

EXECUTIVE SUMMARY

██████████ was retained by ██████████ to conduct excavation and environmental sampling activities on the drilling waste disposal area on the ██████████ wellsite located north of Mayerthorpe, Alberta. ██████████ completed a Phase II Environmental Site Assessment (ESA) on the wellsite in August 2007. The Phase II ESA indicated that the drilling waste disposal area did not meet the applicable remediation guidelines for Benzene, Toluene, Ethylbenzene, F2 hydrocarbons, and F3 hydrocarbons

Beginning on July 7th, 2010, ██████████ personnel supervised the excavation of the impacted soil from the drilling waste disposal area. Approximately 1750 m³ of impacted soil was excavated and placed on a temporary lined containment area.

In July 2011, a microbiological treatment was applied to the impacted soil. As part of the process, the impacted soil was relocated to a 30 mil lined containment area.

██████████ conducted environmental sampling on the treatment pile from September 2010 to August 2011 (Figure 1). All of the soil samples collected throughout the sampling program were submitted to ██████████ for hydrocarbon (BTEX / F1-F4) and available nutrient analysis.

Five composite soil samples were initially collected from the impacted soil on July 9th, 2010 prior to the microbiological treatment being applied to provide a baseline for soils comparison (Table 1 and Table 7).

The first sampling event conducted on the treatment pile was completed on September 1st, 2010. Seven composite soil samples were collected from the treatment pile (Table 2 and Table 8). The second sampling event was completed on October 26th, 2010. Fifteen composite soil samples were collected from the treatment pile (Table 3 and Table 9). The third sampling event was completed on June 2nd, 2011. Fifteen composite soil samples were collected from the treatment pile (Table 4 and Table 10). The fourth sampling event was completed on July 18th, 2011. Fifteen composite soil samples were collected from the treatment pile (Table 5 and Table 11). The final sampling event was completed on August 21st, 2011. Fifteen composite soil samples were collected from the treatment pile (Table 6 and Table 12).

The soil samples analysed for hydrocarbons during the environmental sampling program were compared to the Alberta Environment Tier 1 guidelines for fine grained surface soils under agricultural area land use (AENV 2010). Figure 2 through Figure 13 depicts the trends in the hydrocarbon and nutrient analysis from July 2010 to August 2011.

Based on the results of the laboratory analysis from the environmental sampling that has been completed by ██████████ to date, the impacted soil within the drilling waste disposal area treatment piles meet the applicable remediation guidelines.

[REDACTED]
Table 1. Laboratory Analytical Results - Petroleum Hydrocarbons - July 2010
Remediation [REDACTED]
December 2011

Sample ID	Sample Location	Sample Depth (mbg)	Sample Date (dd-mm-yy)	BTEX (F1-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	Total Xylenes (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
10DWD01	Drilling Waste Disposal Area	Composite	09-Jul-10	0.102	1.34	0.46	1.97	60	193	384	79	28
10DWD02	Drilling Waste Disposal Area	Composite	09-Jul-10	0.048	0.11	0.21	0.68	10	63	357	132	19
10DWD03	Drilling Waste Disposal Area	Composite	09-Jul-10	0.062	0.16	0.22	0.96	20	180	516	149	21
10DWD04	Drilling Waste Disposal Area	Composite	09-Jul-10	0.30	0.53	3.36	14.60	180	485	611	230	21
10DWD05	Drilling Waste Disposal Area	Composite	09-Jul-10	0.52	0.36	0.96	3.77	40	237	440	184	23
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	NC

Notes:

¹ Alberta Environment. 2010. Alberta Tier 1 Soil and Groundwater Remediation Guidelines.

These standards are for fine-textured surface soil under agricultural area land use for all exposure pathways;

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations.

³ Fraction 4 petroleum hydrocarbons (C34-C50 or >C34) as determined by high temperature gas chromatography.

NC - No Criteria Established.

Blank - Not analyzed.

Blank - Greater than the Remediation Objectives

[REDACTED]
Table 2. Laboratory Analytical Results - Petroleum Hydrocarbons - September 2010
Remediation [REDACTED]
December 2011

Sample ID	Sample Location	Sample Depth (mbg)	Sample Date (dd-mm-yy)	BTEX (F1-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	Total Xylenes (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
Sample #1 Row #1	Treatment Pile	Composite	01-Sep-10	0.026	<0.05	0.02	0.05	<10	10	93	20	19
Sample #2 Row #3	Treatment Pile	Composite	01-Sep-10	0.017	<0.05	0.03	<0.05	<10	<10	45	<10	21
Sample #3 Row#4	Treatment Pile	Composite	01-Sep-10	0.284	1.96	6.20	28.60	150	336	395	125	22
Sample #4 Row#6	Treatment Pile	Composite	01-Sep-10	0.015	<0.05	0.04	0.09	<10	33	152	25	20
Sample #5 Row#10	Treatment Pile	Composite	01-Sep-10	0.020	0.07	0.06	0.12	<10	51	243	57	23
Sample #6 Row #11	Treatment Pile	Composite	01-Sep-10	0.01	<0.05	0.01	<0.05	<10	<10	50	11	17
Sample #7 Row #12	Treatment Pile	Composite	01-Sep-10	<0.005	<0.05	0.02	<0.05	<10	<10	53	27	19
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	NC

Notes:

¹ Alberta Environment. 2010. Alberta Tier 1 Soil and Groundwater Remediation Guidelines.

These standards are for fine-textured surface soil under agricultural area land use for all exposure pathways;

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations.

³ Fraction 4 petroleum hydrocarbons (C34-C50 or >C34) as determined by high temperature gas chromatography.

NC - No Criteria Established.

Blank - Not analyzed.

Bold - Greater than the Remediation Objectives

[REDACTED]
Table 3 **Location of Remediation Activities - October 2010**
Remediation [REDACTED]
Page 11

Sample	Location	Depth (g)	Sample Date (dd-mm-yy)	BTEX FI-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	o-xylene (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
Row #1 Comp #1	Treatment Pile	C	-Oct-10	0.031	<0.05	0.3	0.19	<10	<10	121	56	17
Row #1 Comp #2	Treatment Pile	Composite	6-Oct-10	0.00	<0		0.05	0	1	6	67	
Row #1 Comp #1	Treatment Pile	Composite	26-Oct-	0.2	0	0.30	14	<0	1	220	91	20
Row #2 Comp #2	Treatment Pile	Composite	6-Oct-10	0	0.0		16	<0	44	282	12	21
Row #3 Comp #1	Treatment Pile	Composite	26-Oct-1	<0.05	0.0	1		<0	1		80	18
Row #4 Comp #	Treatment Pile	Composite	Oct-1	0.02	1	7	0.8	<	4	24		9
Row #5 Comp #	Treatment Pile	Composite	6-Oct-10	0.21	0.8	0.06	21	0	53	404	1.4	8
Row #6 Comp #	Treatment Pile	Composite	2-Oct-	1	0.0	0.7	0.36	<10	40	251	97	2
Row #7 Comp #1	Treatment Pile	Composite	2-Oct-10	0.0	12	0.0	8	10	35		0.3	2
Row #8 Comp #1	Treatment Pile	Composite	26-Oct-1	0.63	0.20	0.09	0.4	<10	2		0.0	20
Row #9 Comp #1	Treatment Pile	Composite	2-Oct-10	0.1	0.06		1	<		24		20
Row #10 Comp #	Treatment Pile	Composite	26-Oct-10	<0.005	<0	<0.01	0.05	<10	25	196	106	19
Row #11 Comp #1	Treatment Pile	Composite	6-Oct-10	0.005	<0.05	<0.01	<0.05	<10	1	26	3	1
Row #12 Comp #	Treatment Pile	Composite	26-Oct-	<0.00	<0	<0.0	0.05	0	<1	4	3	8
Row #13 Comp #1	Treatment Pile	Composite	26-Oct-10	<0.005	<0.05	0.01	<0.05	<10	56	67	45	9
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	C

Notes:

¹ Alberta Environment 010 Alberta Tier 1 Soil and Groundwater Remediation Guidelines

These standards are for finite duration soil and groundwater use for release pathways

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations

³ Fraction 4 petroleum hydrocarbons (C3-C10) standard hydrocarbon gas chromatography

Criteria Table

Background Analyzed

Background Remediation Objectives

[REDACTED]
Table 4. Laboratory Analytical Results - Petroleum Hydrocarbons - June 2011
Remediation [REDACTED]
December 2011

Sample ID	Sample Location	Sample Depth (mbg)	Sample Date (dd-mm-yy)	BTEX (F1-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	Total Xylenes (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
Row #1 Comp #1	Treatment Pile	Composite	02-Jun-11	0 009	<0 05	0 02	<0 05	<10	<10	64	23	18
Row #1 Comp #2	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	<0 01	<0 05	<10	<10	32	<10	22
Row #2 Comp #1	Treatment Pile	Composite	02-Jun-11	0 008	<0 05	0 02	<0 05	<10	<10	102	31	21
Row #2 Comp #2	Treatment Pile	Composite	02-Jun-11	<0 005	0 13	0 24	0 53	<10	<10	169	54	19
Row #3 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 02	0 06	<10	<10	141	43	19
Row #4 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 02	<0 05	<10	<10	146	40	20
Row #5 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 01	<0 05	<10	55	343	90	23
Row #6 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 02	<0 05	<10	<10	154	41	19
Row #7 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 06	0 09	<10	38	252	64	22
Row #8 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 03	<0 05	<10	19	188	56	20
Row #9 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	0 02	<0 05	<10	17	314	77	23
Row #10 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	<0 01	<0 05	<10	<10	114	29	20
Row #11 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	<0 01	<0 05	<10	<10	40	<10	18
Row #11 Comp #2	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	<0 01	<0 05	<10	<10	30	<10	18
Row #12 Comp #1	Treatment Pile	Composite	02-Jun-11	<0 005	<0 05	<0 01	<0 05	<10	<10	24	<10	17
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	NC

Notes:

¹ Alberta Environment 2010 Alberta Tier 1 Soil and Groundwater Remediation Guidelines

These standards are for fine-textured surface soil under agricultural area land use for all exposure pathways

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations

³ Fraction 4 petroleum hydrocarbons (C34-C50 or >C34) as determined by high temperature gas chromatography

NC - No Criteria Established

Blank - Not analyzed

Bold - Greater than the Remediation Objectives

[REDACTED]
Table 5. Laboratory Analytical Results - Petroleum Hydrocarbons - July 2011
Remediation [REDACTED]
December 2011

Sample ID	Sample Location	Sample Depth (mbg)	Sample Date (dd-mm-yy)	BTEX (F1-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	Total Xylenes (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
Row #1 Comp #1	Treatment Pile	Composite	18-Jul-11	<0.005	<0.05	0.03	0.07	<10	<10	138	63	22
Row #1 Comp #2	Treatment Pile	Composite	18-Jul-11	<0.005	<0.05	0.01	<0.05	<10	<10	159	61	22
Row #2 Comp #1	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.03	0.10	<10	10	181	68	20
Row #2 Comp #2	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.03	0.10	<10	12	212	81	23
Row #3 Comp #1	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.03	0.08	<10	18	204	87	21
Row #4 Comp #1	Treatment Pile	Composite	18-Jul-11	0.028	0.06	0.07	0.28	<10	32	293	84	21
Row #5 Comp #1	Treatment Pile	Composite	18-Jul-11	0.013	0.05	0.04	0.13	<10	36	190	61	16
Row #6 Comp #1	Treatment Pile	Composite	18-Jul-11	<0.005	<0.05	0.04	0.11	<10	37	307	90	22
Row #7 Comp #1	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.03	0.07	<10	21	187	55	22
Row #8 Comp #1	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.05	0.15	<10	59	310	95	21
Row #9 Comp #1	Treatment Pile	Composite	18-Jul-11	0.016	<0.05	0.05	0.14	<10	22	249	84	27
Row #10 Comp #1	Treatment Pile	Composite	18-Jul-11	0.014	<0.05	0.03	0.08	<10	32	223	70	20
Row #11 Comp #1	Treatment Pile	Composite	18-Jul-11	<0.005	<0.05	0.01	<0.05	<10	<10	58	23	20
Row #11 Comp #2	Treatment Pile	Composite	18-Jul-11	0.01	<0.05	0.01	<0.05	<10	<10	52	12	21
Row #12 Comp #1	Treatment Pile	Composite	18-Jul-11	<0.005	<0.05	0.01	<0.05	<10	<10	71	19	20
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	NC

Notes:

¹ Alberta Environment 2010 Alberta Tier 1 Soil and Groundwater Remediation Guidelines

These standards are for fine-textured surface soil under agricultural area land use for all exposure pathways

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations

³ Fraction 4 petroleum hydrocarbons (C34-C50 or >C34) as determined by high temperature gas chromatography

NC - No Criteria Established

Blank - Not analyzed

Blank - Greater than the Remediation Objectives

[REDACTED]
Table 6. Laboratory Analytical Results - Petroleum Hydrocarbons - August 2011
Remediation [REDACTED]
December 2011

Sample ID	Sample Location	Sample Depth (mbg)	Sample Date (dd-mm-yy)	BTEX (F1-F4)								Moisture
				Benzene (mg/Kg)	Toluene (mg/Kg)	Ethylbenzene (mg/Kg)	Total Xylenes (mg/Kg)	Fraction 1 (mg/Kg) ²	Fraction 2 (mg/Kg)	Fraction 3 (mg/Kg)	Fraction 4 (mg/Kg) ³	
Row #1 Comp #1	Treatment Pile	Composite	21-Aug-11	0.010	<0.05	0.02	0.10	<10	19	110	43	21
Row #1 Comp #2	Treatment Pile	Composite	21-Aug-11	0.008	<0.05	<0.01	<0.05	<10	10	110	36	21
Row #2 Comp #1	Treatment Pile	Composite	21-Aug-11	0.011	<0.05	0.02	0.09	<10	18	147	57	22
Row #2 Comp #2	Treatment Pile	Composite	21-Aug-11	0.007	<0.05	0.01	<0.05	<10	25	116	36	22
Row #3 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	0.02	<0.05	<10	15	131	45	21
Row #4 Comp #1	Treatment Pile	Composite	21-Aug-11	0.009	<0.05	0.01	<0.05	<10	34	171	44	24
Row #5 Comp #1	Treatment Pile	Composite	21-Aug-11	0.009	<0.05	0.02	0.08	<10	44	216	50	23
Row #6 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	0.01	<0.05	<10	20	130	25	20
Row #7 Comp #1	Treatment Pile	Composite	21-Aug-11	0.011	<0.05	0.04	0.09	<10	76	290	81	20
Row #8 Comp #1	Treatment Pile	Composite	21-Aug-11	0.009	<0.05	0.02	0.08	<10	33	222	56	19
Row #9 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	0.01	<0.05	<10	27	231	58	20
Row #10 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	0.02	0.07	<10	44	208	61	20
Row #11 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	<0.01	<0.05	<10	<10	36	<10	19
Row #11 Comp #2	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	<0.01	<0.05	<10	<10	33	<10	19
Row #12 Comp #1	Treatment Pile	Composite	21-Aug-11	<0.005	<0.05	<0.01	<0.05	<10	<10	22	<10	19
Remediation Objectives: AENV Tier 1 2010¹				0.046	0.52	0.11	15	210	150	1,300	5,600	NC

Notes:

¹ Alberta Environment 2010 Alberta Tier 1 Soil and Groundwater Remediation Guidelines

These standards are for fine-textured surface soil under agricultural area land use for all exposure pathways

² Fraction 1 petroleum hydrocarbons (C6-C10) minus benzene, toluene, ethylbenzene and xylene concentrations

³ Fraction 4 petroleum hydrocarbons (C34-C50 or >C34) as determined by high temperature gas chromatography

NC - No Criteria Established

Blank - Not analyzed

Bold - Greater than the Remediation Objectives

Figure 2. Average Concentration of Benzene in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

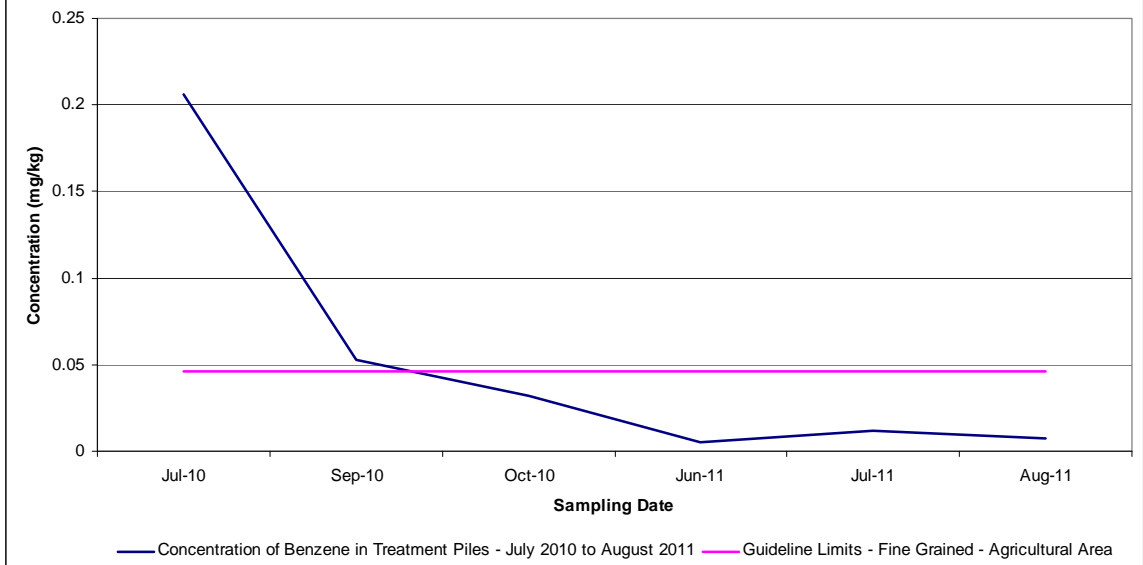


Figure 3. Average Concentration of Toluene in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

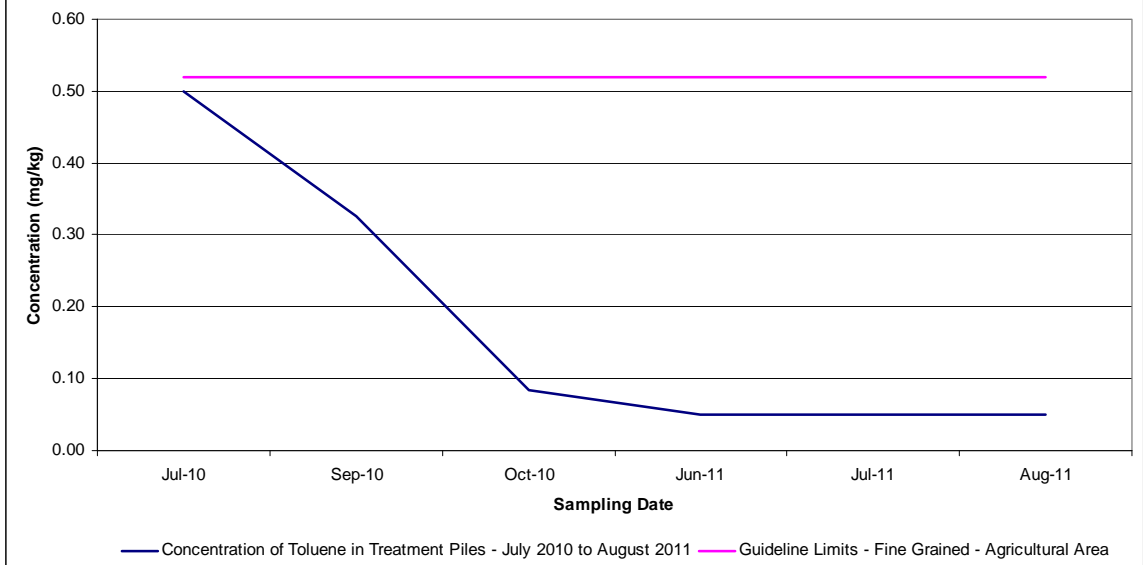


Figure 4. Average Concentration of Ethylbenzene in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

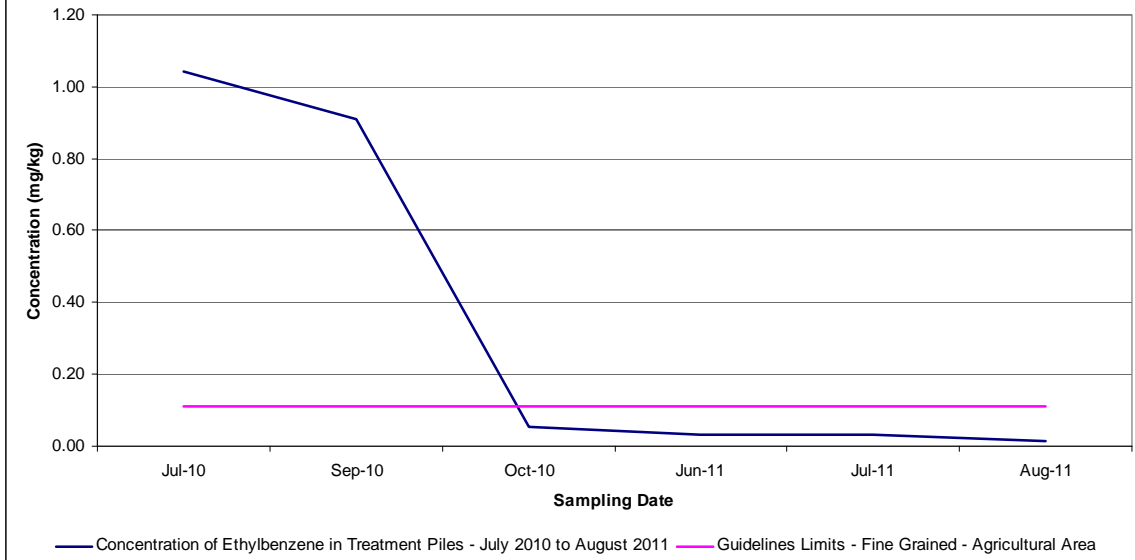


Figure 5. Average Concentration of Total Xylenes in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

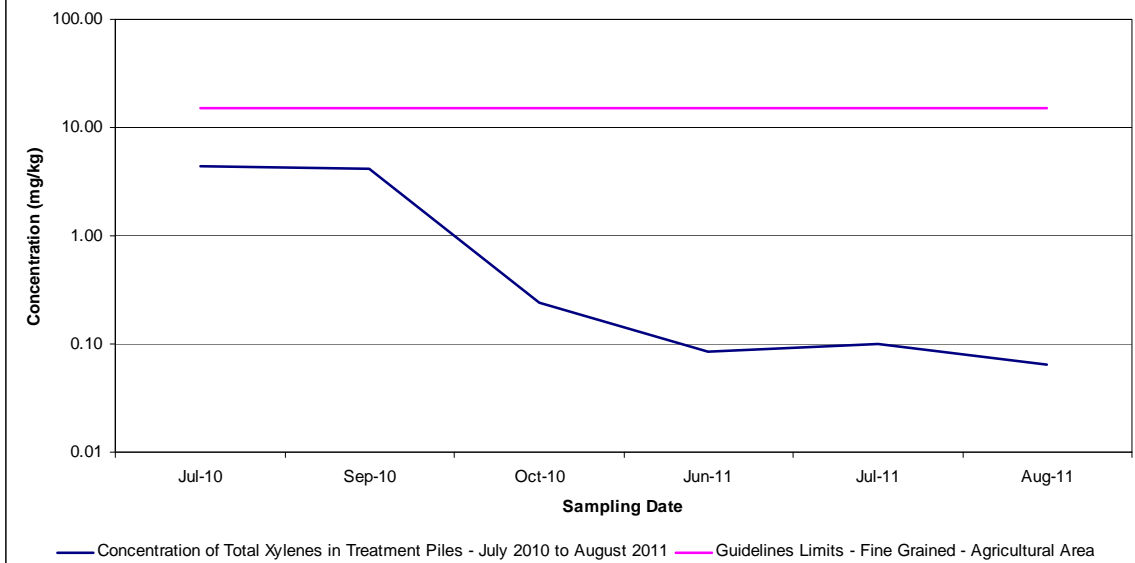


Figure 6. Average Concentration of BTEX in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

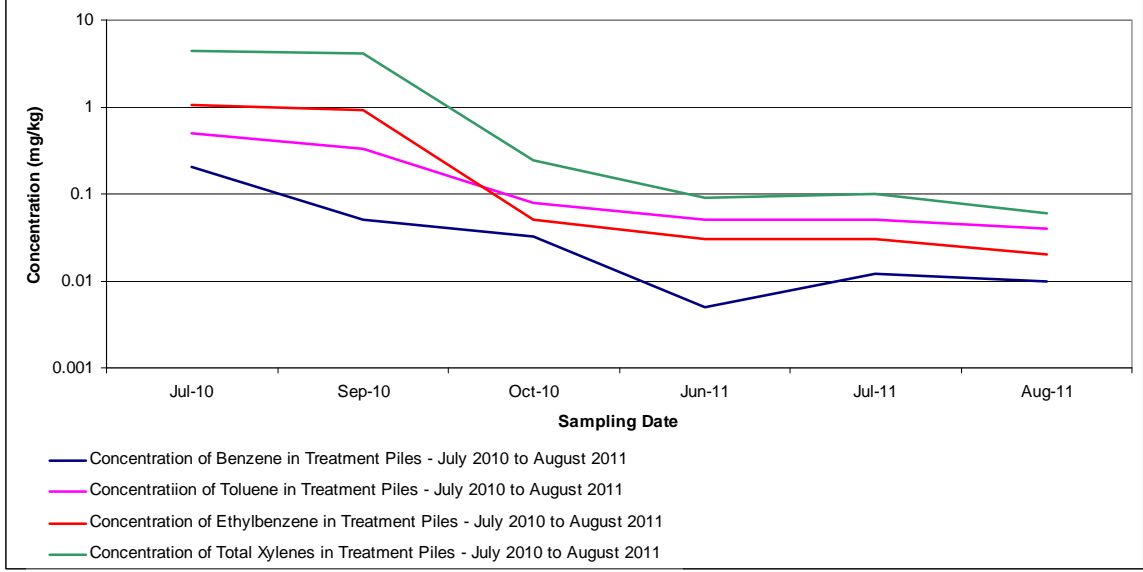


Figure 7. Average Concentration of F1 Hydrocarbons in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

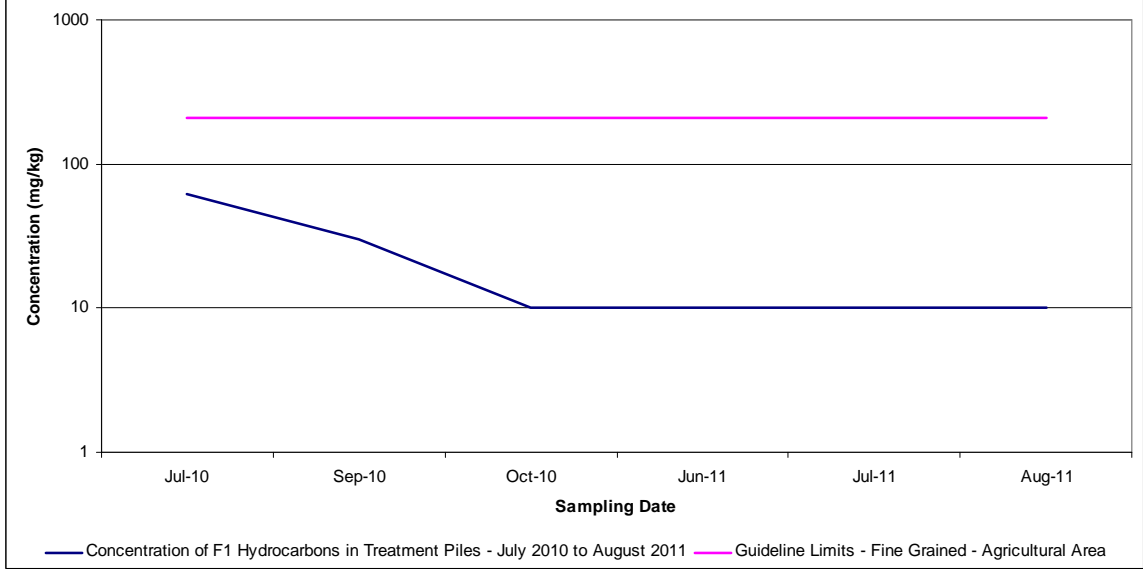


Figure 8. Average Concentration of F2 Hydrocarbons in the Composite Soil Samples Collected From the Treatment Piles - [REDACTED]

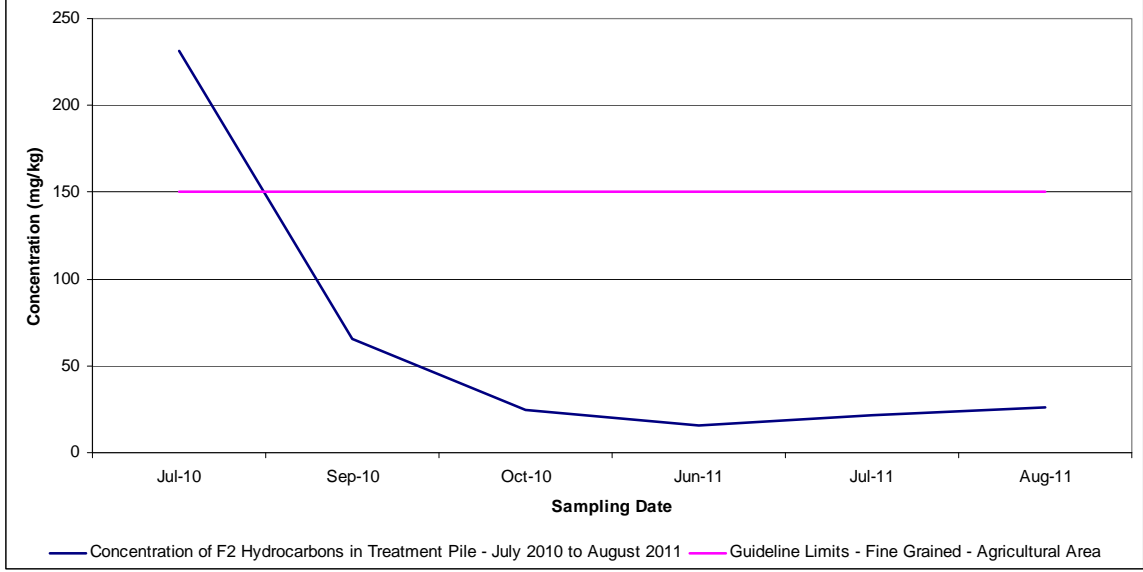


Figure 9. Average Concentration of F3 Hydrocarbons in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

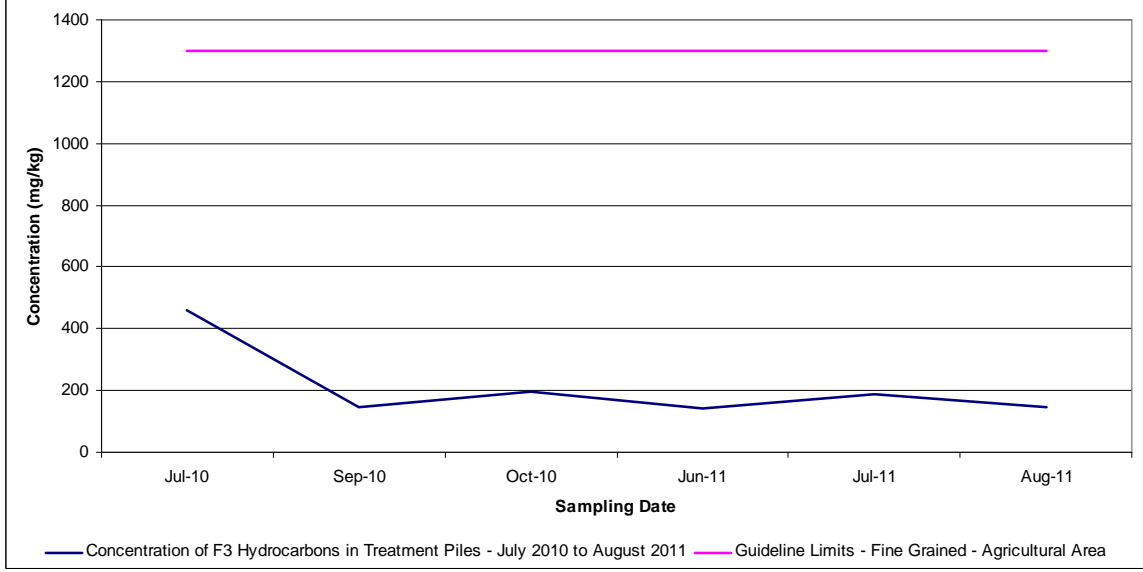


Figure 10. Average Concentration of F4 Hydrocarbons in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

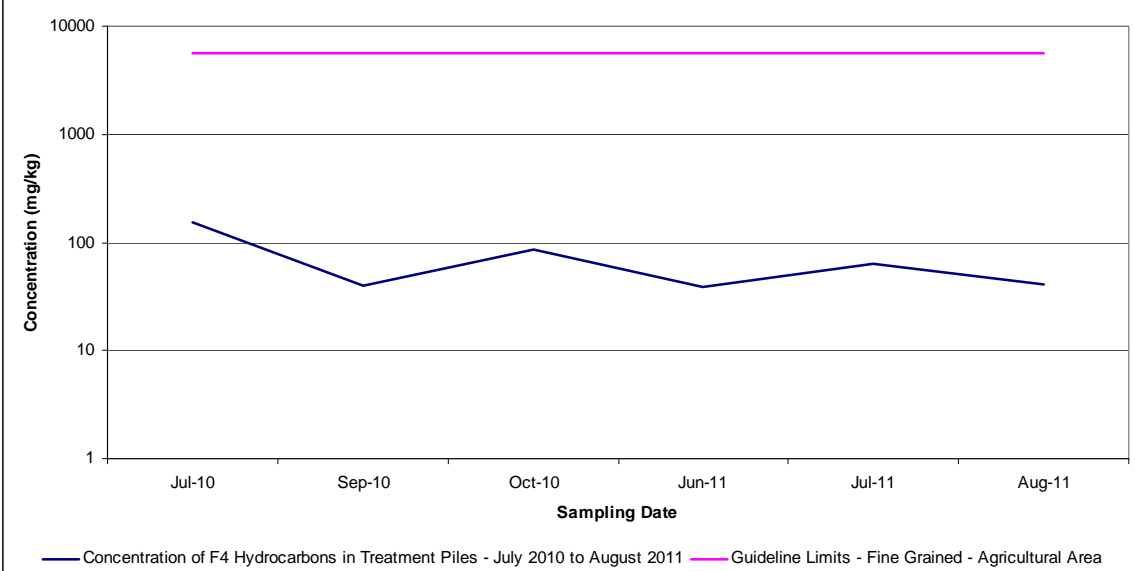


Figure 11. Average Concentration of F1-F4 Hydrocarbons in the Composite Soil Samples Collected from the Treatment Piles - [REDACTED]

