

# Comparative Field Studies of Real-Time Soil Screening Techniques for Two Petroleum Hydrocarbon Sites

RemTech 2021

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envirosearch

# Background

## Site # 1 - Remedial Excavation & Site #2 - Site Assessment

### Challenges

- Limited or no historical data
- Site infrastructure removed
- Field screening for unknown or degraded hydrocarbons
- Winter conditions
- Budget and timeline

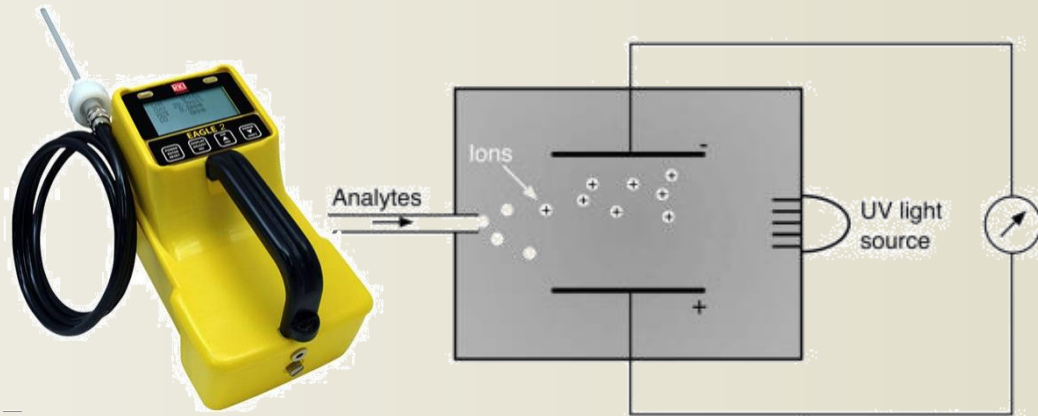
### Field screening

- PID and NIRS

# Field Instruments

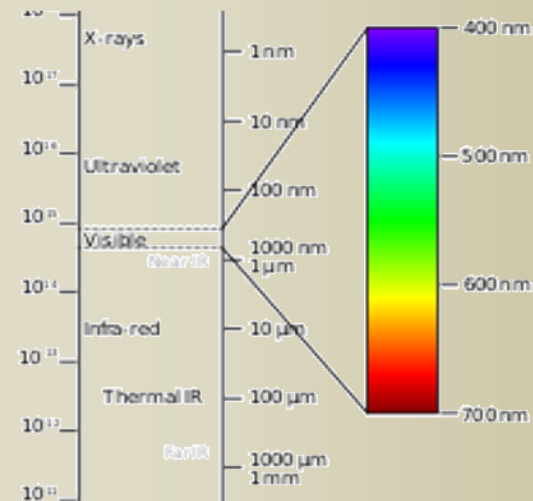
## Photoionization Detector (PID)

- Ultraviolet light to irradiate sample
- Current created between two plates
- Intensity of current = measure of amount of ionized molecules (ppm)
- 10.6 eV lamp
- Best with lighter compounds (volatiles) with IP < 10 eV

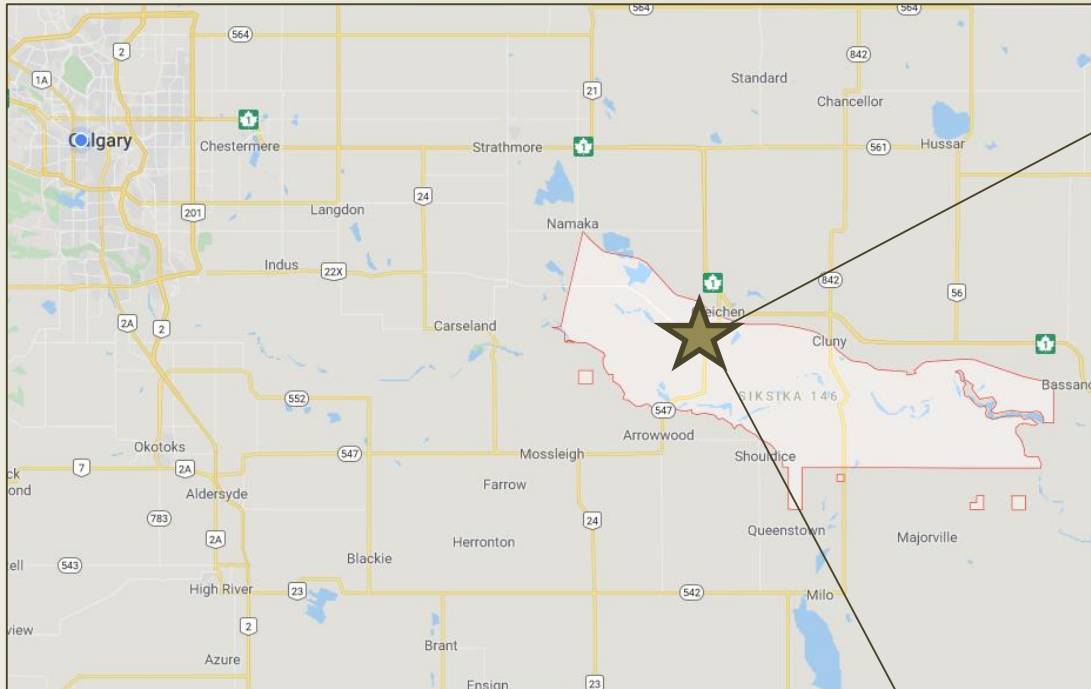


## Near Infrared Spectroscopy (NIRS)

- Different types of covalent bonds absorb different specific light wavelengths
- Majority of soil properties have spectral features in the short wave infrared portion of the electromagnetic spectrum



# Site # 1 – Siksika Nation - Site Assessment



# Proposed Excavation



~25 m<sup>3</sup>

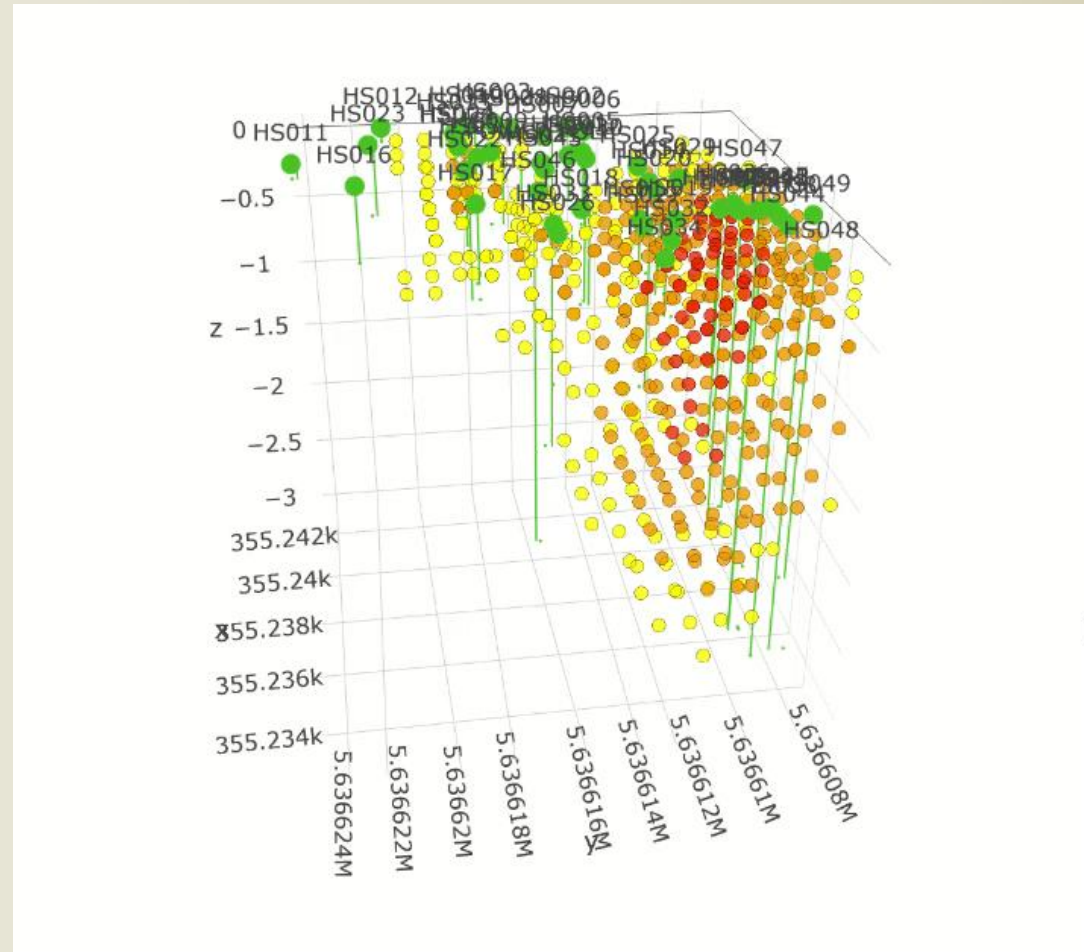
## January Challenges

- Winter Conditions:
  - Safety (-22°C)
  - Frozen ground to 4 feet
  - Limited daylight
  - Degraded petroleum hydrocarbons

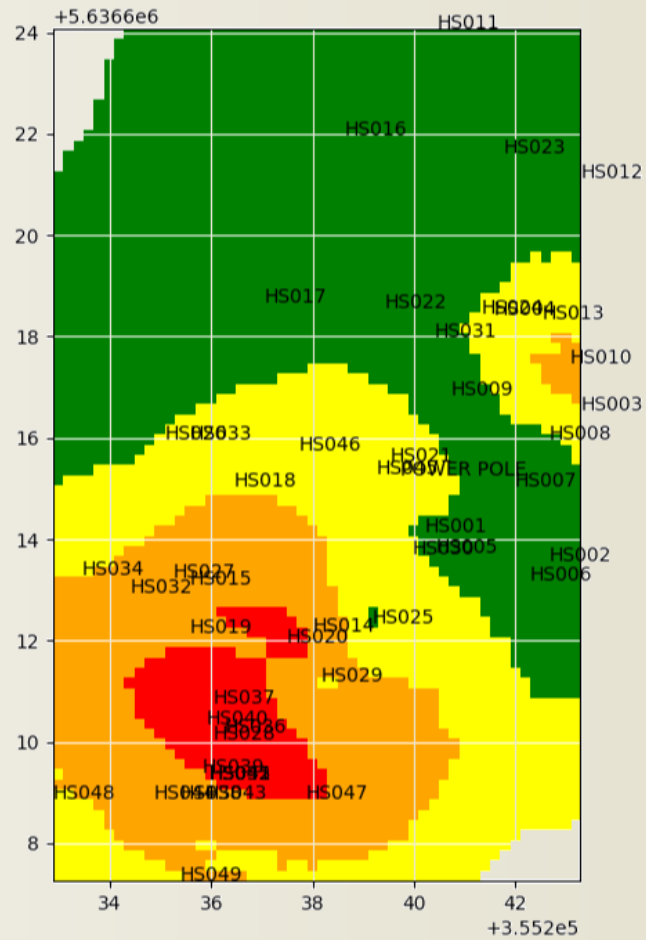
# Soil Sample Locations



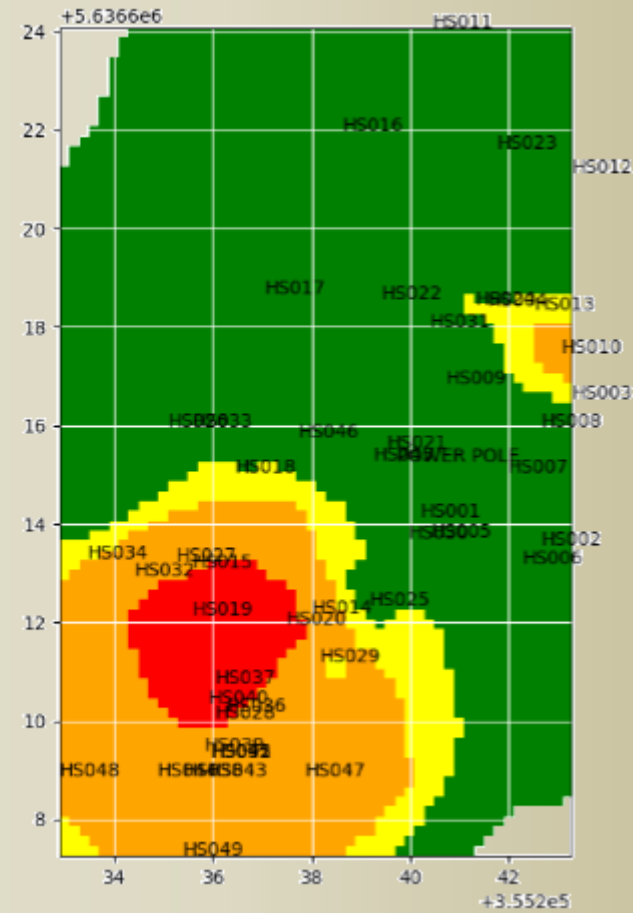
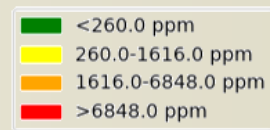
# NIRS 3D Data Output – F2



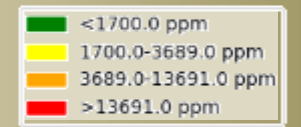
# NIRS Data Output – 0.5m Depth



F2

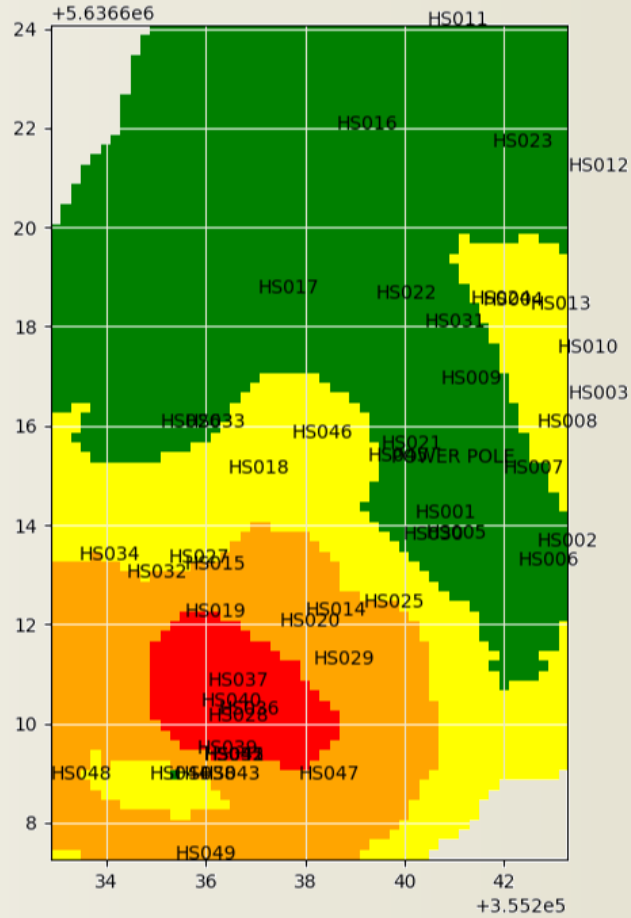


F3

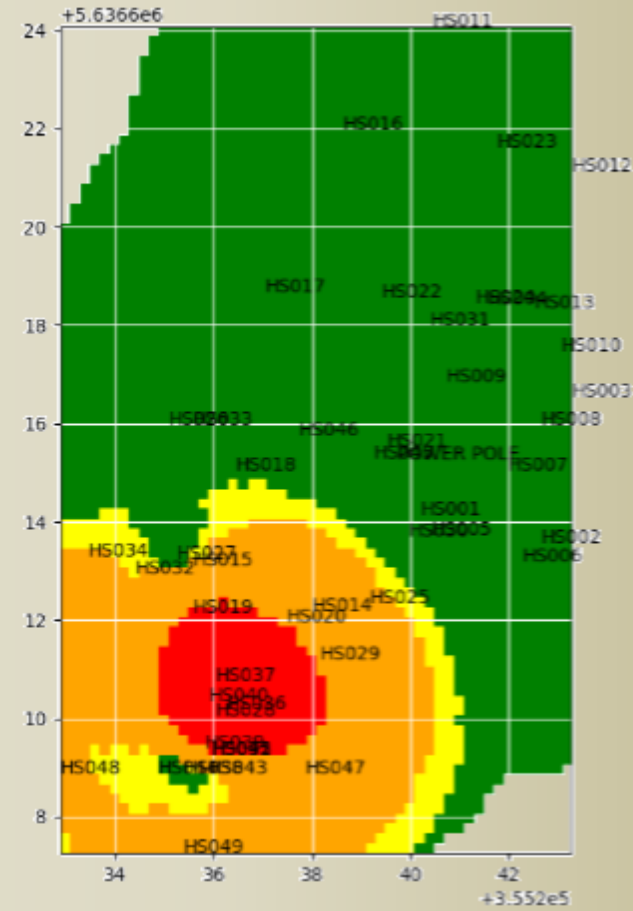
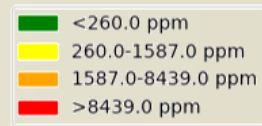




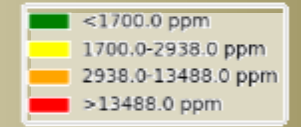
# NIRS Data Output – 1.0m Depth



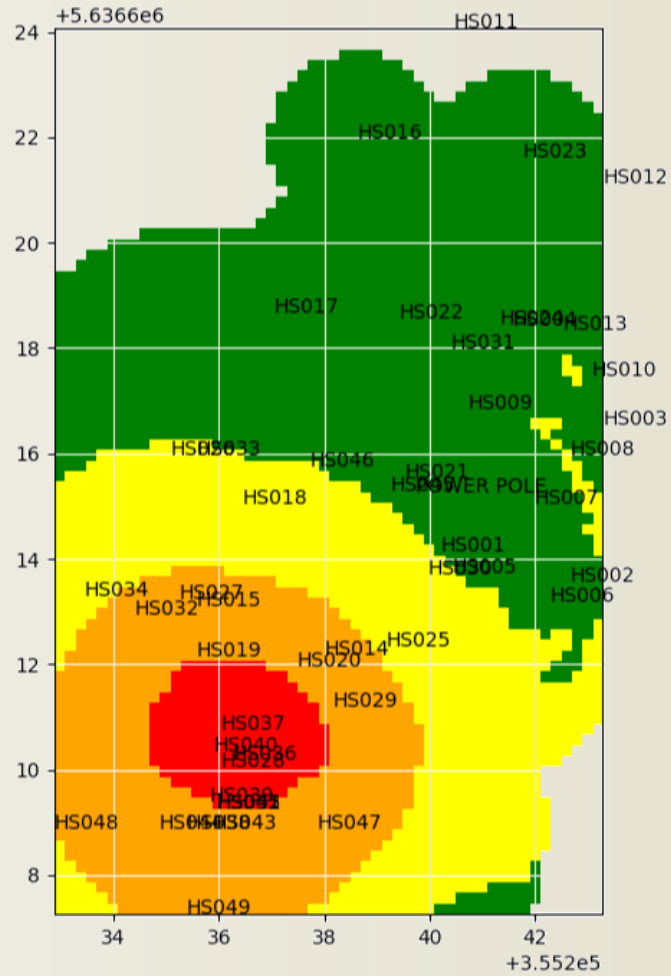
F2



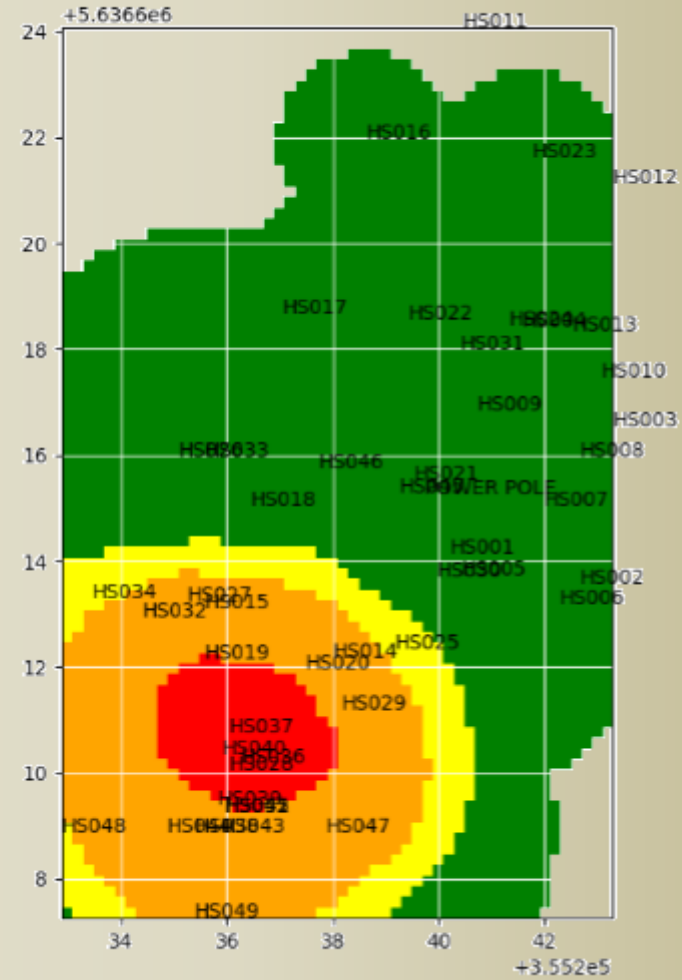
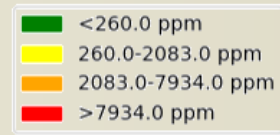
F3



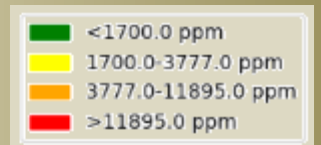
# NIRS Data Output – 1.5m Depth



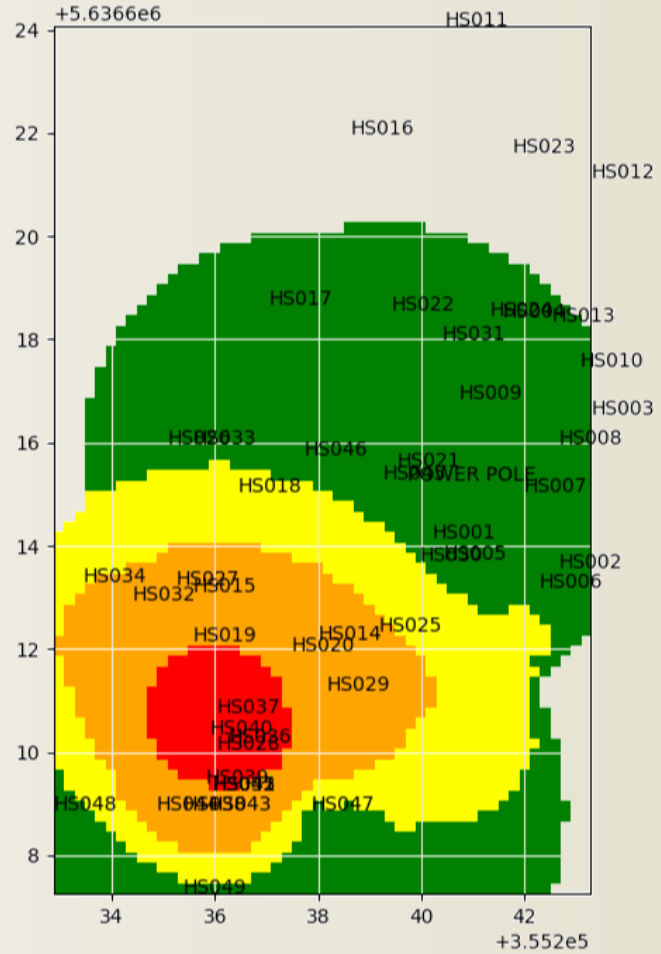
**F2**



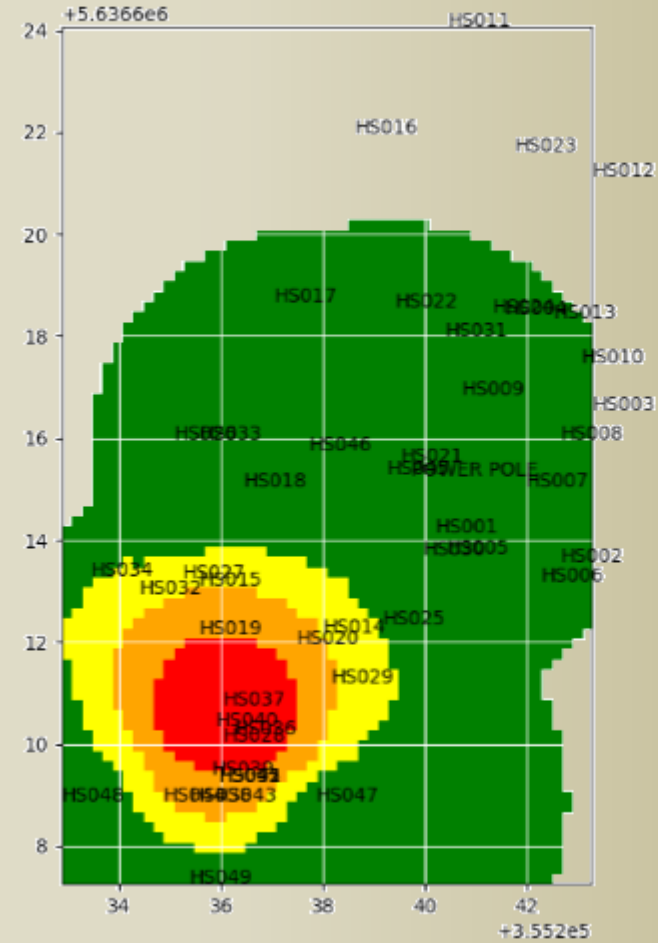
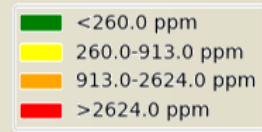
**F3**



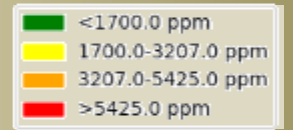
# NIRS Data Output – 2.0m Depth



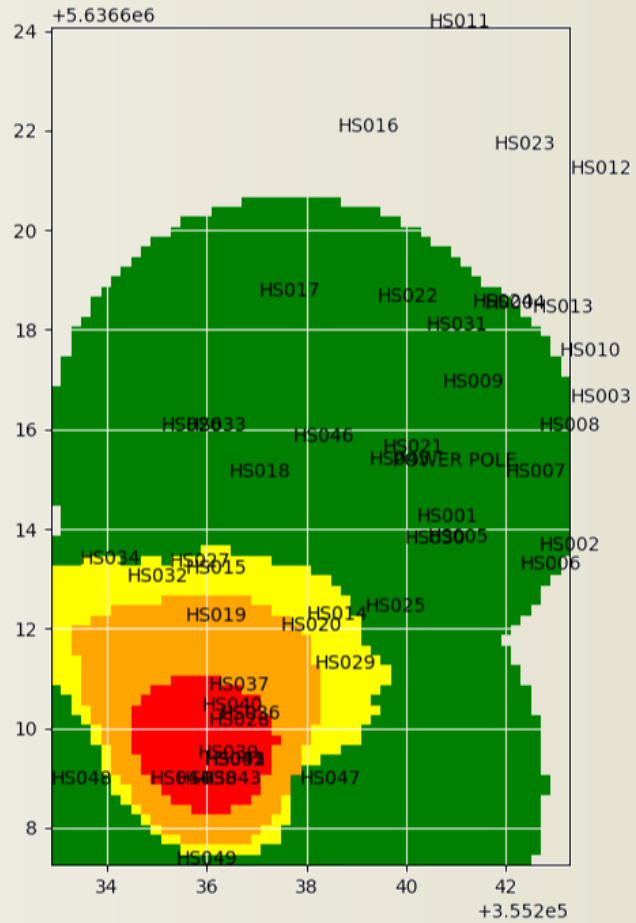
F2



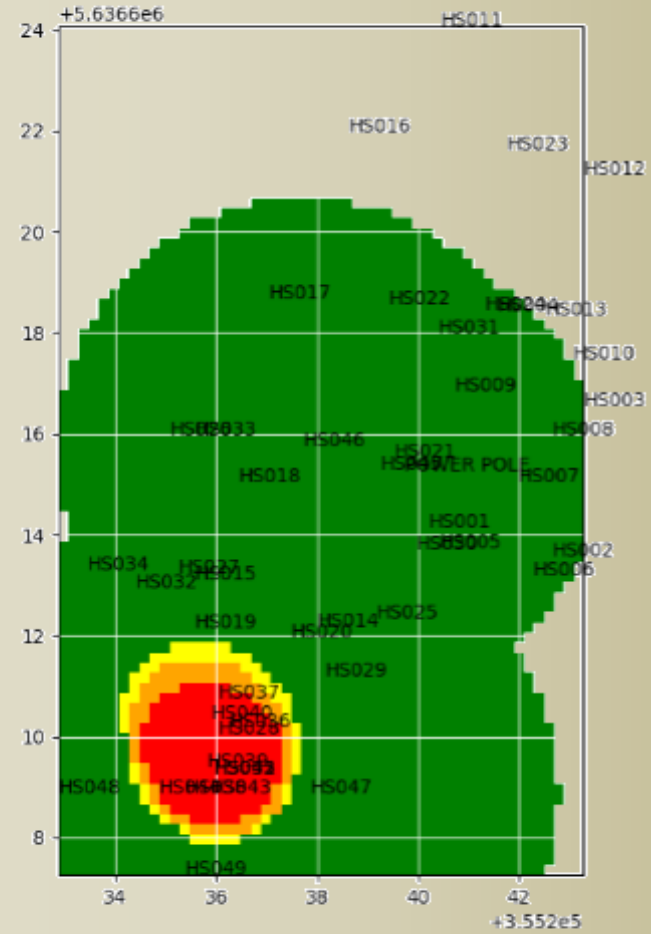
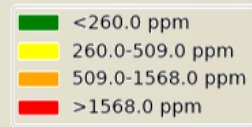
F3



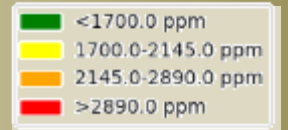
# NIRS Data Output – 2.5m Depth



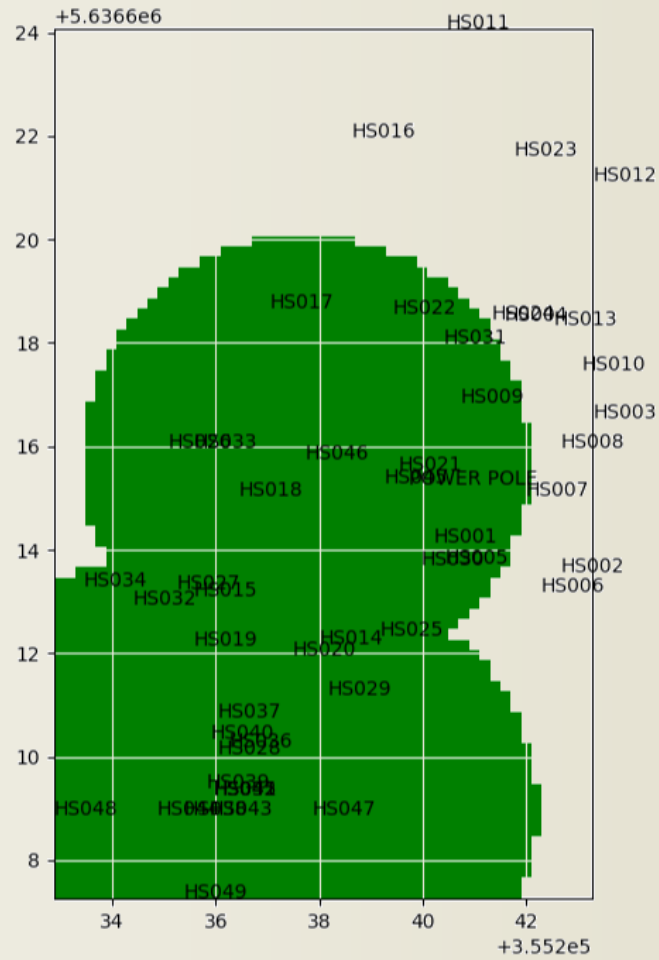
F2



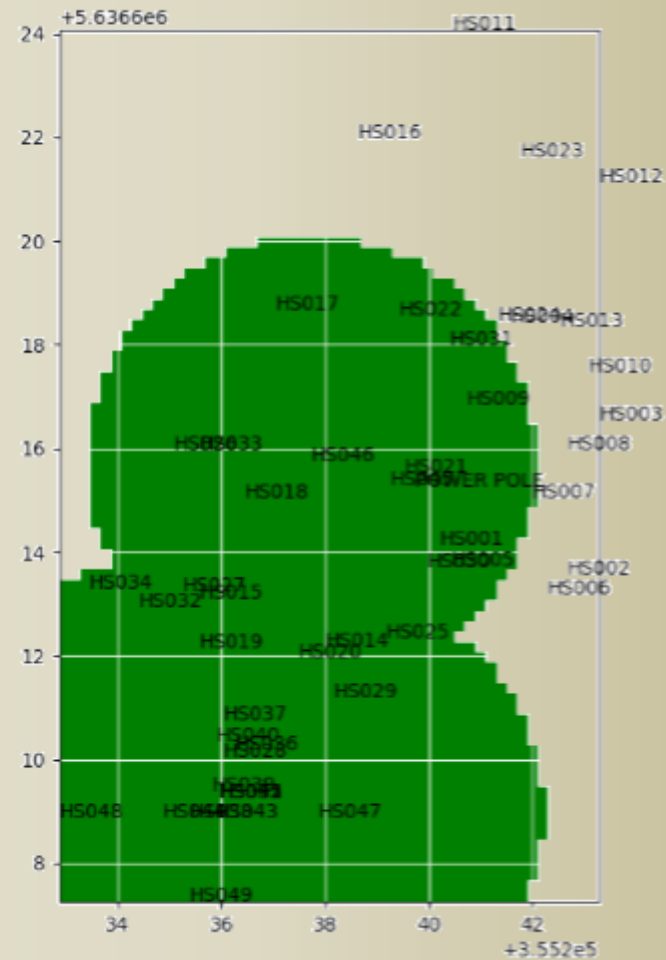
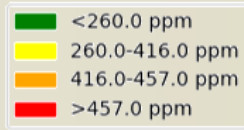
F3



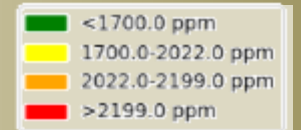
# NIRS Data Output – 3.0m Depth



**F2**



**F3**



# Remedial Excavation



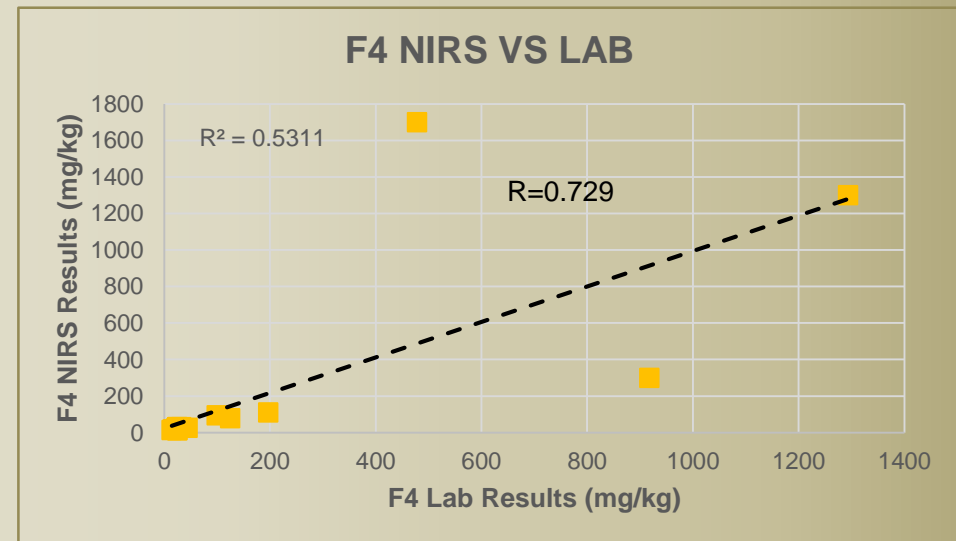
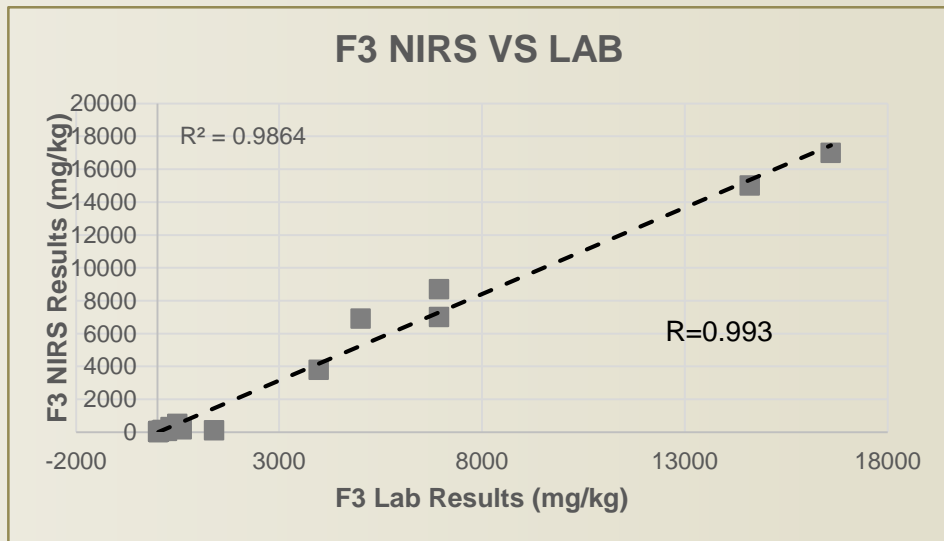
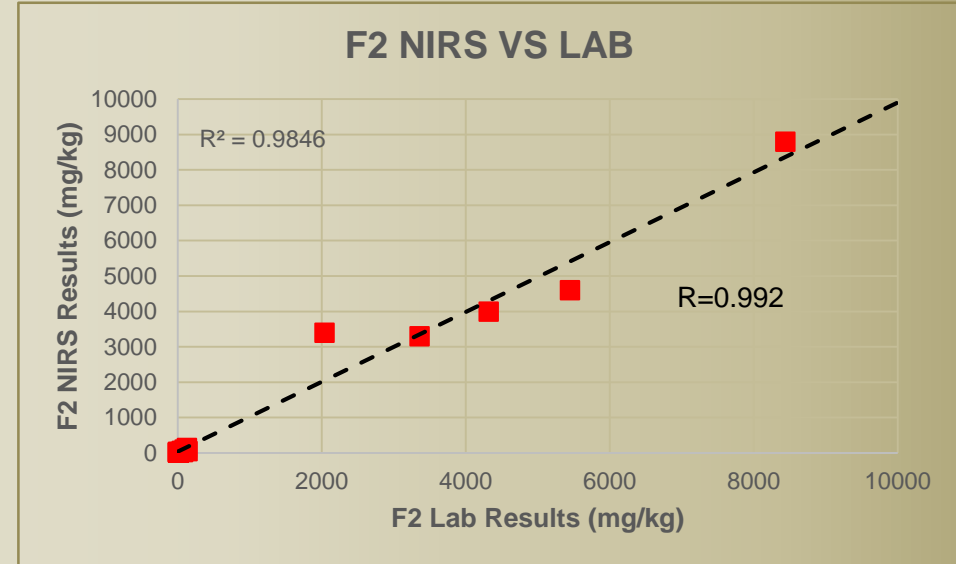
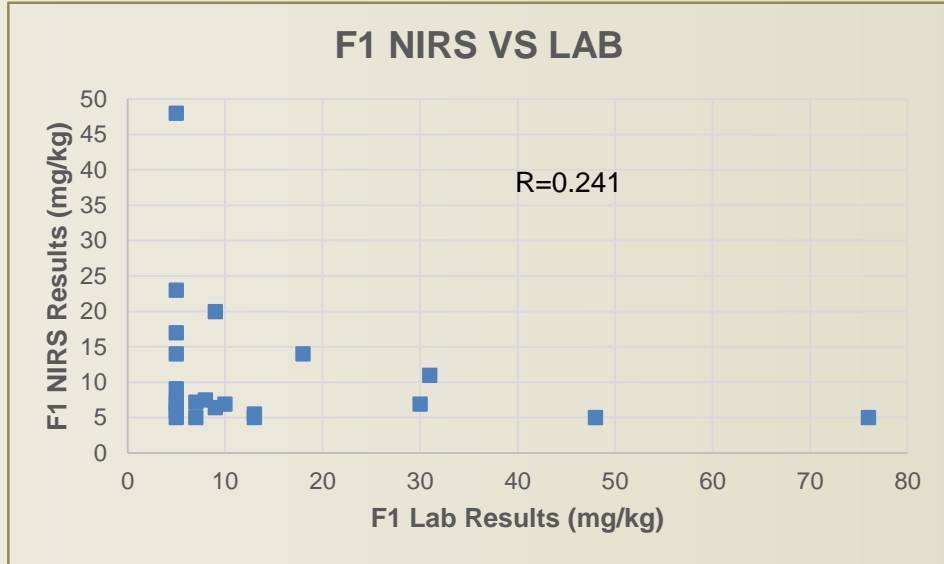
# Field Screening and Lab Results - Siksika

Borehole	Depth (mb gl)	PID Data (ppm)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)		
			Criteria - CCME Com. Fine Grained									
			320		260		2500		6600			
Parameter		F1	F2	F3	F4							
HS001	0.3	0	14		31		37		33			
HS002	0.3	0	49		32		190		32			
HS003	0.3	0	63		390		250		140			
HS004	0.3	0	41		28		160		78			
HS005	0.5	0	12		72		240		94			
HS006	0.5	0	18		17		49		49			
HS007	0.5	0	19		67		600		160			
HS008	0.5	0	7.2	<10	29	76	110	1400	29	<50		
HS009	0.5	0	30		22		30		19			
HS010	0.5	0	27		940		5200		980			
HS010	0.5	0	6.9	30	4600	5450	6900	5010	79	125		
HS011	0.1	0	31		17		56		81			
HS012	0.1	0	41		82		370		97			
HS013	0.1	0	30		26		360		65			
HS013a	0.5	0	14	18	61	61	300	326	14	14		
HS013b	0.5	0	5.5	13	140	132	510	488	17	17		
HS014	0.1	0	20	9	3400	2040	8700	6940	1700	478		
HS014	0.5	0	10		2000		7300		440			
HS015	0.1	0	34		20		42		41			
HS016	0.5	0	15		43		100		44			
HS017	0.5	0	14	<10	15	13	77	240	25	<50		
HS018	0.5	0	44		190		1200		65			
HS018	0.5	0	11	31	3300	3360	3800	3980	94	99		
HS019	0.5	0	74		2400		18000		1600			
HS019	0.5	0	5	76	10000	10160	15000	14600	1300	1294		
HS020	0.5	0	170		14000		26000		5100			
HS020	0.5	0	5	48	8800	8440	17000	16600	300	918		
HS021	0.5	0	36		1000		1100		230			
HS022	0.5	0	19		17		35		12			
HS023	0.5	0	9.1	<10	55	140	180	600	29	<50		
HS024	0.5	0	17		260		2100		200			
HS025	0.5	0	12		37		110		37			
HS026	0.1	0	22		6.5		5		350			

## LAB ANALYSIS

Borehole	Depth (mbgl)	PID Data (ppm)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)		
			Criteria - CCME Com. Fine Grained Soil									
			320		260		2500		6600			
Parameter		F1	F2	F3	F4							
HS027	1.0	0	30		64		47		22			
HS028	0.2	0	63		21000		22000		4900			
HS029	0.5	0	65		59		190		35			
HS030	1.0	0	56		27		35		21			
HS031	1.0	0	120		19		51		24			
HS032	0.1	0	150		210		1300		76			
HS033	1.0	0	66		29		130		29			
HS034	0.2	0	40		75		92		92			
HS035	0.2	0	14		1500		10000		1300			
HS036	1.0	0	180		27000		44000		14000			
HS037	1.5	0	22		10000		16000		600			
HS038	1.0	0	25		45		390		65			
HS039	1.5	0	110		8500		12000		510			
HS040	2.0	0	14		4200		8900		1100			
HS041	2.5	0	310		8700		16000		1100			
HS042	2.5	0	5	5	11	11	22	25	29	32		
HS042	3.0	0	7	<10	15	<10	32	<50	25	<50		
HS043	3.0	0	12		18		61		21			
HS044	3.0	0	7.9		20		39		25			
HS045	2.0	0	30		40		29		21			
HS046	2.5	0	5.8	<10	16	<10	27	<50	25	<50		
HS047	2.0	0	23	<10	40	<10	74	<50	24	<50		
HS047	2.5	0	5	7	14	14	20	21	25	25		
HS048	2.0	0	17	<10	13	<10	18	<50	13	<50		
HS048	2.5	0	7.2	7	13	14	23	23	24	23		
HS049	2.0	0	48	<10	12	11	17	<50	11	<50		
HS049	2.5	0	7.5	8	15	17	25	28	27	31		
SP001	0.0	0	52		2300		13000		440			
SP001	0.0	0	6.4	9	4000	4320	7000	6940	110	197		
SP002	0.0	0	42		93		160		230			
SP002	0.0	0	5	13	99	98	130	124	16	16		
SP003	0.0	0	39		43		190		66			
SP003	0.5	0	6.9	10	23	23	81	88	25	44		

# Correlation Data – Siksika





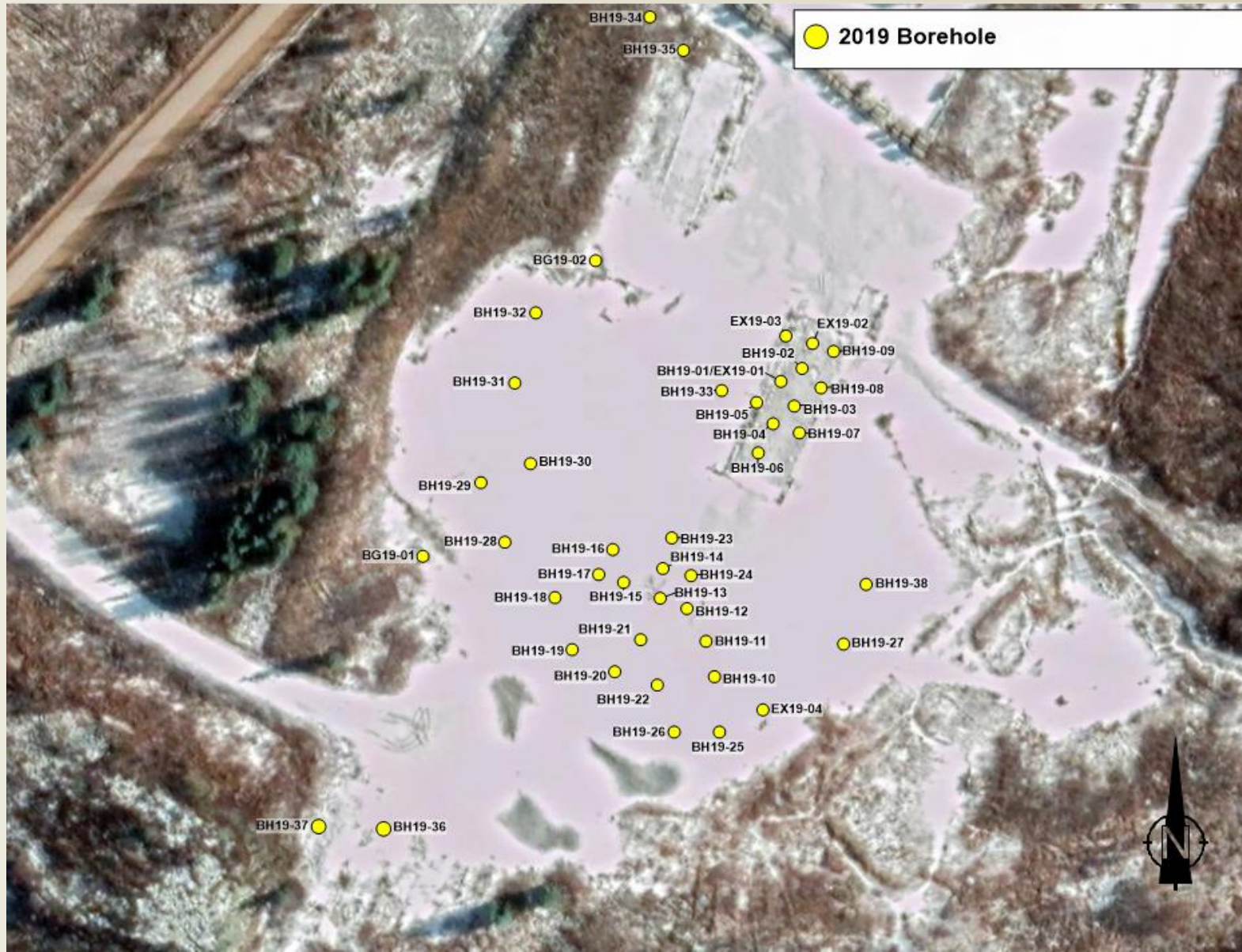
# Site # 2 – Alberta Fuel Distribution Site



# December 2019 Site Assessment



# Site #2 – Site Assessment



## December Challenges

- Winter Conditions:
  - Safety (-28°C)
  - Frozen ground to 5 feet
  - Limited daylight
  - No physical landmarks
  - Historical aerial imagery
  - No previous data



# Field Screening and Lab Results – Site #2

Borehole	Depth (mbgl)	PID Data (ppm)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)
	Criteria - AT1 Soil Coarse (Comm)		270		260		1700		3300	
	Criteria - AT1 Subsoil Coarse		440		520		3400		6600	
	Parameter		F1	F2	F3	F4				
BG19-01	0.1	0	11		38		170		120	
BG19-01	0.5	0	8.8	<10	27	<10	61	<50	38	<50
BG19-01	1	0	14		30		70		32	
BG19-01	1.2	0	20		52	<10	200	<50	120	<50
BG19-02	0.15	0	21		120		430		120	
BG19-02	0.5	0	13	<10	60	<10	140	<50	45	<50
BG19-02	1	0	9.9		25		62		37	
BG19-02	1.2	0	45		130		190		61	
BG19-03 (EX19-04)	0.1	0	13		78		140		42	
BG19-03 (EX19-04)	0.5	0	19		90		230		73	
BG19-03 (EX19-04)	0.8	0	30		280		480		170	
BG19-03 (EX19-04)	1	5	41		190		420		55	
BG19-03 (EX19-04)	1.3	0	19	<10	66	210	250	1700	95	790
BG19-03 (EX19-04)	1.6		32		39		340		93	
BH19-01	1.5	75	29	<10	830	320	750	2400	240	1000
BH19-01	3	15	17	<10	24	<10	59	<50	32	<50
BH19-01	4	25	13		96		110		63	
BH19-01	4.5	35	13		31		140		65	
BH19-02	0.7	25	10		35		81		41	
BH19-02	1.4	60	23		40		190		120	
BH19-03	0.5	115	14		39		170		93	
BH19-03	1.2	145	19		82		250		100	
BH19-03	2	5	13		32		110		73	
BH19-03	3	35	33		120		240		130	
BH19-04	0.7	530	42		150		220		120	
BH19-04	1.5	30	28	<10	300	130	410	1100	150	590
BH19-04	2.5	70	12		55		83		34	
BH19-05	0.5	0	14		36		86		49	
BH19-05	1.5	25	17		86		150		61	
BH19-06	0.3	0	20		120		130		58	
BH19-06	1.5		29		240		250		84	
BH19-07	0.3	5	12		35		100		45	
BH19-07	1.4	10	43		1200		1200		400	
BH19-07	2.5	35	17		97		120		69	
BH19-08	0.3	5	15		33		90		42	
BH19-08	1.5	45	30	<10	1400	130	420	1000	230	410
BH19-08	2	90	18		58		350		86	
BH19-08	2.7	35	14		71		420		180	
BH19-09	0.3	190	15		120		560		140	
BH19-09	1.5	95	13		43		220		63	
BH19-09	2.5		14		43		240		88	
BH19-10	0.3	80	19		33		110		52	
BH19-10	1.5	35	14		60		150		58	
BH19-10	1.7	45	27		40		150		47	
BH19-10	3	100	27		64		140		54	
BH19-11	0.5	210	26		72		150		58	
BH19-11	1	220	11	<10	28	<10	85	<50	37	<50

Borehole	Depth (mbgl)	PID Data (ppm)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)
	Criteria - AT1 Soil Coarse (Comm)		270		260		1700		3300	
	Criteria - AT1 Subsoil Coarse		440		520		3400		6600	
	Parameter		F1	F2	F3	F4				
BH19-11	2	50	12		36		100		39	
BH19-11	3	30	11		25		80		33	
BH19-12	0.3	45	21		68		190		75	
BH19-12	1.5	450	20		180		200		83	
BH19-12	2		13		68		150		56	
BH19-12	3		13	<10	72	<10	110	<50	58	<50
BH19-13	0	25	39		4000		13000		1400	
BH19-13	0.6	610	19		40		240		81	
BH19-13	1.8	60	12		29		220		59	
BH19-13	2.3	250	12		40		89		51	
BH19-13	3.3	165	12		45		180		47	
BH19-14	0	0	14		78		280		100	
BH19-14	0.3	410	78		2000		1100		280	
BH19-14	1.5	285	41	<10	1400	1200	1100	6900	400	3500
BH19-14	2	420	260		2100		1800		590	
BH19-14	3	95	140	43	1700	1300	2100	7700	540	3600
BH19-15	0.3	430	19		150		560		170	
BH19-15	1.2	310	18		350		340		120	
BH19-15	2	660	11	<10	64	<10	190	<50	89	<50
BH19-15	3	790	11		60		180		110	
BH19-16	0.3	420	44		150		530		180	
BH19-16	1	380	34		390		370		270	
BH19-16	2	300	68	<10	360	67	350	380	180	170
BH19-16	3	320	120		870		610		260	
BH19-17	0.3	440	170		1800		1000		380	
BH19-17	1	400	25	<10	250	200	300	1200	150	580
BH19-17	2	330	81	<10	310	24	240	180	120	86
BH19-17	3	440	69	<10	270	<10	280	<50	73	<50
BH19-18	0.3	70	14		57		110		42	
BH19-18	1.5	35	17		35		130		57	
BH19-18	3	70	12		34		92		48	
BH19-19	0.3	145	14		34		130		53	
BH19-19	1	200	12		99		220		60	
BH19-19	2	340	15	<10	98	370	220	2400	79	1200
BH19-19	3	55	23		330		510		94	
BH19-20	0.3	145	27		360		1000		96	
BH19-20	1	970	26		220		690		78	
BH19-20	2	920	9.4	<10	25	33	58	150	31	65
BH19-20	3	360	11		29		66		42	
BH19-21	0.3	1550	14		50		200		73	
BH19-21	1	710	16	<10	54	<10	210	<50	70	<50
BH19-21	3	210	11		34		100		54	
BH19-22	0	0	31		1300		3500		1300	
BH19-22	0.3	2150	16	<10	84	<10	170	<50	43	<50
BH19-22	1.3	410	13	<10	35	<10	87	<50	35	<50
BH19-22	3	35	15		35		110		33	
BH19-23	0.3	780	77		1300		1000		200	
BH19-23	1.5	260	260	53	3000	1300	3200	7300	590	3400
BH19-23	2	710	290		2300		2000		380	
BH19-23	2.7	810	63	45	810	610	470	3400	110	1600

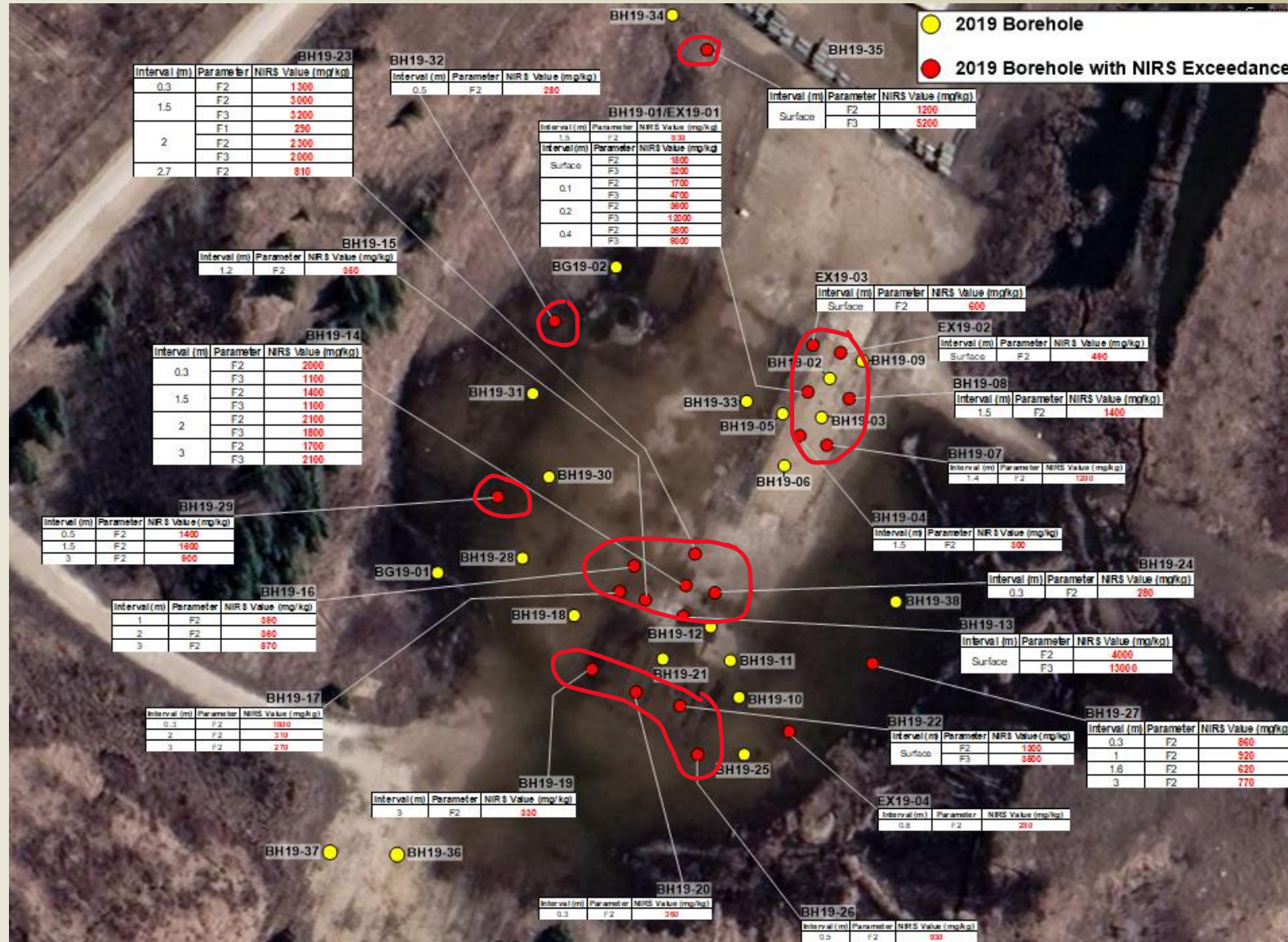
LAB ANALYSIS



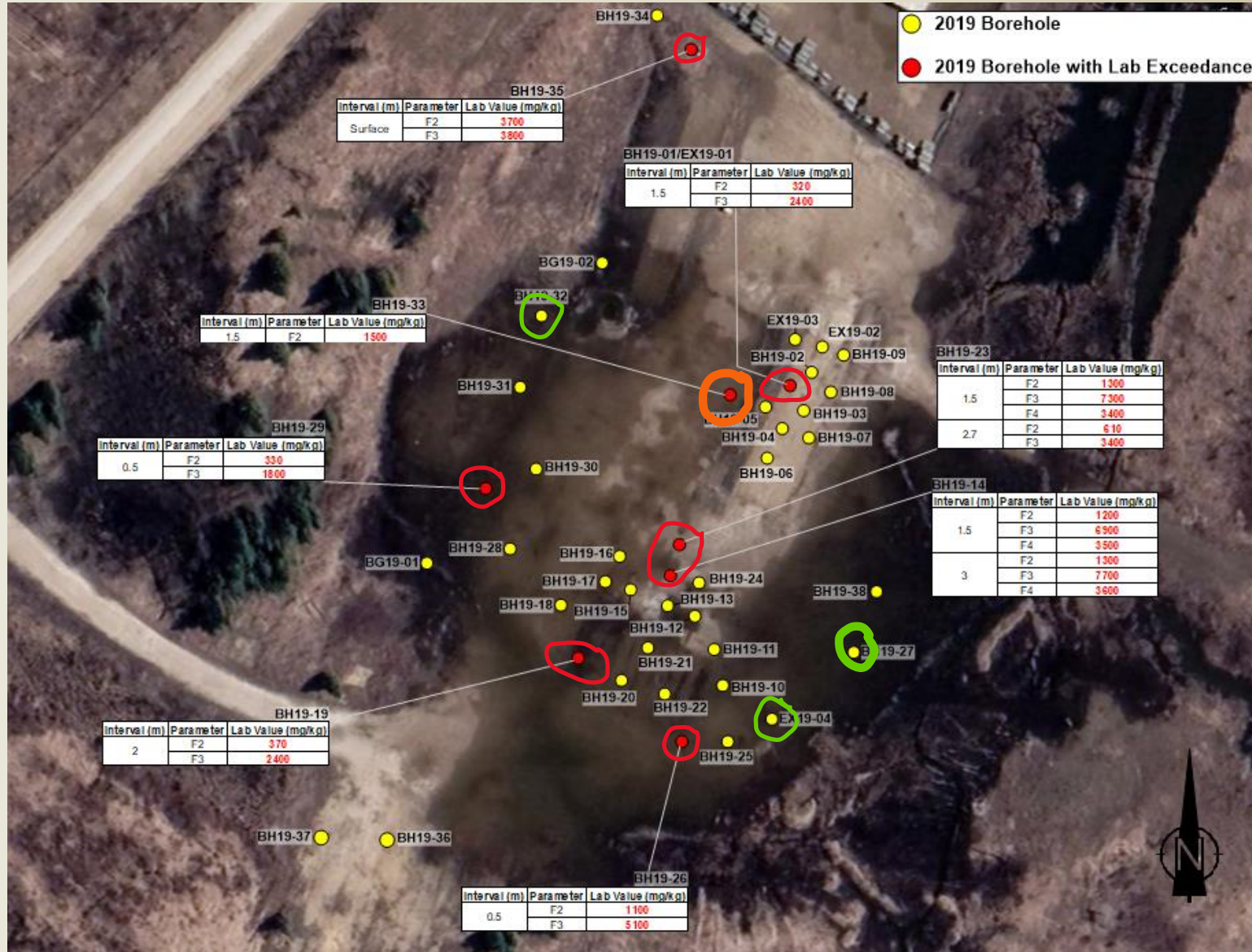
# Field Screening and Lab Results – Site #2

Borehole	Depth (m bgl)	PID Data (ppm)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)	NIRS (mg/kg)	LAB (mg/kg)
	Criteria - AT1 Soil Coarse (Comm)		270		260		1700		3300	
	Criteria - AT1 Subsoil Coarse		440		520		3400		6600	
	Parameter		F1		F2		F3		F4	
BH19-23	4.5	1000	30	<10	160	120	380	650	85	310
BH19-23	5.6	570	43		400		360		90	
BH19-23	6	360	60	<10	150	<10	310	<50	110	<50
BH19-24	0.3	560	74		280		430		180	
BH19-24	1	1000	31	<10	150	53	490	280	98	110
BH19-24	2		20		170		550		100	
BH19-24	3		17		140		210		64	
BH19-25	0	0	15		71		370		160	
BH19-25	0.5	50	10		150		330		150	
BH19-25	1.5	80	13	<10	91	55	290	510	250	290
BH19-25	3	0	30		100		260		72	
BH19-26	0	0	12		42		160		68	
BH19-26	0.5	115	26	31	930	1100	630	5100	90	2500
BH19-26	1.5	95	15	<10	57	16	180	91	68	<50
BH19-26	3	200	24		130		190		63	
BH19-27	0.3	115	58		860		750		150	
BH19-27	1	160	60	<10	920	<10	1500	<50	380	<50
BH19-27	1.6	115	44		620		530		170	
BH19-27	3	220	70	<10	770	<10	1300	<50	410	<50
BH19-28	0	0	29		53		120		47	
BH19-28	0.5	185	42	<10	140	<10	140	56	95	<50
BH19-28	1.6	610	15		37		96		49	
BH19-28	3	0	15		32		140		56	
BH19-29	0	0	51		82		360		74	
BH19-29	0.5	50	57	<10	1400	330	670	1800	580	780
BH19-29	1.5	85	55		1600		860		560	
BH19-29	3	45	57		900		460		350	
BH19-30	0	5	11		47		86		54	
BH19-30	0.5	530	11	<10	40	<10	77	<50	40	<50
BH19-30	1.5	20	14	<10	35	<10	120	<50	53	<50
BH19-30	3	115	15		51		210		110	
BH19-31	0	20	10		34		120		60	
BH19-31	1	5	9.1		75		150		78	
BH19-31	1.5	430	10		75		160		91	
BH19-31	3	30	20		47		250		64	
BH19-32	0		18		74		320		120	
BH19-32	0.5		26	<10	280	77	340	530	140	250
BH19-32	1.5		23		130		390		190	
BH19-32	3		17		43		180		63	
BH19-33	0	460	14		40		290		81	
BH19-33	1.5	310	9.1	35	94	1500	180	970	72	70
BH19-33	3	180	9.4	<10	79	<10	200	<50	98	<50
BH19-34	0	0	14		100		290		130	
BH19-34	0.5	65	12		85		260		130	
BH19-34	1.5	120	10		160		280		81	
BH19-34	3	45	24		120		290		120	
BH19-35	0	0	18	90	1200	3700	5200	3800	1400	770
BH19-35	0.5	35	20		110		240		65	
BH19-35	1.5	145	41		220		320		110	
BH19-35	3	55	21	<10	120	<10	320	<50	75	<50
BH19-36	0	10	10		43		150		73	
BH19-37	0	5	10		37		140		52	
BH19-38	0	15	12		72		260		140	
EX19-01	0	0	51		1800		3200		540	
EX19-01	0.1	0	34		1700		4700		1700	
EX19-01	0.2	70	23		3600		12000		2300	
EX19-01	0.4	65	45		3600		9300		2400	
EX19-01	0.7	210	50		77		320		200	
EX19-01	0.9	10	15		31		74		42	
EX19-02	0	0	46		490		910		450	
EX19-02	0.4	0	14	<10	260	11	460	330	320	230
EX19-02	1	0	14		82		87		53	
EX19-03	0	0	44		600		1500		330	
EX19-03	0.5		12		170		340		200	
EX19-03	1		14		140		190		110	

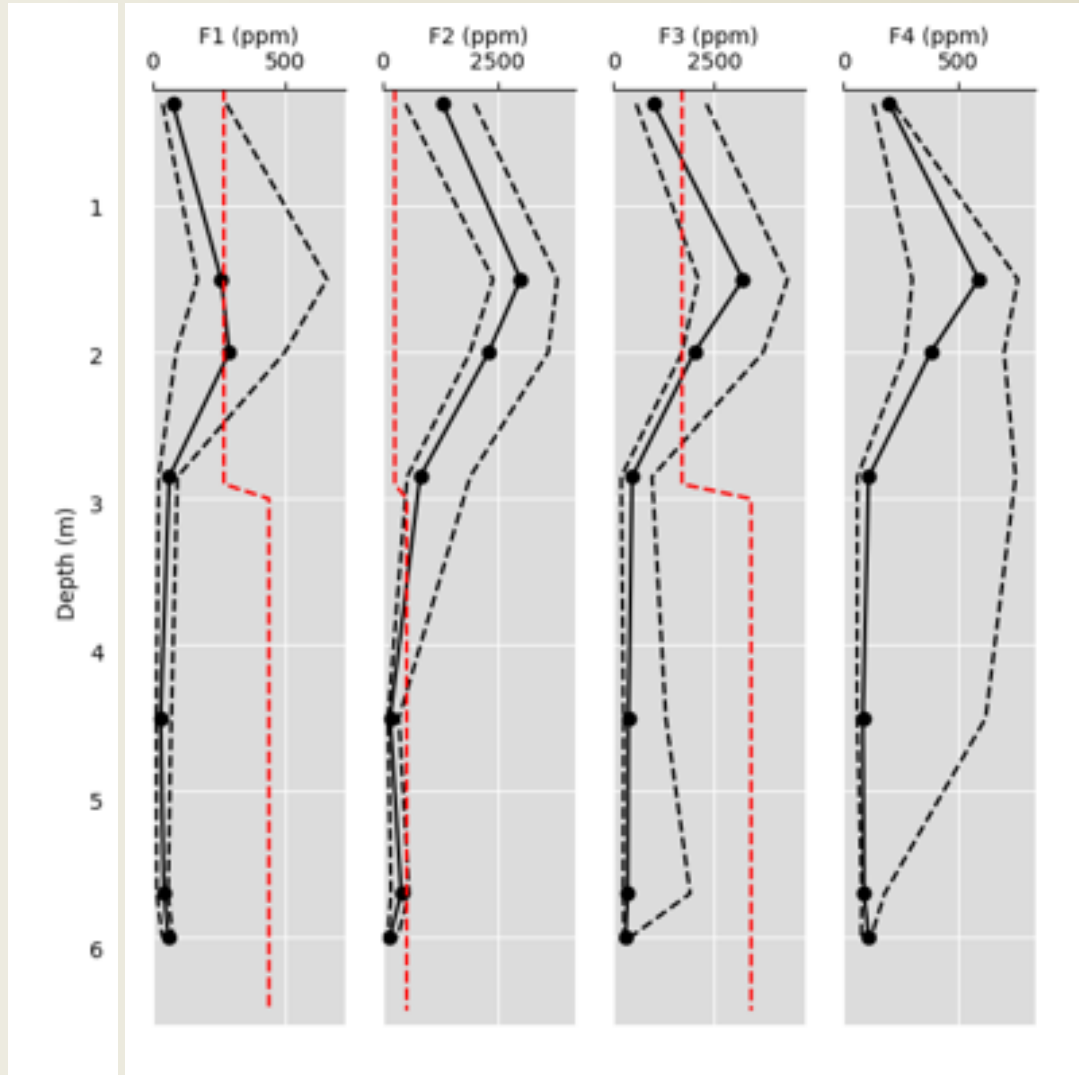
# Field Screening Exceedances



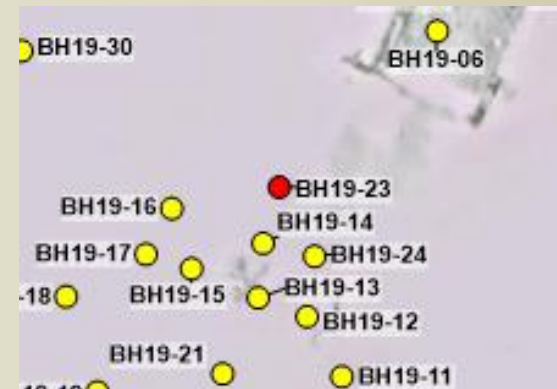
# Confirmation Lab Samples



# BH19-23 (Till)

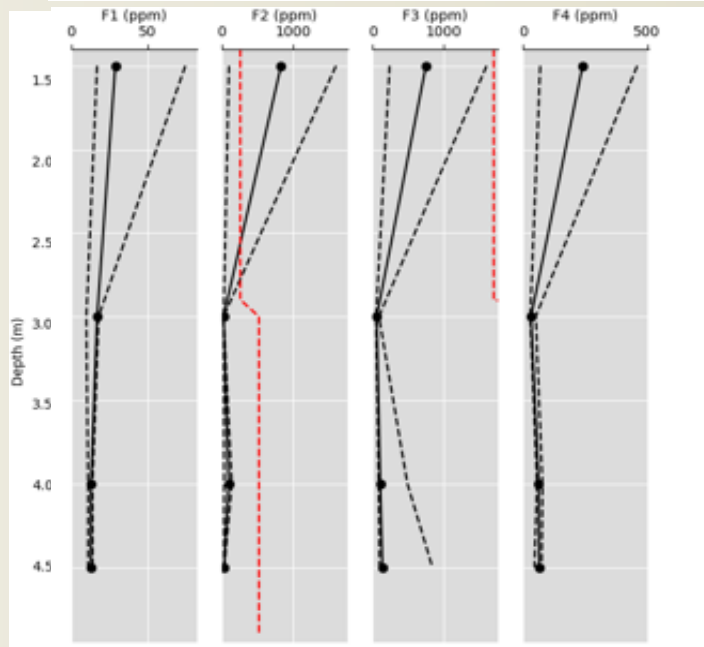
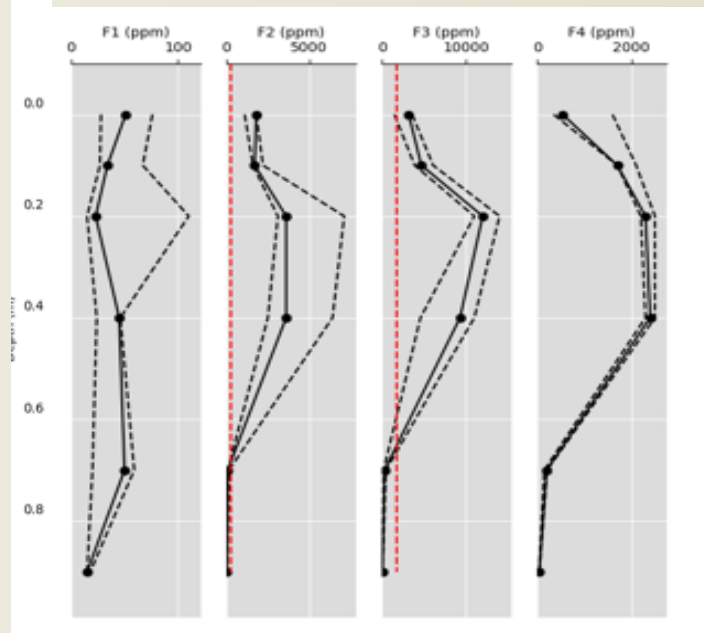


Site Location	Soil		F1 (C6-C10)		F2 (C10-C16)		F3 (C16-C34)		F4 (C34-C50)	
	Criteria	Subsoil	Units		mg/kg		mg/kg		mg/kg	
Alberta	AT1 Soil (Cc		270	440	260	520	1700	3400	3300	6600
Sample ID	Depth (m)	PID ppm	NIRS	Lab	NIRS	Lab	NIRS	Lab	NIRS	Lab
BH19-23B	0.3	780	77		1300		1000		200	
BH19-23B	1.5	260	260	53	3000	1300	3200	7300	590	3400
BH19-23B	2	710	290		2300		2000		380	
BH19-23B	2.7	810	63	45	810	610	470	3400	110	1600
BH19-23B	4.5	1000	30	<10	160	120	380	650	85	310
BH19-23B	5.6	570	43		400		360		90	
BH19-23B	6	360	60	<10	150	<10	310	<50	110	<50

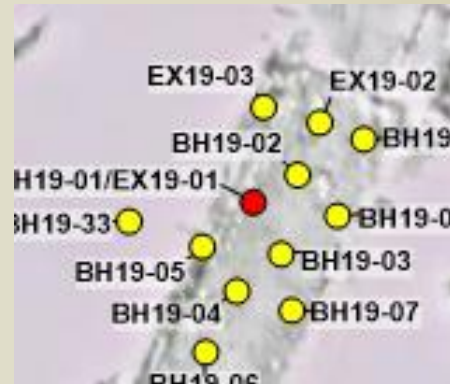




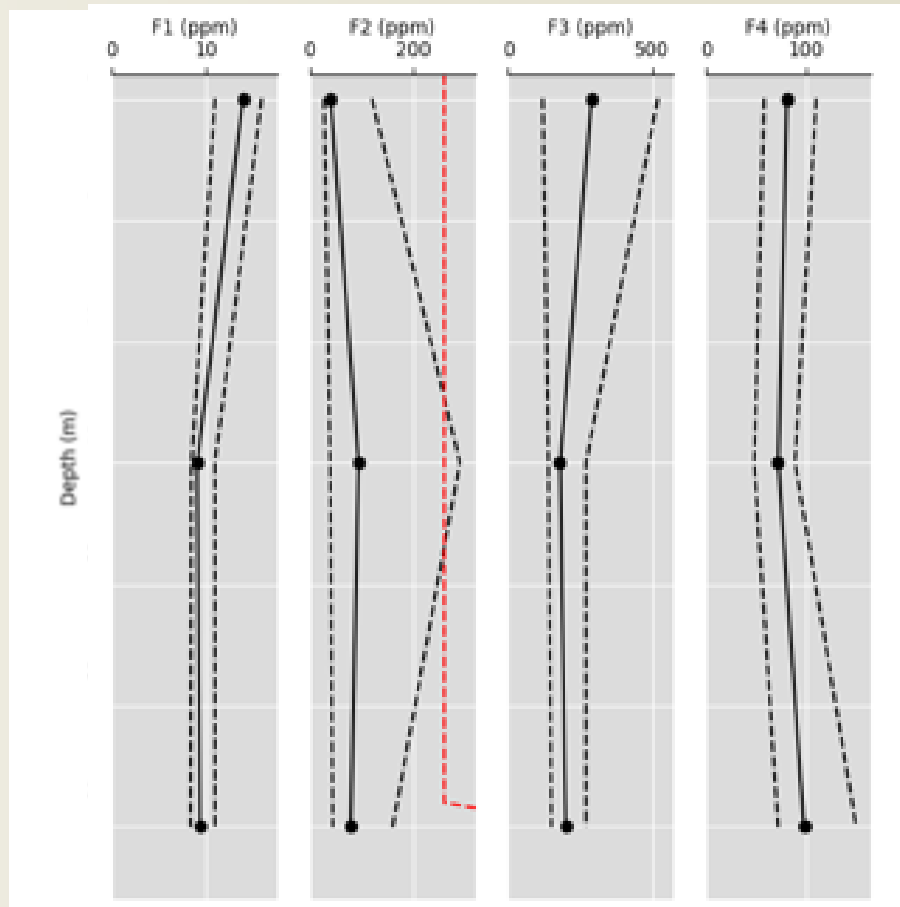
# BH19-01/EX19-01 (Sand)



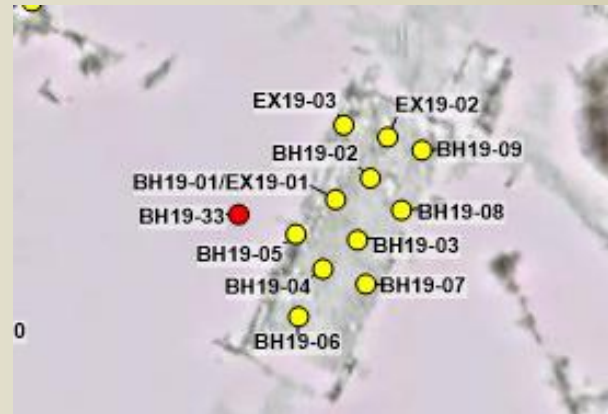
Site Location	Alberta		F1 (C6-C10)		F2 (C10-C16)		F3 (C16-C34)		F4 (C34-C50)	
	Criteria	Soil	mg/kg		mg/kg		mg/kg		mg/kg	
	AT1 Soil (Cc	Subsoil								
		Units								
Sample ID	Depth (m)	PID ppm	NIRS	Lab	NIRS	Lab	NIRS	Lab	NIRS	Lab
EX19-01	0	0	51		1800		3200		540	
EX19-01	0.1	0	34		1700		4700		1700	
EX19-01	0.2	70	23		3600		12000		2300	
EX19-01	0.4	65	45		3600		9300		2400	
EX19-01	0.7	210	50		77		320		200	
EX19-01	0.9	10	15		31		74		42	
BH19-01	3	15	17	<10	24	<10	59	<50	32	<50
BH19-01	4	25	13		96		110		63	
BH19-01	4.5	35	13		31		140		65	



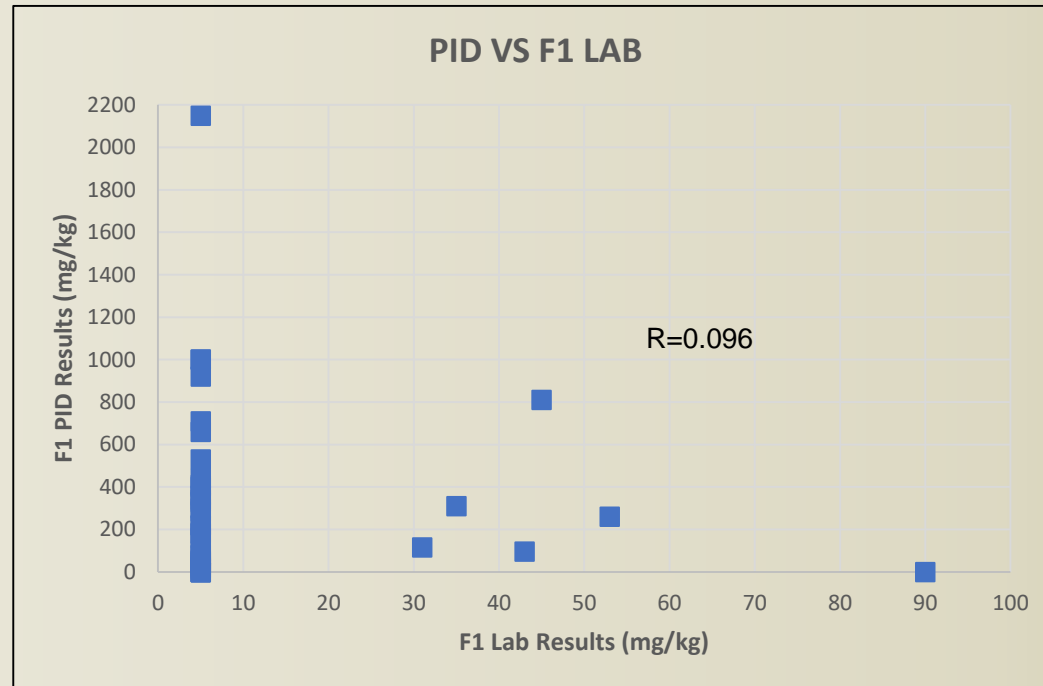
# BH19-03 (Gravel)



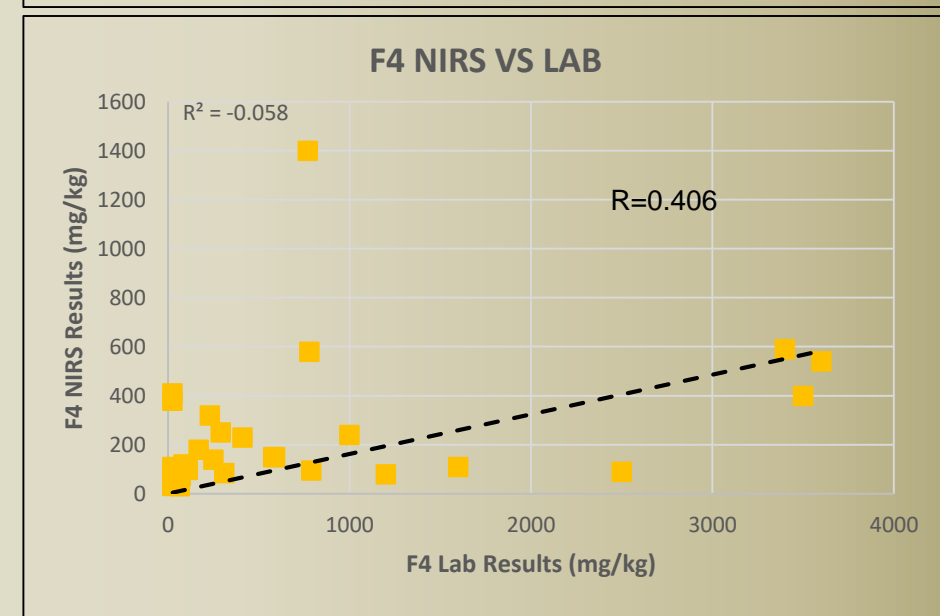
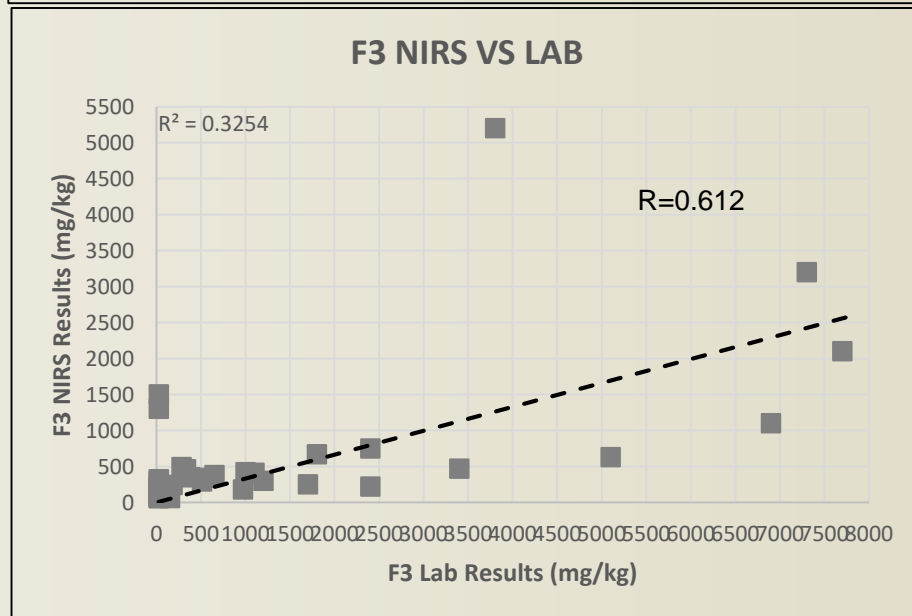
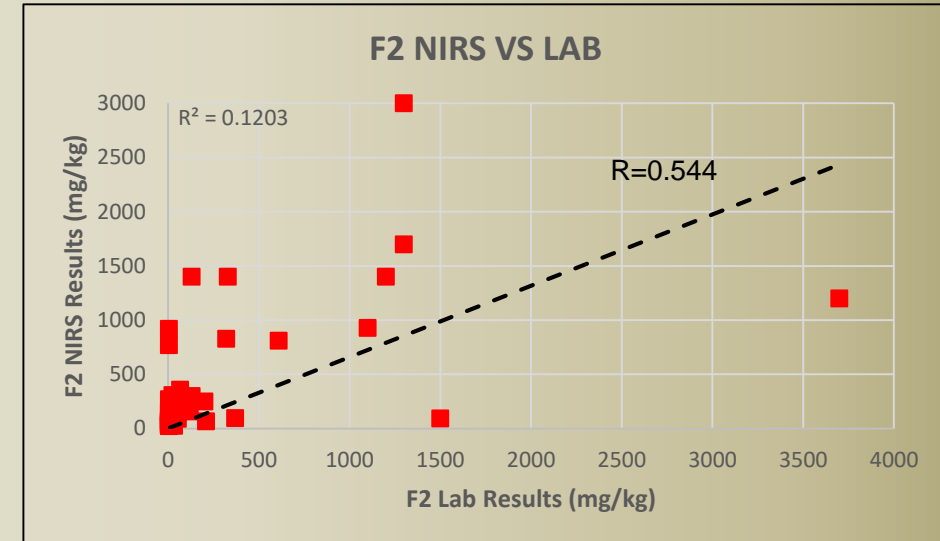
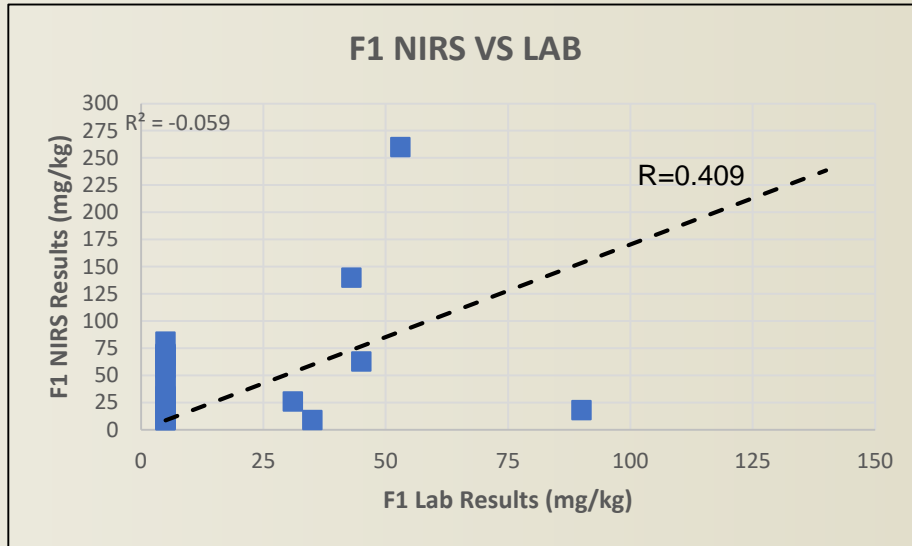
Site Location	Alberta	Soil	F1 (C6-C10)		F2 (C10-C16)		F3 (C16-C34)		F4 (C34-C50)		
			Criteria	Units	NIRS	Lab	NIRS	Lab	NIRS	Lab	NIRS
		AT1 Soil (Cc Subsoil	270		260		1700		3300		
			440		520		3400		6600		
Sample ID	Depth (m)	PID ppm	NIRS	Lab	NIRS	Lab	NIRS	Lab	NIRS	Lab	
BH19-33	0	460	14		40		290		81		
BH19-33	1.5	310	9.1	35	94	1500	180	970	72	70	
BH19-33	3	180	9.4	<10	79	<10	200	<50	98	<50	



# Correlation Data – Site #2



# Correlation Data – Site #2



# Summary

- Field screening instrumentation is critical
- PID limited with diesel-impacted soils and winter conditions
- Water content can play a significant role
- NIRS field screening key for F2 and F3 fractions
- Program flexibility and adaptability





Questions?

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