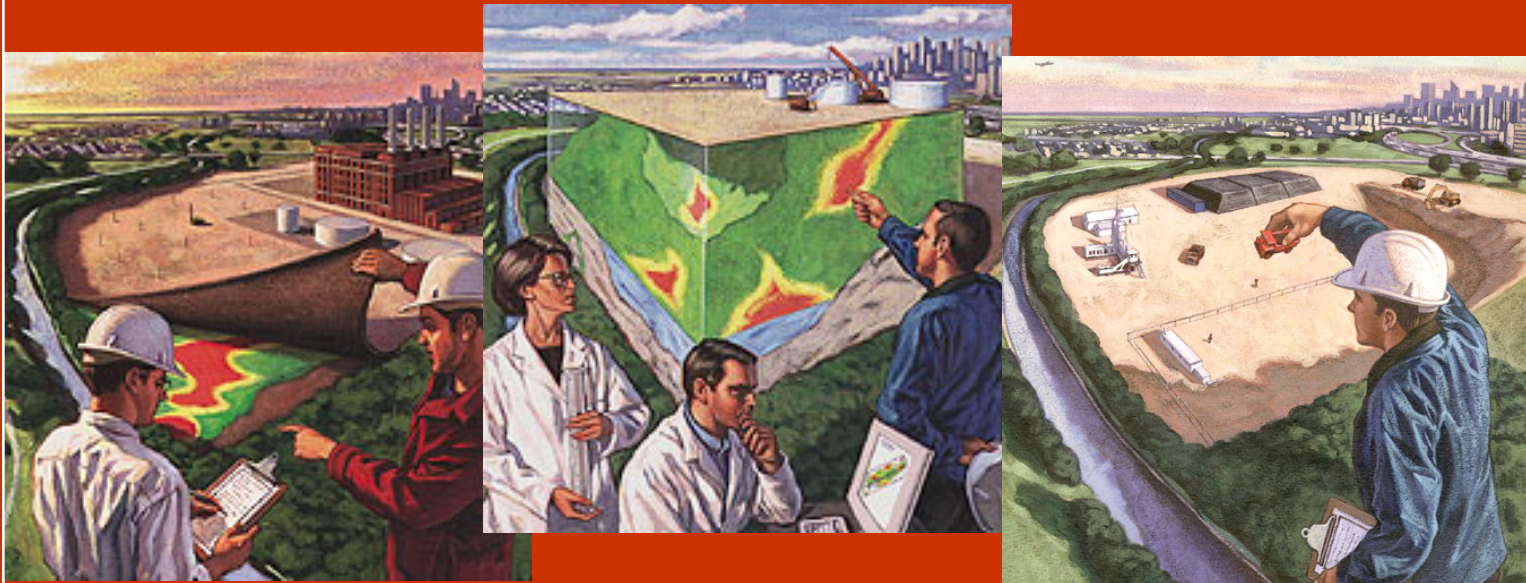


Assess

Design

Implement



Remediation Technologies Symposium 2009

Guaranteed Site Remediation Solutions



Remediation Technologies Symposium 2009

Remediation of 26,200 m<sup>3</sup> of  
Hydrocarbon-impacted Soil at a  
Former Wellsite Using the *Ex situ*  
Biopile Process

Presented by: Wade Simpson, B.Sc., P.Ag.

Guaranteed Site Remediation Solutions



# Introduction

- Biogenie was retained to complete remediation of a wellsite in north central Alberta
- Client was responsible for remediation of a former flare pit



# Background

- Initial soil assessment was conducted at the lease in 1996
- Shallow monitoring wells were installed in 2001
- Deeper wells replaced these in 2002
- Supplementary soil assessments were completed in 2002 and 2004
- Biogenie reviewed associated reports in early 2006





# Background (continued)

- Preliminary estimate of impacted soil volume = 17,150 m<sup>3</sup>
- ~ 2,500 m<sup>3</sup> would likely require pre-treatment and then landfill disposal
- Based on characterization of material, the Biopile option was chosen as the remedial method
- Non-impacted overburden identified above impacted material



# *Ex situ* Biopile Advantages

- *Ex situ* Biopile process was selected as the most cost-effective remedial solution based on:
  1. Volume of impacted soil
  2. Depth of impacted material (> 9 m bgs)  
precluded use of *In Situ* Biopile



# Other Considerations

- Environmentally “friendly” compared to landfill disposal
- Safety issues with movement off site
- beneficial reuse of material



# Initial Scope of Work

- Assess proposed treatment pad area for proximity to groundwater
- Assess flare pit source material for landfill suitability
- Determine background salinity levels to compare to those on-lease



# Remedial Objectives (soil)

- Alberta Tier I (AENV, 2001) criteria for coarse-grained soil and Agricultural land use
- Salt Contamination Assessment and Remediation Guidelines (AENV, 2001)
- Surface and subsoil guidelines available for hydrocarbon criteria
- No exposure pathways could be eliminated
- CCME guidelines used for assessment of metals



# Initial Work

- End of March 2006 – drilled 11 boreholes to assess treatment pad suitability, background salinity levels, and source waste characterization





BH06-08	BH06-08-AU2
SOIL	5.0-6.0 m
Benzene	0.27 <span style="color:red">■</span>
Toluene	<0.1 <span style="color:green">●</span>
Ethylbenzene	0.7 <span style="color:red">■</span>
Xylenes	1.1 <span style="color:green">●</span>
F1	26 <span style="color:green">●</span>
F2	16 <span style="color:green">●</span>
F3	90 <span style="color:green">●</span>
F4	33 <span style="color:green">●</span>
SAR	0.6 <span style="color:green">●</span>
EC	1.140 <span style="color:green">●</span>
pH	7.4 <span style="color:green">●</span>

BH06-07	BH06-07-AU1	BH06-07-AU2	BH06-07-AU4
SOIL	0.0-0.3 m	1.0-2.0 m	4.0-4.5 m
Benzene	<0.04 <span style="color:green">●</span>	1.62 <span style="color:red">■</span>	0.30 <span style="color:red">■</span>
Toluene	<0.1 <span style="color:green">●</span>	0.6 <span style="color:red">■</span>	<0.1 <span style="color:green">●</span>
Ethylbenzene	<0.1 <span style="color:green">●</span>	12.3 <span style="color:red">■</span>	3.7 <span style="color:red">■</span>
Xylenes	<0.2 <span style="color:green">●</span>	61.1 <span style="color:red">■</span>	16.7 <span style="color:red">■</span>
F1	48 <span style="color:red">■</span>	663 <span style="color:red">■</span>	376 <span style="color:red">■</span>
F2	327 <span style="color:red">■</span>	2,940 <span style="color:red">■</span>	1,260 <span style="color:red">■</span>
F3	136 <span style="color:green">●</span>	97 <span style="color:green">●</span>	51 <span style="color:green">●</span>
F4	12 <span style="color:green">●</span>	14 <span style="color:green">●</span>	15 <span style="color:green">●</span>
SAR	---	8.2 <span style="color:red">■</span>	3.8 <span style="color:red">■</span>
EC	---	0.740 <span style="color:green">●</span>	0.308 <span style="color:green">●</span>
pH	---	7.6 <span style="color:green">●</span>	7.3 <span style="color:green">●</span>

BH06-11	BH06-11-AU1
SOIL	5.5-6.0 m
Benzene	<0.04 <span style="color:green">●</span>
Toluene	<0.1 <span style="color:green">●</span>
Ethylbenzene	0.6 <span style="color:red">■</span>
Xylenes	<0.2 <span style="color:green">●</span>
F1	90 <span style="color:red">■</span>
F2	310 <span style="color:red">■</span>
F3	51 <span style="color:green">●</span>
F4	16 <span style="color:green">●</span>
SAR	1.0 <span style="color:green">●</span>
EC	0.654 <span style="color:green">●</span>
pH	7 <span style="color:green">●</span>

BH06-09	BH06-09-AU1
SOIL	4.0-4.5 m
Benzene	0.16 <span style="color:red">■</span>
Toluene	<0.1 <span style="color:green">●</span>
Ethylbenzene	3.6 <span style="color:red">■</span>
Xylenes	17.9 <span style="color:red">■</span>
F1	368 <span style="color:red">■</span>
F2	681 <span style="color:red">■</span>
F3	78 <span style="color:green">●</span>
F4	25 <span style="color:green">●</span>
SAR	4.7 <span style="color:red">■</span>
EC	0.482 <span style="color:green">●</span>
pH	7.2 <span style="color:green">●</span>

### LEGEND

- Site Boundaries (Not Surveyed)
- Treatment Boundaries
- Pipe (Approx. Location)
- Buried Cable
- Estimated Impacted Area
- Monitoring Well (Others, 2004)
- Borehole (Biogenie, 2006) (Approximate location)

Alberta Tier 1 - Agricultural Land Use Fine-Grained Soil Criteria			
	Surface Soil	Subsoil	Unit
B	0.048	0.054	mg/kg
T	0.16	0.16	mg/kg
E	0.36	0.36	mg/kg
X	14	15	mg/kg
F1	30	40	mg/kg
F2	150	190	mg/kg
F3	400	2,500	mg/kg
F4	2,800	10,000	mg/kg
pH	6.0 to 8.0		---
EC	<2	<3	dS/m
SAR	<4	<4	---
Result below criterion			●
Result exceeding criterion			■

A	DRAFT VERSION	06-12-18	P.L.	A.M.T.	G.L.
NO.	VERSION	DATE	BY	VERIF.	APPR.

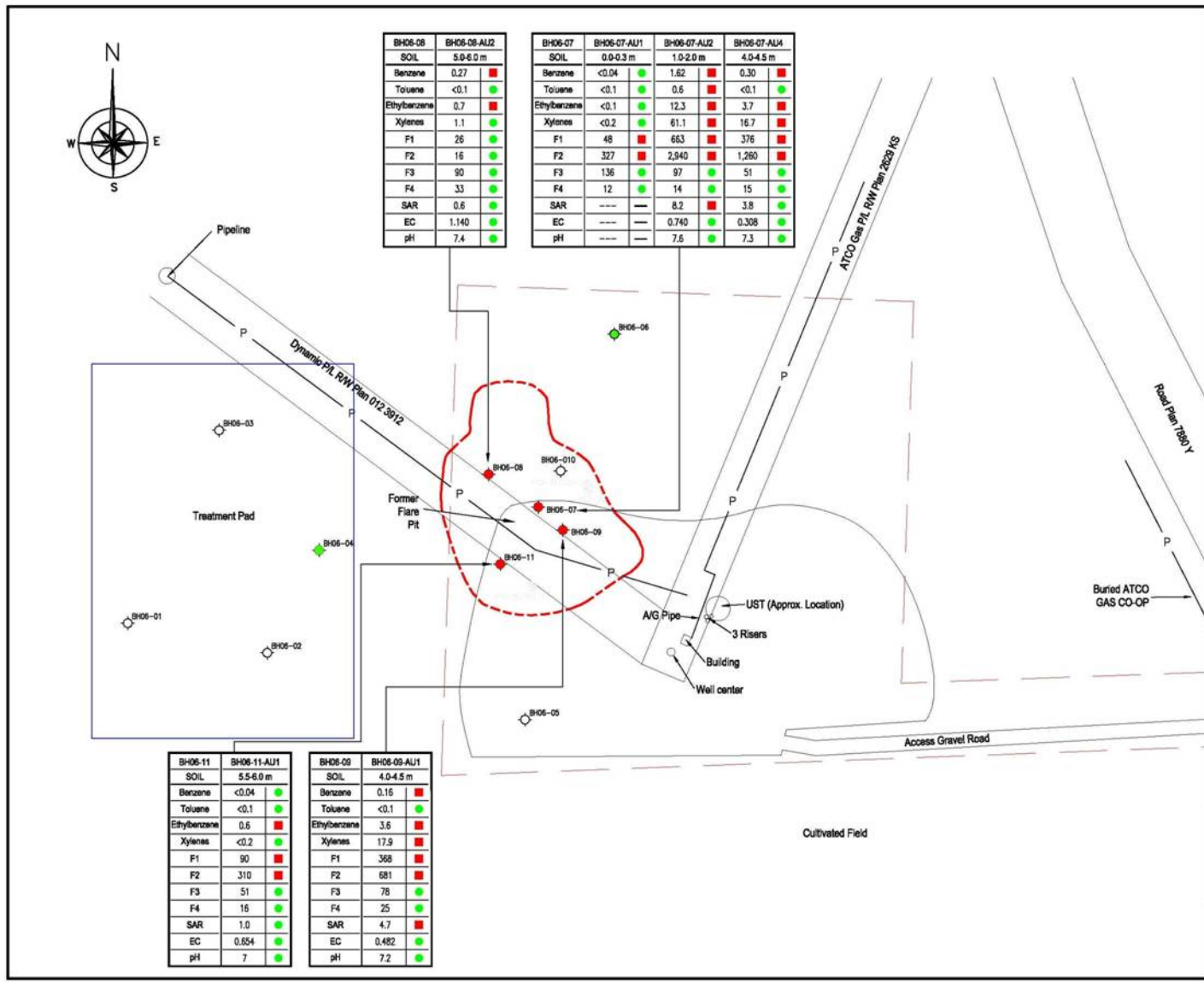
REMEDATION OF THE FORMER WELL SITE  
SOIL CHEMICAL ANALYSIS RESULTS OF SITE ASSESSMENT

SITE REMEDIATION SOLUTIONS

Biogenie S.R.D.C. Inc.  
#38, 2001 Premier Way  
Sherwood Park, Alberta, T8H 3K9, Canada  
Phone: (780) 416-0414 Fax: (780) 416-0417

Metre	1 : 1,000	DECEMBER 2008
P. LEGARE	A.-M. TESSIER	G. LAVOIE

**FIGURE 4**





# Results of March 2006 Assessment

- Treatment pad was suitable and approval granted by AEUB
- Source material met landfill disposal guidelines
- Source material was determined to be treatable
- No salinity or metals issues identified
- May 1, 2006 - began work on remediation of the flare pit



# Remediation Activities

- Fenced entire work area
- Removed topsoil from treatment pad and non-impacted overburden from former flare pit
- Stockpiled on lease and sampled to confirm that piles met criteria























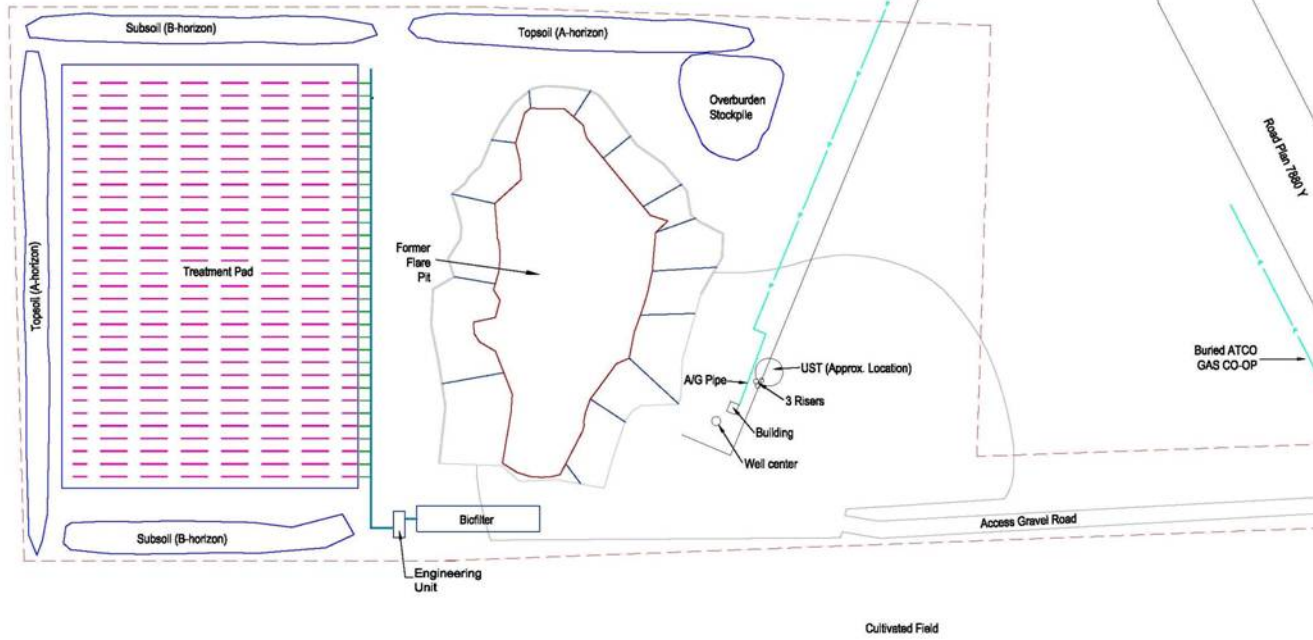


# Remediation Activities (continued)

- Commence construction of treatment pad and install liner (30 mil)
- At the same time, begin excavation of impacted soil from former flare pit area
- Collect confirmatory samples from excavation extents
- Install piping and place impacted material on treatment pad







**LEGEND**

- - - Site Boundaries (Not Surveyed)
- Pipe (Approx. Location)
- Buried Cable
- Existing
- Treatment Boundaries
- Excavation Limits
- Excavation Floor
- - - Aeration Pipes



NO.	VERSION	DATE	BY	VERIF.	APPR.
A	DRAFT VERSION	08-11-18	P.L.	A.M.T.	G.L.

**REMEDICATION OF THE FORMER WELL SITE**

**TREATMENT PAD GENERAL LAYOUT**

SITE REMEDIATION SOLUTIONS

Biogénie

Biogénie S.R.D.C. Inc.  
 #108, 2021 Premier Way  
 Sherwood Park, Alberta, T8H 2G8, Canada  
 Phone: (780) 416-0414 Fax: (780) 416-0417

Metre	1 : 1,000	NOVEMBER 2008
P. LEGARE	A.-M. TESSIER	G. LAVOIE

**FIGURE 6**





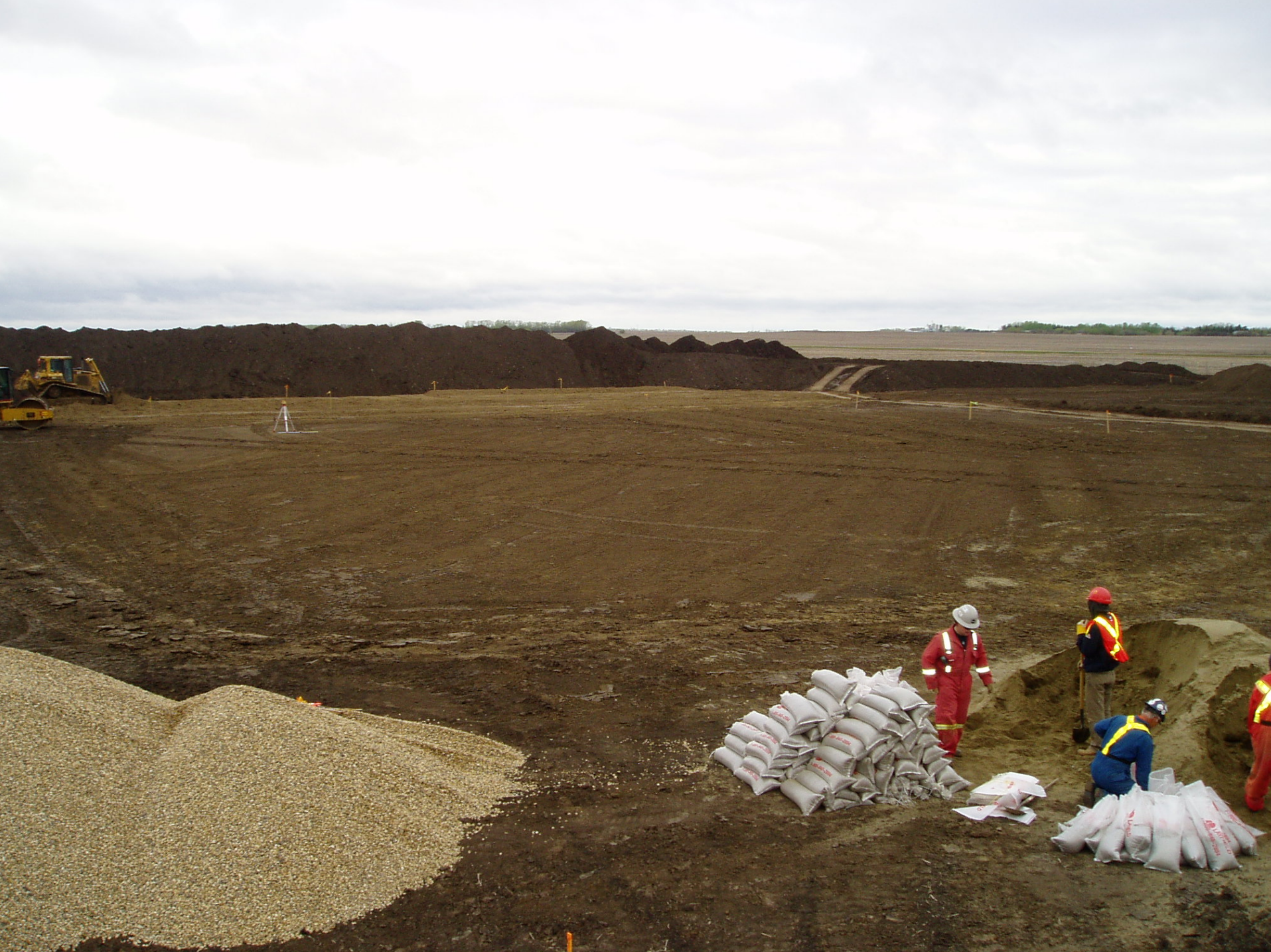




































SM-1-B-1































































# Bio-treatment

- Mid summer of 2006, all impacted material was removed and placed onto the biopile
- “Time Zero” sampling was completed
- Non-impacted overburden was placed back into the excavation
- End of August 2006, treatment unit was activated







Time Zero - BTEX and PHCs (F1 through F4)

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Parameters							
			Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Xylenes mg/kg	PHC (F1) mg/kg	PHC (F2) mg/kg	PHC (F3) mg/kg	PHC (F4) mg/kg
	TEST 1	2006-05-29	0.14	<0.1	0.7	0.9	10	445	99	53
LOT-1	LOT-1-A	2006-05-18	0.21	<0.1	4.8	22.2	777	1,650	50	25
	LOT-1-B	2006-05-18	0.13	<0.1	4.6	21.0	830	1,520	43	17
LOT-2	LOT-2-A	2006-05-18	0.64	<0.1	17.8	89.6	1,430	1,850	65	28
	LOT-2-B	2006-05-31	1.01	<0.1	5.2	18.3	296	953	37	<10
LOT-3	LOT-3-A	2006-05-18	0.35	<0.1	7.7	38.7	819	1,650	42	12
	LOT-3-B	2006-05-31	1.45	<0.1	26.0	50.4	2,040	3,850	65	<10
LOT-4	LOT-4-A	2006-05-19	<0.04	<0.1	1.8	2.3	194	513	43	43
	LOT-4-B	2006-05-31	<0.04	<0.1	0.4	0.8	60	236	34	<10
LOT-5	LOT-5-A	2006-05-19	0.11	<0.1	2.5	5.5	231	473	37	34
	LOT-5-B	2006-05-31	0.56	<0.1	16.0	22.0	1,300	2,870	58	<10
LOT-6	LOT-6-A	2006-06-02	<0.04	<0.1	0.4	0.5	38	525	31	<10
	LOT-6-B	2006-06-02	1.43	<0.1	7.9	29.4	435	658	46	<10
LOT-7	LOT-7-A	2006-06-02	0.84	<0.1	2.3	8.3	108	611	43	<10
	LOT-7-B	2006-06-02	0.25	<0.1	3.0	6.7	226	452	35	<10
	LOT-7-B-TT	2006-06-02	0.37	<0.1	4.2	10.8	779	640	57	<10
LOT-8	LOT-8-A	2006-06-03	0.55	<0.1	3.1	8.7	243	383	52	22
	LOT-8-B	2006-06-03	0.24	<0.1	2.6	4.3	209	287	25	20
LOT-9	LOT-9-A	2006-06-05	0.92	0.3	17.9	52.3	835	1,110	60	15
	LOT-9-B	2006-06-05	3.68	<0.1	32	110	2,540	2,230	60	<10
LOT-10	LOT-10-A	2006-06-06	1.03	<0.1	14.3	50.8	989	3,290	72	13
	LOT-10-A-TT	2006-06-06	0.73	<0.1	20.4	74.4	1,590	2,590	55	<10
	LOT-10-B	2006-06-06	4.52	14.0	11.5	38.7	520	532	60	23
LOT-11	LOT-11-A	2006-06-06	<0.04	<0.1	1.8	<0.1	118	441	42	23
	LOT-11-B	2006-06-07	0.35	0.1	2.5	8.3	161	266	47	24
Guidelines <sup>(1)</sup>			0.048	0.16	0.36	14	30	150	400	2,800

(1):





Time Zero - BTEX and PHCs (F1 through F4)

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Parameters							
			Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Xylenes mg/kg	PHC (F1) mg/kg	PHC (F2) mg/kg	PHC (F3) mg/kg	PHC (F4) mg/kg
LOT-12	LOT-12-A	2006-06-07	0.77	<0.1	1.0	2.4	50	199	75	37
	LOT-12-B	2006-06-07	1.47	<0.1	4.7	15.5	256	407	70	34
LOT-13	LOT-13-A	2006-06-13	<0.04	<0.1	0.8	1.1	117	438	21	<10
	LOT-13-B	2006-06-13	<0.04	<0.1	1.0	1.5	158	375	27	<10
LOT-14	LOT-14-A	2006-06-14	<0.04	<0.1	<0.1	0.1	15	31	11	<10
	LOT-14-B	2006-06-14	<0.04	<0.1	<0.1	<0.1	<10	25	23	<10
LOT-15	LOT-15-A	2006-06-14	<0.04	<0.1	1.5	1.9	78	713	13	<10
	LOT-15-B	2006-06-14	<0.04	<0.1	1.1	1.2	147	565	27	<10
LOT-16	LOT-16-A	2006-06-14	2.49	2.9	8.3	21.7	531	875	55	<10
	LOT-16-B	2006-06-19	<0.04	<0.1	0.3	<0.1	111	457	30	<10
LOT-17	LOT-17-A	2006-06-19	<0.04	<0.1	1.2	0.2	180	467	30	<10
	LOT-17-B	2006-06-19	0.26	0.9	1.6	6.0	132	314	51	<10
LOT-18	LOT-18-A	2006-06-19	0.43	<0.1	1.4	1.6	70	94	47	<10
	LOT-18-B	2006-06-19	0.44	<0.1	2.7	5.0	270	232	49	<10
LOT-19	LOT-19-A	2006-06-20	0.07	<0.1	1.1	2.5	153	420	34	<10
	LOT-19-B	2006-06-20	0.16	<0.1	0.5	0.9	60	97	22	<10
LOT-20	LOT-20-A	2006-06-20	0.44	<0.1	3.8	6.7	226	238	33	<10
	LOT-20-B	2006-06-21	<0.04	<0.1	<0.1	<0.1	39	112	28	33
LOT-21	LOT-21-A	2006-06-21	0.18	<0.1	1.9	2.4	74	92	60	48
	LOT-21-B	2006-06-21	1.59	0.4	8.9	31.4	493	988	57	39
LOT-22	LOT-22-A	2006-06-22	<0.04	<0.1	0.9	1.2	88	408	50	39
	LOT-22-B	2006-06-22	0.17	<0.1	5.1	3.9	521	1210	36	29
Guidelines <sup>(1)</sup>			0.048	0.16	0.36	14	30	150	400	2,800

(1): Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (AENV, 2001) for Agricultural land use soil)

(coarse-grained soil)





Time Zero - BTEX and PHCs (F1 through F4)

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Parameters							
			Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Xylenes mg/kg	PHC (F1) mg/kg	PHC (F2) mg/kg	PHC (F3) mg/kg	PHC (F4) mg/kg
LOT-23	LOT-23-A	2006-06-22	1.27	0.2	8.9	31.4	621	550	62	41
	LOT-23-B	2006-06-23	0.51	0.2	2.7	3.9	332	439	N/A	N/A
LOT-24	LOT-24-A	2006-06-23	3.19	4.1	25.8	89.8	1,500	1,190	N/A	N/A
	LOT-24-B	2006-06-23	0.11	<0.1	0.3	0.5	30	30	N/A	N/A
LOT-25	LOT-25-A	2006-06-24	0.48	<0.1	5.3	5.5	382	317	54	14
	LOT-25-B	2006-06-24	0.41	0.2	6.0	21.0	479	699	64	15
	LOT-25-C	2006-07-10	0.56	<0.1	<0.1	<0.1	<10	<10	110	54
LOT-26	LOT-26-A	2006-06-24	18.9	5	69	241	6,830	3,900	89	<10
	LOT-26-B	2006-06-24	0.32	0.2	1.7	6.1	137	359	49	28
LOT-27	LOT-27-A	2006-06-26	7.1	6	50	177	3,790	2,740	76	15
	LOT-27-B	2006-06-26	2.95	4.8	13.2	46.1	1,070	215	48	29
LOT-28	LOT-28-A	2006-06-26	1.95	<0.1	9.7	26.3	685	789	38	15
	LOT-28-B	2006-06-26	10.4	23	56	208	4,380	1,640	53	13
LOT-29	LOT-29-A	2006-06-26	0.29	<0.1	1.1	1.2	123	207	<10	<10
	LOT-29-B	2006-06-26	0.51	<0.1	4.7	17.1	367	326	39	18
LOT-30	LOT-30-A	2006-06-29	0.21	0.1	3.1	8.3	252	477	71	42
	LOT-30-B	2006-06-29	0.23	<0.1	9.8	39.2	679	695	37	11
	LOT-30-C	2006-07-10	0.14	<0.1	0.4	0.7	33	61	94	44
LOT-31	LOT-31-A	2006-06-29	0.34	<0.1	10.9	45.3	590	929	50	17
	LOT-31-B	2006-06-29	0.79	<0.1	11.2	41.5	744	859	38	13
LOT-32	LOT-32-A	2006-07-04	<0.04	<0.1	0.8	3.8	113	99	46	<10
	LOT-32-B	2006-07-04	0.12	<0.1	3.0	6.1	327	230	52	13
LOT-33	LOT-33-A	2006-07-05	0.12	<0.1	2.0	7.2	251	341	71	34
	LOT-33-B	2006-07-05	32.8	27	107	402	9,020	2,740	95	14
LOT-34	LOT-34-A	2006-07-10	<0.04	0.3	0.6	2.6	130	46	70	46
	LOT-34-B	2006-07-10	<0.04	<0.1	<0.1	<0.1	>10	16	28	18
Guidelines <sup>(1)</sup>			0.048	0.16	0.36	14	30	150	400	2,800

(1):



# Bio-treatment (continued)

- June of 2007, top tier of the biopile was sampled to assess remedial progress
- Three lots (grids) did not meet criteria
- Third party consultant confirmed sampling results
- In August 2007, top tier was re-sampled
- September 2007, all but 2 lots of the top tier were backfilled into the excavation





# Bio-treatment (continued)

- In September/October of 2007, bottom tier was sampled
- 18 of 30 lots met criteria
- October to early November 2007, turning and mixing of soil undergoing treatment
- November and December 2007, final sampling
- April 2008, treatment finished







**Top Layer of the Biopile - BTEX and PHCs (F1 through F4)  
Confirmatory Sampling**

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Depth Below Grade m - m	Parameters							
				Benzene	Toluene	Ethylbenzene	Xylenes	PHC (F1)	PHC (F2)	PHC (F3)	PHC (F4)
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1-1	1-1A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	34	81	37
	1-1B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	30	63	33
1-2	1-2A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	59	64	31
	1-2C	2007-06-05	2.25	<0.0050	<0.020	<0.010	<0.040	<10	89	69	34
1-3	1-3A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	30	49	23
	1-3C	2007-06-05	2.25	<0.0050	<0.020	<0.010	<0.040	<10	25	71	33
1-4	1-4A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	17	84	38
	1-4B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	47	74	35
1-5	1-5A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	23	85	44
	1-5B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	35	69	29
1-6	1-6B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	20	77	35
	1-6C	2007-06-05	2.25	<0.0050	<0.020	<0.010	<0.040	<10	38	64	29
1-7	1-7A	2007-06-05	0.75	<0.0050	0.024	<0.010	<0.040	<10	29	62	28
	1-7B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	21	62	29
1-8	1-8B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	34	66	27
	1-8C	2007-06-05	2.25	<0.0050	<0.020	<0.010	<0.040	<10	33	53	22
1-9	1-9-B	2007-06-05	1.50	<0.0050	0.023	<0.010	<0.040	<10	20	75	31
	1-9C	2007-06-05	2.25	<0.0050	<0.020	<0.010	<0.040	<10	20	82	34
1-10	1-10A	2007-06-05	0.75	<0.0050	<0.020	<0.010	<0.040	<10	23	66	26
	1-10B	2007-06-05	1.50	<0.0050	<0.020	<0.010	<0.040	<10	23	72	28
<b>Guidelines<sup>(1)</sup></b>				<b>0.048</b>	<b>0.16</b>	<b>0.36</b>	<b>14</b>	<b>30</b>	<b>150</b>	<b>400</b>	<b>2,800</b>

<sup>(1)</sup>: Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (AENV, 2001) for Agricultural land use (coarse-grained-soil)





**Top Layer of the Biopile - BTEX and PHCs (F1 through F4)  
Confirmatory Sampling**

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Depth Below Grade m - m	Parameters							
				Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Xylenes mg/kg	PHC (F1) mg/kg	PHC (F2) mg/kg	PHC (F3) mg/kg	PHC (F4) mg/kg
LOT1-11	LOT1-11-B	2007-06-07	1.50	0.0075	<0.020	0.021	<0.040	<10	<10	44	38
	LOT1-11-C	2007-06-07	2.25	<0.0050	<0.020	<0.10	<0.040	<10	<10	99	68
LOT1-12	LOT1-12-A	2007-06-07	0.75	0.0074	<0.020	0.022	<0.040	<10	30	44	37
	LOT1-12-C	2007-06-07	2.25	0.0087	<0.020	0.025	<0.040	<10	13	46	38
LOT1-13	LOT1-13-B	2007-06-07	1.50	<0.0050	<0.020	0.015	<0.040	<10	<10	38	31
	LOT1-13-C	2007-06-07	2.25	<0.0050	<0.020	<0.010	<0.040	<10	17	34	33
LOT1-14	LOT1-14-B	2007-06-07	1.50	<0.0050	<0.020	0.019	<0.040	<10	10	40	34
	LOT1-14-C	2007-06-07	2.25	<0.0050	<0.020	<0.010	<0.040	<10	<10	30	28
LOT1-15	LOT1-15-A	2007-06-07	0.75	0.0084	<0.020	0.024	<0.040	<10	<10	42	35
	LOT1-15-C	2007-06-07	2.25	<0.0050	<0.020	<0.010	<0.040	<10	<10	20	27
LOT1-16	LOT1-16-A	2007-06-07	0.75	0.0076	<0.020	0.016	<0.040	<10	<10	31	33
	LOT1-16-B	2007-06-07	1.50	0.0088	<0.020	0.021	0.056	<10	22	37	32
LOT1-17	LOT1-17-A	2007-06-07	0.75	<0.0050	<0.020	<0.010	<0.040	<10	<10	28	28
	LOT1-17-C	2007-06-07	2.25	<0.0050	<0.020	0.015	<0.040	<10	<10	34	33
LOT1-18	LOT1-18-B	2007-06-07	1.50	<0.0050	<0.020	<0.010	<0.040	<10	<10	31	31
	LOT1-18-C	2007-06-07	2.25	0.0065	<0.020	0.017	<0.040	<10	<10	35	31
LOT1-19	LOT1-19-A	2007-06-07	0.75	0.0091	<0.020	0.019	<0.040	<10	<10	42	34
	LOT1-19-B	2007-06-07	1.50	0.012	<0.020	0.027	0.054	<10	13	36	31
LOT1-20	LOT1-20-A	2007-06-07	0.75	<0.0050	<0.020	<0.010	<0.040	<10	<10	33	30
	LOT1-20-C	2007-06-07	2.25	0.014	<0.020	0.033	0.072	33	128	50	33
<b>Guidelines<sup>(1)</sup></b>				<b>0.048</b>	<b>0.16</b>	<b>0.36</b>	<b>14</b>	<b>30</b>	<b>150</b>	<b>400</b>	<b>2,800</b>

<sup>(1)</sup>: Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (AENV, 2001) for Agricultural land use (coarse-grained-soil)





Top Layer of the Biopile - BTEX and PHCs (F1 through F4)

Confirmatory Sampling

Sample Location	Sample ID	Sampling Date yyyy-mm-dd	Depth Below Grade m - m	Parameters							
				Benzene	Toluene	Ethylbenzene	Xylenes	PHC (F1)	PHC (F2)	PHC (F3)	PHC (F4)
				mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
LOT1-21	LOT1-21-B	2007-06-07	1.50	<0.0050	0.051	<0.010	<0.040	<10	15	68	29
	LOT1-21-C	2007-06-07	2.25	<0.0050	0.13	<0.010	<0.040	<10	16	68	31
LOT1-22	LOT1-22-B	2007-06-07	1.50	<0.0050	0.10	<0.010	0.049	<10	43	43	19
	LOT1-22-C	2007-06-07	2.25	<0.0050	0.080	<0.010	<0.040	91	28	63	28
LOT1-23	LOT1-23-A	2007-06-07	0.75	0.013	0.17	<0.010	<0.040	<10	11	48	22
	LOT1-23-C	2007-06-07	2.25	<0.0050	0.087	<0.010	<0.040	<10	11	66	31
LOT1-24	LOT1-24-A	2007-06-07	0.75	<0.0050	0.13	<0.010	<0.040	<10	12	67	32
	LOT1-24-B	2007-06-07	1.50	<0.0050	0.058	<0.010	<0.040	<10	47	54	24
LOT1-25	LOT1-25-A	2007-06-07	0.75	<0.0050	0.11	<0.010	<0.040	<10	<10	46	26
	LOT1-25-B	2007-06-07	1.50	<0.0050	0.12	<0.010	<0.040	<10	17	75	35
LOT1-26	LOT1-26-A	2007-06-07	0.75	0.031	0.078	0.031	0.10	<10	<10	77	39
	LOT1-26-B	2007-06-07	1.50	<0.0050	0.072	<0.010	<0.040	<10	<10	60	31
LOT1-27	LOT1-27-B	2007-06-07	1.50	<0.0050	0.074	<0.010	<0.040	<10	<10	61	31
	LOT1-27-C	2007-06-07	2.25	<0.0050	0.038	<0.010	<0.040	<10	<10	32	<10
Guidelines <sup>(1)</sup>				0.048	0.16	0.36	14	30	150	400	2,800

<sup>(1)</sup>: Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities (AENV, 2001) for Agricultural land use (coarse-grained-soil)



# Project Results

Parameter	Initial Mean Concentration (mg/kg)	Final Mean Concentration (mg/kg)	Reduction Value (%)	Target Value
Benzene	2.86	0.002	99	0.048
Ethylbenzene	13.4	0.006	99	0.36
PHC-F1 (C6-C10)	1013	2.2	99	30
PHC-F2 (C10-C16)	912	20	97	150

















# Summary

- Excavation, segregation, and sampling of 26,212 m<sup>3</sup> of impacted material
- All confirmatory sampling results from excavation met applicable criteria
- Treatment monitoring in *ex situ* Biopile over a period of 16 months
- At completion, all confirmatory samples from Biopile met criteria





# Questions?

## Remediation of 26,200 m<sup>3</sup> of Hydrocarbon-impacted Soil at a Former Wellsite Using the *Ex situ* Biopile Process

Presented by: Wade Simpson, B.Sc., P.Ag.

Guaranteed Site Remediation Solutions

