2. High Positive Pressure - If the system pressure becomes positive due to a huge increase in the Btu value of the contaminate, blow-off covers in the Multi-tube dust collector, and the heat exchanger will activate to release the pressure and ensure the safety of the people working in the area of the plant.

   Small positive pressure occurrences in the PTU, are contained by the PTU seals, unique to SPI plants, until the plant automated controls, or the operator, has adjusted ID fan to bring the plant back into a negative pressure operation.

3. Emergency Shutdown - The plant has an emergency shutdown button in clear view of the operator that, when activated, shuts down all components of the LTTD plant including the electrical power feed to each component.

4. Feed System Bypass Chute: The feed system conveyor that carries feed soil to the Primary Treatment Unit, has a bypass chute that is hydraulically controlled from the Control House. The diversion chute is used in situations where the feed material should be stopped immediately. Such an example would be a loss in burner control in the PTU.

5. PTU Tee Flights: The PTU drum uses flighting or lifters to veil the soil as it moves through the drum. The flights near the burner end of the drum are designed to separate the flame from the soils. This avoids creating additional contaminants that would be produced if cold material were allowed to contact the flame and cause partial quenching

6. Alarm Lights - The Envirosoil Limited LTTD system is equipped with an Alarm Lights section located on the Plant Motor Control console. This section is dedicated to identifying a component failure that interferes with the continued operations of the plant. These enunciators will light and blink to identify when a problem exists with a plant component. An audible alarm will also sound.

4.4.4 Environmental Safeguards

Environmental safeguards for Low Temperature Thermal Desorption will fall into 1 of 3 general categories: soil analysis, stack monitoring, and site monitoring.

Soil Analysis

The soil is tested for its contaminant constituents before and after treatment. The soil is pre-screened to determine the contaminants associated with the soil. The pre-screening is most often done by consultants, and is done on-site for the owner or at Envirosoil. Soil entering Envirosoil's facility with no advance chemical analyses, does so under an emergency agreement that gives Envirosoil the right to test the soil and reject it if it does not meet the entrance requirements. All soils entering the facility are individually identified and reported to the Nova Scotia Department of the Environment through submission of quarterly monitoring reports.

The soil is tested after treatment to confirm the success of the LTTD treatment. No soils are removed from the contaminated soil holding areas until this confirmation is received.

Stack Monitoring

Envirosoil's LTTD plant includes continuous stack monitoring as standard equipment. A digital readout is located in the operator's control house and provides a continuous readout of oxygen and combustible levels of the stack gases. The oxygen and combustible content of the stack gases is a direct indication of the LTTD plant's performance.

Site Monitoring

Additional environmental safeguards can be designed into the facility and these will be different at each site that the LTTD plant operates. Envirosoil's Rocky Lake facility is located within the boundaries of a 2500 acre quarry site. The soil treatment and storage area is isolated from the remaining quarry site by a clay liner that completely encompasses the site. A collection pond, with a 100 year storm design volume collects all surface runoff. A water treatment facility located on the clay lined site pumps and treats all pond water, before it is discharged off-site.

There are monitoring wells located around the perimeter of the Envirosoil site. The groundwater is sampled and tested by an independent professional consultant on a monthly basis. Water discharged from the site in surface ditches, as well as the down gradient ponds located outside the quarry, are also routinely tested. The data and results of the monitoring program are reported to the Nova Scotia Department of the Environment, by an independent professional consulting firm, on a quarterly basis.

5. LTTD PLANT DEMONSTRATION TEST OPERATING CONDITIONS

Prior to the start of each test, the operating temperatures of the LTTD Plant were increased to the intended test temperatures, while the unit was processing existing "non-spiked" hydrocarbon impacted soil. Once the operating conditions had stabilized, the feed soil was changed from the "non-spiked" soil to the test soil.. Stack emission testing began approximately one half hour after introduction of the feed soil, allowing the LTTD unit to reach steady state. Additional soil was treated prior to the start of Test #1, due to increased time required for stack testing equipment set up.

5.1 Material Feed

The soil feed rate was held relatively constant at 25 tonnes per hour for Tests #1 and Test #2, and reduced to approximately 22.5 tonnes per hour for Test #3 due to limited feedstock material. Lime was mixed with the gas stream through an injection hopper installed precedent to the baghouse. Lime was added at the rate of approximately 280 lbs/hr. (130 kg/hr). The lime feed began before the soil feed was switched to the spiked test soil, and continued through the entire LTTD test period.

5.2 Operating Conditions

A summary of the operating temperatures for the LTTD plant during the demonstration tests are shown in Table 4 below:

Table 4 Summary of LTTD Plant Operating Parameters

	Run #1	Run #2	Run #3
Soil Feed Rate (tonnes/hr.)	25	25	22.5
Average Soil Moisture (%)	9.27	9.88	9.27
PTU Temp. (°C)	510	482	455
STU Temp. (°C)	955	955	955
Baghouse Inlet Temp (°C)	215	215	215
Baghouse Δ P (cm H_2O)	10-16	10-15	20
Lime Feed Rate (kg/hr)	130	130	130

Stack gas temperature, velocities and flow rates are presented in Table 2 and Table 3 of the CanadEER Report (attached).

The chart records for the PTU and STU operating temperatures are provided in Appendix 2. The absolute temperature variance exceeded the intended 14°C (25°F) tolerance on several occasions, however the temperature fluctuated within the tolerance for the majority of each test.

The rotational speed of the PTU drum ranged between 13 to 14 rpm. This provided a soil residence time of approximately 8 minutes.

Following Test #1 and #2, approximately 12 bags from the baghouse (a small percentage of the overall 1285 bags) were replaced. This was done based on a manual black lighting inspection procedure; the bags showed obvious defects or signs of wear. It should also be noted that the remaining bags are likely to be at 75 to 80% of their expected life, considering the volume of soil treated to date by the LTTD unit. Scheduling for bag replacement will vary due to the variable nature of the feed material.

5.3 Heat and Material Balance

Table 5 summarizes the key parameters involved in the heat and material balance for the LTTD system. The table identifies points within the LTTD process which are shown on the Flow Diagram to identify the specific item. The flow diagram is provided in Appendix 4. The column referenced as "Mass Balance Theoretical" identifies the flow of input and output for solids and gases from each of the components. The structure of the mass balance utilized the same basis as the original plant design, but adapted to the conditions that were expected during the test demonstration. The column identified as "Actual Data from Field Test" shows the measured parameters from test runs which were conducted to simulate the demonstration test conditions. This set of data includes some items only for the purpose of identifying capacity of a particular component such as capacity of a burner or electrical drive unit. The column referenced as "Data from Stack Test" shows the stack test parameters measured during the test demonstration. In most cases, the data in the table is given in both English and metric units, for comparison purposes. Since there were some variation in the input parameters used in the mass balance versus the actual test conditions, the resulting data varies slightly. Overall, there is good correlation between the projected and actual conditions as well as the process performance.

Table 5 Envirosoil PCP/PAH Test Burn Mass Balance

Flow Chart Point	Parameter	Mass Balance Theoretical	Actual Data From Field Test	Average Data From Stack Test
1	Soil moisture content (%)	17	18	9.5
1	Soil contamination level (ppm)	12,500	20,000	
2	Soil discharge temperature °C (°F)	468 (876)	491-512 (915-954)	482 (900)
1	Feed rate (tonnes/hr)	25	21 - 28	24.2
3	PTU gas exit temperature °C (°F)	926	1038-1138	
3	PTU gas exit oxygen (%)	6.1	4.1 - 8.1	
3	NO_x Content (PPM)		100 - 123	
3	PTU exit volume (ACFM)	34,347		
4	PTU Burner Stable pressure (in.w.c.)		.08 - .38	
5	PTU Firing Rate (%)	79	12 - 36	
5	PTU Fuel flow (GPM)	4.7	3.5	
6	Fuel Pressure (psi)		6.5	
6	PTU amperage draw (%)		60	
7	Pugmill cooling water flow rate (GPM)	21.0		
8	Pugmill amperage draw (%)		35 - 40	
9	Pugmill scavenge pressure (in w.c.)		.50	
10	Pugmill discharge temperature °C (°F)	85 (185)	61-62 (142-144)	
11	STU inlet temperature °C (°F)	440 (825)		
11	Oxygen content (%)	6.1		
12	STU Firing Rate (%)	42	0 - 24.4	
12	STU Fuel Flow (GPM)	2.5	1 - 2.3	
12	Fuel Pressure (psi)		65	

Flow Chart Point	Parameter	Mass Balance Theoretical	Actual Data From Field Test	Average Data From Stack Test
13	STU Exit Temperature °C (°F)	927 (1700)	945-964 (1733-1767)	955 (1750)
13	STU exit volume (ACFM)	83,810		
14	Pre-cooler air (ACFM)	4608		
14	Pre-cooler air temp °C (°F)	16 (80)	18 (80)	
15	Heat exchange inlet temperature °C (°F)	788 1450)	753-786 (1388-1447)	
16	Combustion air temp °C (°F) - PTU	260 (600)	178 (349)	
16	Combustion air temp °C (°F) - STU	260 (500)	281 (637)	
17	Heat exchanger fan amperage		80/86	
18	Heat exchanger exit temperature °C (°F)	204 (400)	213-219 (415-427)	
18	Oxygen Content (%)		12.4 - 15.4	
18	CO Content (PPM)		6-10	
18	Nox Content (PPM)		96-138	
19	Dry additive feed rate kg/hr (lb/hr)	(188 - 352)		130 (287)
20	Pugmill scavenge temperature °C (°F)	116 (240)	188-187 (371-368)	
21	Baghouse Inlet temperature °C (°F)	202 (395)	191-202 (376-396)	
21	Baghouse inlet volume (ACFM)	17,938		
21	Baghouse air-to-cloth ratio	4.07:1		4.42:1
22	Baghouse exit temperature °C (°F)	174 (345)	166-167 (331-332)	
22	Exhaust fan damper (%)		34-39	
22	Exhaust fan amperage draw (old motor/new)		60/70	
23	Stack temperature °C (°F)	202 (395)	188-167 (331-332)	162 (324)
23	Stack flow rate (ACFM)	47,938		52,038
23	Stack oxygen content (volume, % dry)	11.2	13.0 - 14.2	13.9
23	Stack CO content (PPM)	55	13 - 70	
23	Stack PAH content lb/hr (ug/m^3)	0.07		.001 (9.0)
23	Stack pentachlorophenol content lb/HR (ng/DSCM)			3.38 x 10 (*42.1)
23	Stack HCl ng/s (mg/DSCM)	4.74		2.76 (*34.1)
23	Stack Nox content (PPM)	173.3	72 - 123	
23	Stack velocity (ft/sec)	64.9		70.5
23	Stack particulate lb/HR (mg/DSCM)	3.9		4.1 (*52.5)
23	Stack dioxin content 2,3,7,8,T4CDD TEF lb/HR (pg/DSCM)			4.7 x 10 (59.7) X/O - 291

6. TESTING RESULTS

6.1 Soils Testing

Soil samples were collected from the feed soil and the treated soil discharge during each of the demonstration test runs. Samples were collected every 15 minutes for the first hour and then every 30 minutes for the remaining 3 hours of in stack testing. A composite of the feed soil and a composite of the treated soil, for each test run, was submitted to MDS Laboratories for analysis of TPH/BTEX, PAH, PCP and METALS. A summary of the results are shown in Tables 6, 7 and 8.

As shown in the Tables, the soil discharge consistently met the CCME Residential/Parkland Criteria for PAHs and Pentachlorophenol. The NSDOE Level I criteria for BTEX/TPH guidelines were also met for all soils treated.

Table 6 Soil Petroleum Hydrocarbon Chemistry
Envirosoil Demonstration Test, October 16-18, 1996

Sample ID	BTEX Parameters Concentration in mg/kg (Dry Weight Basis)					Total Petroleum Hydrocarbons Concentration in mg/kg (Dry Weight Basis)				Resemblance
	Benzene	Toluene	Ethyl-Benzene	Xylenes	Total BTEX	C6-C10	C11-C20	C21-C32	TPH	
Test #1 Feed	nd	nd	2.63	10.2	12.83	258	13100	4390	17748	Weathered fuel oil fraction.
Test #1 Discharge	nd	nd	nd	nd	nd	nd	nd	nd	nd	-
Test #2 Feed	nd	nd	2.47	9.39	11.86	256	13100	4530	17886	Weathered fuel oil fraction.
Test #2 Discharge	nd	nd	nd	nd	nd	nd	nd	nd	nd	-
Test #3 Feed	nd	nd	3.1	11.6	14.7	309	15800	5300	21409	Weathered fuel oil fraction.
Test #3 Discharge	nd	nd	nd	nd	nd	nd	nd	nd	nd	-
LOQ	0.4	0.4	0.4	0.8		4	15	15		-
NSDOE Guidelines	0.5	-	-	-	1.0	-	-	-	100	-

Notes
nd = not detected, na = not applicable
LOQ = Analytical "limit of quantification
Samples analyzed by MDS Environmental Services, Halifax, N.S.
NSDOE Guidelines = NSDOE Level I Criteria

Table 7 Soil PAH and Pentachlorophenol Chemistry
Envirosoil Demonstration Test, October 16 - 18, 1996

PARAMETER	UNIT	CCME CRITERIA Res/Park	Sample Identification					
			Test # 1 Feed	Test # 1 Discharge	Test # 2 Feed	Test # 2 Discharge	Test # 3 Feed	Test # 3 Discharge
Naphthalene	mg\kg	5.0	127	0.02	112	0.03	138	< 0.01
Perylene	mg\kg	-	3.75	< 0.01	3.99	< 0.01	5.07	< 0.01
1-Methylnaphthalene	mg\kg	-	206	< 0.01	189	< 0.01	239	< 0.01
2-Methylnaphthalene	mg\kg	-	482	< 0.01	435	0.01	542	< 0.01
Acenaphthylene	mg\kg	-	< 1	< 0.01	< 1	< 0.01	< 1	< 0.01
Acenaphthene	mg\kg	-	311	< 0.01	277	< 0.01	337	< 0.01
Fluorene	mg\kg	-	235	< 0.01	208	< 0.01	255	< 0.01
Phenanthrene	mg\kg	5.0	592	0.02	522	0.04	637	< 0.01
Anthracene	mg\kg	-	84.9	< 0.01	76.6	< 0.01	90.7	< 0.01
Fluoranthene	mg\kg	-	223	< 0.01	193	0.01	237	< 0.01
Pyrene	mg\kg	10.0	154	< 0.01	131	< 0.01	165	< 0.01
Benz (a) anthracene	mg\kg	1.0	33.7	< 0.01	28.9	< 0.01	35.3	< 0.01
Chrysene	mg\kg	-	39.2	< 0.01	33.7	< 0.01	43.0	< 0.01
Benzo (b) Fluoranthene	mg\kg	1.0	18.0.	< 0.01	14.1	< 0.01	20.1	< 0.01
Benzo (k) Fluoranthene	mg\kg	1.0	18.0	< 0.01	14.1	< 0.01	20.1	< 0.01
Benzo (a) Pyrene	mg\kg	1.0	14.7	< 0.01	14.0	< 0.01	17.1	< 0.01
Indeno (1,2,3 - cd) Pyrene	mg\kg	1.0	3.86	< 0.01	1.66	< 0.01	3.64	< 0.01
Dibenzo (a,h) Anthracene	mg\kg	1.0	< 1	< 0.01	< 1	< 0.01	< 1	< 0.01
Benzo (g,h,i) Perylene	mg\kg	-	3.97	< 0.01	2.66	< 0.01	3.86	< 0.01
1-Chloronaphthalene	mg\kg	-	< 1	< 0.01	< 1	< 0.01	< 1	< 0.01
2-Chloronaphthalene	mg\kg	-	< 1	< 0.01	< 1	< 0.01	< 1	< 0.01
Pentachlorophenol	mg\kg	0.5	780	< 0.5	720	< 0.5	870	< 0.5

Notes:
1. CCME = Canadian Council of Ministers of the Environment Remediation Criteria for Soils.
2. - = no guideline value established
3. Samples analyzed by MDS Environmental Services Ltd., Halifax, N.S.
4. Laboratory Detection Limit of 0.5 mg/kg for Feed, and 0.05 mg/kg for discharge soil
5. Laboratory Detection Limit of 0.5 mg/kg for Pentachlorophenol
6. Samples collected October 16 - 18, 1996

Table 8 Soil Metals Chemistry
Envirosoil Demonstration Test, October 16 - 18, 1996

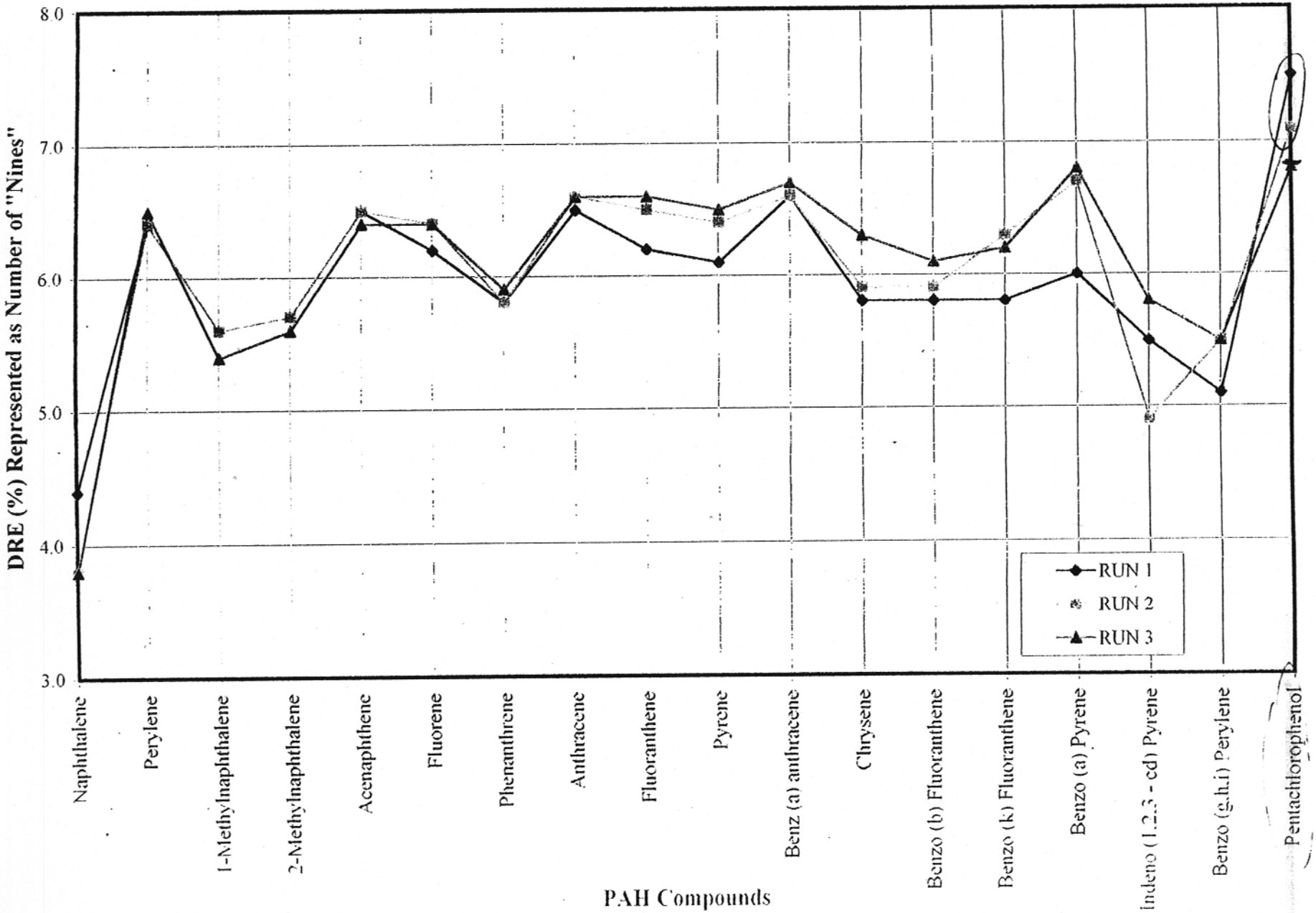
PARAMETER	UNIT	MDL	CCME	Soil Sample Identification					
			Res / Park	Test #1	Test #1	Test #2	Test #2	Test #3	Test #3
		mg/kg	mg/kg	Feed	Discharge	Feed	Discharge	Feed	Discharge
Aluminum	mg\kg	10	-	12000	17000	12000	13000	11000	13000
Antimony	mg\kg	2	20	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	mg\kg	2	30	30	33	31	29	37	31
Barium	mg\kg	5	500	120	120	140	120	120	120
Beryllium	mg\kg	5	4	< 5	< 5	<5	< 5	< 5	< 5
Boron	mg\kg	5	-	< 5	15	< 5	8	< 5	7
Cadmium	mg\kg	0.3	5	0.3	0.3	0.4	0.3	0.4	0.7
Chromium	mg\kg	2	250	18	23	22	19	18	17
Cobalt	mg\kg	1	50	9	9.3	9.1	8.4	9.3	8
Copper	mg\kg	2	100	58	62	59	48	62	50
Iron	mg\kg	20	-	30000	32000	33000	26000	30000	25000
Lead	mg\kg	0.1	500	330	370	380	300	300	330
Manganese	mg\kg	2	-	440	590	410	450	410	400
Molybdenum	mg\kg	2	10	2	2	2	2	2	2
Nickel	mg\kg	2	100	17	19	17	16	18	15
Selenium	mg\kg	2	3	< 2	< 2	< 2	< 2	< 2	< 2
Silver	mg\kg	0.5	20	<0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	mg\kg	5	-	18	26	18	24	18	29
Thallium	mg\kg	0.1	-	0.2	0.2	0.2	0.2	0.2	0.2
Uranium	mg\kg	0.1	-	0.9	1	1	1	1	1
Vanadium	mg\kg	2	200	22	30	21	25	22	25
Zinc	mg\kg	2	500	160	160	180	130	180	140

Notes:
1. CCME = Canadian Council of Ministers of the Environment Remediation Criteria for Soils. (Residential / Parkland Guidelines)
2. Guideline not Established
3. Samples analyzed by MDS Environmental Services Ltd., Halifax, N.S. by ICP-MS.
4 Samples collected October 16-18, 1996 by JWEL.

Figure 1

Destruction Removal Efficiency (DRE %) vs. PAH Compound

(Pentachlorophenol Included)



6.2 Emissions Testing

The results of emission testing are detailed in a separate report by CanadEER which is submitted as an attachment to this report. The results of PAH and pentachlorophenol Destruction Removal Efficiencies (DREs) are summarized in Tables 9 through Table 11 of this report. The DREs were found to exceed the CCME Criteria of 99.99% for all PAHs with the exception of Naphthalene, which had a DRE of greater than 99.99 % for Test #1 and greater than 99.98% for Tests 2 and 3. A graph is provided in Figure 1 which presents the DREs vs PAH parameter for each of the three tests. The majority of the PAH parameters (including benzo(a)pyrene) are shown to exceed a DRE of 6 "nines". The remaining parameters (excluding Naphthalene) exceed a DRE of 5 "nines".

Due to the factors identified in Section 4.0 (Plant Configuration) it is thought that the location of the dilution air intake in relation to the test soil feed pile and nearby loader traffic to and from the soil feed hopper may have compromised the quality of the test results for the volatile components (primarily Naphthalene).

This problem would be avoided in future applications by improved material handling procedures and site logistics.

DREs for pentachorophenol were consistently greater than the "six nines" required by CCME guidelines. Average HCl emissions were 34.1 mg/Rm^3 which is below the CCME guideline criterion of 75 mg/Rm^3. PCDD/PCDF levels were met within the stack.

The particulate emissions are shown in Table 2 of the CanadEER report (attached). The particulate loading decreased from 69 mg/Rm^3 in Test # 1 to 38 mg/Rm^3 in Test # 3, with the average value at 52.5 mg/Rm^3.

Envirosoil's Operating Permit at Rocky Lake, for petroleum impacted soils has a requirements for particulate emissions to be below 90 mg/Rm^3. The target particulate loading for the demonstration test was 20 mg/Rm^3, which is the CCME Guideline for PAH and pentachlorophenol impacted soils.

Table 10 PAH and Pentachlorophenol Destruction Removal Efficiencies For Test # 1
Average Soil Feed Rate of 25 tonnes per hour at 9.27% Moisture
Envirosoil Demonstration Test, October 16 - 18, 1996

PARAMETER	LAB DETECTION LIMIT (Soil) mg/kg	CCME CRITERIA Res/Park (mg/kg)	Test Run # 1 PTU at 510 °C (950 °F) and STU at 955 °C (1750 °F)					
			Test #1 Feed (mg/kg)	Test #1 Discharge (mg/kg)	Parameter Feed Rate (g/s)	Stack Emissions Total (ng)	Emission mass flow (g/s)	DRE %
Naphthalene	0.01	5	127	0.02	**0.800**	15212	4.6056E-05	99.99424
Perylene	0.01	-	3.75	< 0.01	0.024	nd 4	1.211E-08	> 99.99995
1-Methylnaphthalene	0.01	-	206	< 0.01	1.298	1327	4.0176E-06	> 99.99969
2-Methylnaphthalene	0.01	-	482	< 0.01	3.037	2609	7.899E-06	> 99.99974
Acenaphthylene	0.01	-	< 1	< 0.01	*	256	7.7506E-07	*
Acenaphthene	0.01	-	311	< 0.01	1.959	316	9.5672E-07	> 99.99995
Fluorene	0.01	-	235	< 0.01	1.481	346	1.0475E-06	> 99.99993
Phenanthrene	0.01	5	592	0.02	3.730	1669	5.0531E-06	99.99986
Anthracene	0.01	-	84.9	< 0.01	0.535	< 80	2.4221E-07	> 99.99995
Fluoranthene	0.01	-	223	< 0.01	1.405	371	1.1232E-06	> 99.99992
Pyrene	0.01	10	154	< 0.01	0.970	284	8.5984E-07	> 99.99991
Benz (a) anthracene	0.01	1	33.7	< 0.01	0.212	< 24	7.2662E-08	> 99.99997
Chrysene	0.01	-	39.2	< 0.01	0.247	93	2.8157E-07	> 99.99989
Benzo (b) Fluoranthene	0.01	1	18.0	< 0.01	0.113	58	1.756E-07	> 99.99985
Benzo (k) Fluoranthene	0.01	1	18.0	< 0.01	0.113	51	1.5441E-07	> 99.99986
Benzo (a) Pyrene	0.01	1	14.7	< 0.01	0.093	30	9.0828E-08	> 99.99990
Indeno (1,2,3 - cd) Pyrene	0.01	1	3.86	< 0.01	0.024	38	1.1505E-07	> 99.99953
Dibenzo (a,h) Anthracene	0.01	1	< 1	< 0.01	*	< 9	2.7248E-08	*
Benzo (g,h,i) Perylene	0.01	-	3.97	< 0.01	0.025	67	2.0285E-07	> 99.99919
2-Chloronaphthalene	0.01	-	< 1	< 0.01	*	< 53	1.6046E-07	*
Pentachlorophenol	0.5	0.5	780	< 0.5	4.911	< 76	2.301E-07	> 99.99999

1. CCME = Canadian Council of Ministers of the Environment Remediation Criteria for Soils.
2. - = no guideline value established
3. Soil Samples analyzed by MDS Environmental Services Ltd., Halifax, N.S.
4. Stack sampling train analyzed by Wellington Laboratories in Ontario
5. Samples collected October 16 - 18, 1996
6. * = Parameter not detected in the feed soil