12. REVIEW/REVISION

This procedure will be reviewed approximately once per year from the date of the last review or revision. Suggestions or comments regarding this SOP are welcome. Please direct them to:

Materials Engineering and Testing Quality Coordinator  
Stork Southwestern Laboratories, Inc.  
222 Cavalcade  
Houston, Texas 77009  
Phone: 713-692-9151  
Fax: 713-696-6307

### Revision History

Revision	Date	Initials	Description
0	01/31/00	CMT	Initial version
1	01/14/02	CMT	Removed reference to Walkley-Black method.

ATTACHMENT

Example Analytical Sequence

**Total Organic Carbon By  
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**Attachment-EXAMPLE: 11 SAMPLES FOR ANALYSIS**

Sample Preparation Sequence	Analysis Sequence
<i>Note: Sample preparation may include air drying samples, drilling steel samples, or weighing samples prior to analysis.</i>	<i>The LECO instrument is calibrated according to manufacturer's specifications and the calibration is saved in the data system memory.</i>
	<i>ICB            Acceptance Limit [ less than reporting limit ]</i>
	<i>ICV            Acceptance Limit            [ Specified or •10% of true value ]</i>
	<i>LCS            Acceptance Limit            [ Specified or •20% of true value ]</i>
	<i>Sample 1</i>
	<i>Sample 2</i>
	<i>Sample 3</i>
	<i>Sample 4</i>
	<i>Sample 5</i>
	<i>Sample 6</i>
	<i>Sample 7</i>
	<i>Sample 8</i>
	<i>Sample 9</i>
	<i>Sample 10</i>
	<i>Spike Sample 1            Acceptance Limit [ 80-120% Recovery ]</i>
	<i>Duplicate Sample 1            Acceptance Limit [ 20% RPD ]</i>
	<i>Sample 11</i>
	<i>Spike Sample 2            Acceptance Limit [ 80-120% Recovery ]</i>
	<i>Duplicate Sample 2            Acceptance Limit [ 20% RPD ]</i>
	<i>CCV            Acceptance Limit            [ Specified or •10% of true value ]</i>
	<i>CCB Acceptance Limit [ less than reporting limit ]</i>