



# High Vacuum Dual Phase Extraction and Mobile Groundwater Treatment

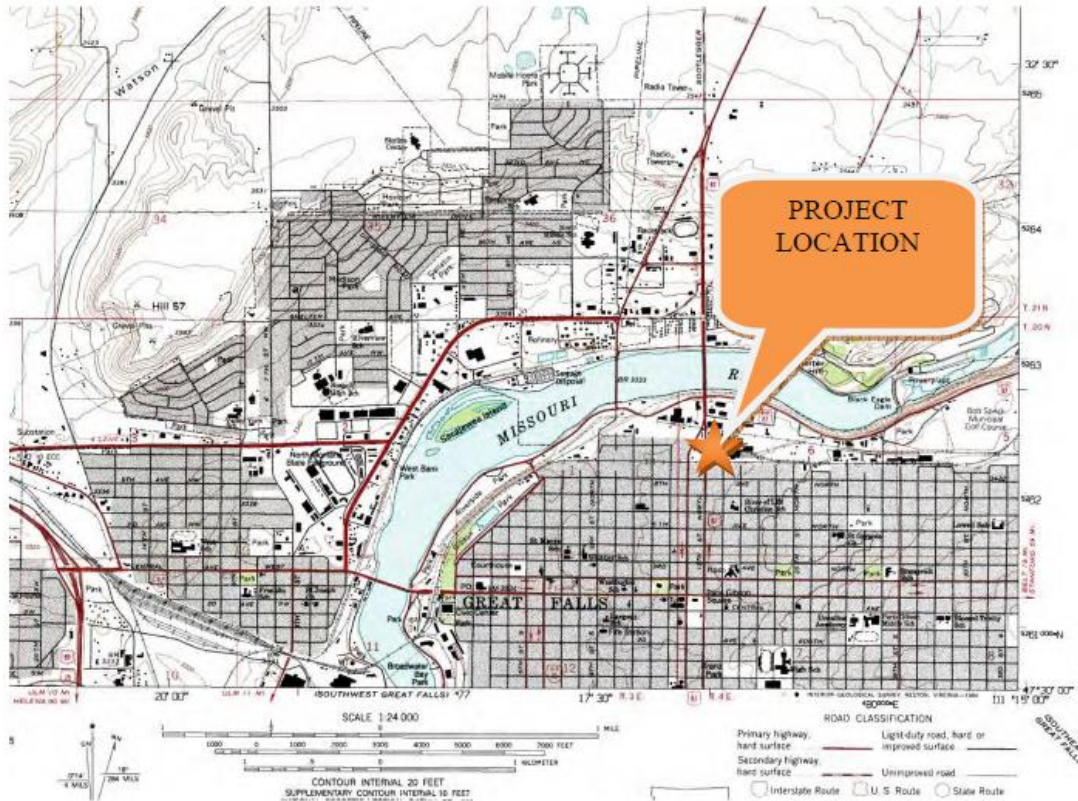
Joe Murphy, P.E. and Paxton Ellis, E.I.  
Big Sky Civil & Environmental, Inc.

# Kernaghan's Pik N Pump

- Release #397 opened December 1988
- Building demo/UST removal July 1989
- Soil excavation/removal 548 CY
- Release resolved/closed 1990
- Release 4005 opened March 2001
- Multiple phases of investigation and GWM

# Kernaghan's Service Inc.

- Release #607 opened February 1991
- Release resolved/closed July 1994
- Release 3400 opened April 1998
- Multiple phases of investigation & GWM
  
- Considered numerous alternative treatment technologies



**FIGURE 1 – VICINITY MAP**

**SCALE: 1" = 750'**

*Source: USGS Quadrangle Maps*

*15-Minute Series (Topographic)*

*“Great Falls, Montana”*

**TITLE:**

VICINITY MAP

**PROJECT:**

KERNAGHAN'S PIK & PUMP

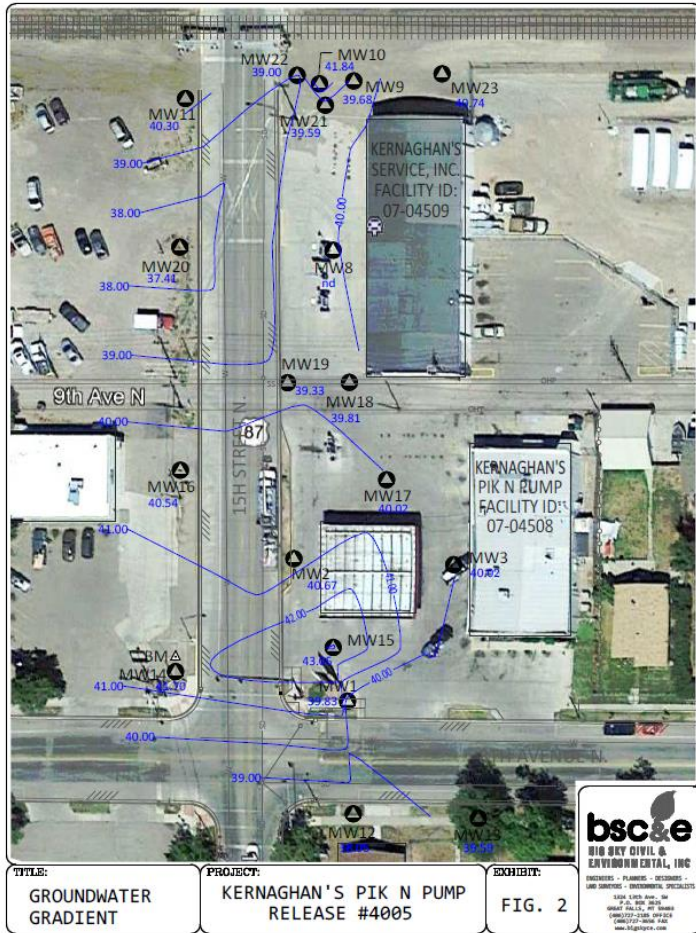
**bsc&e**  
BIG SKY CIVIL &  
ENVIRONMENTAL, INC

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LAND SURVEYORS - ENVIRONMENTAL SPECIALISTS  
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# HVDPE

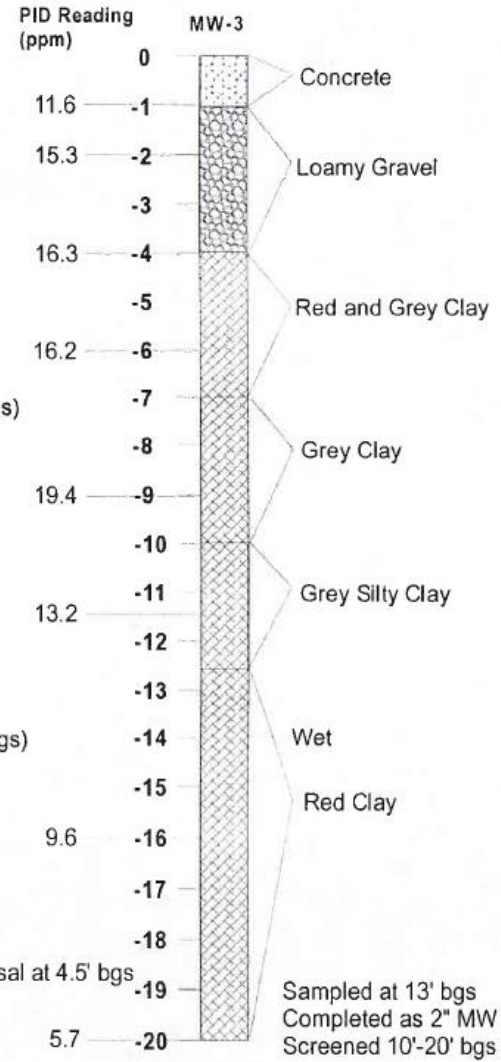
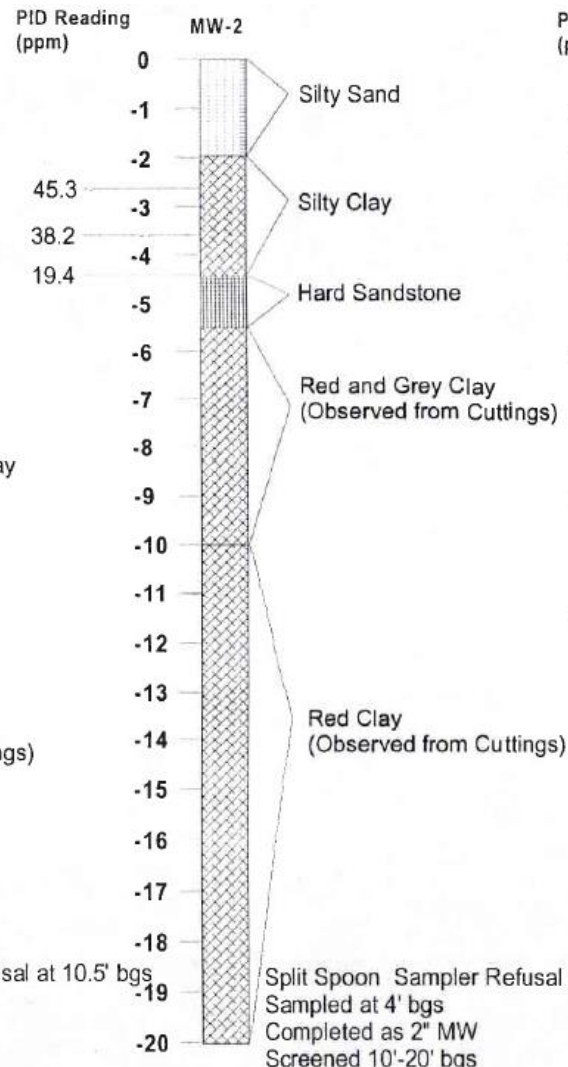
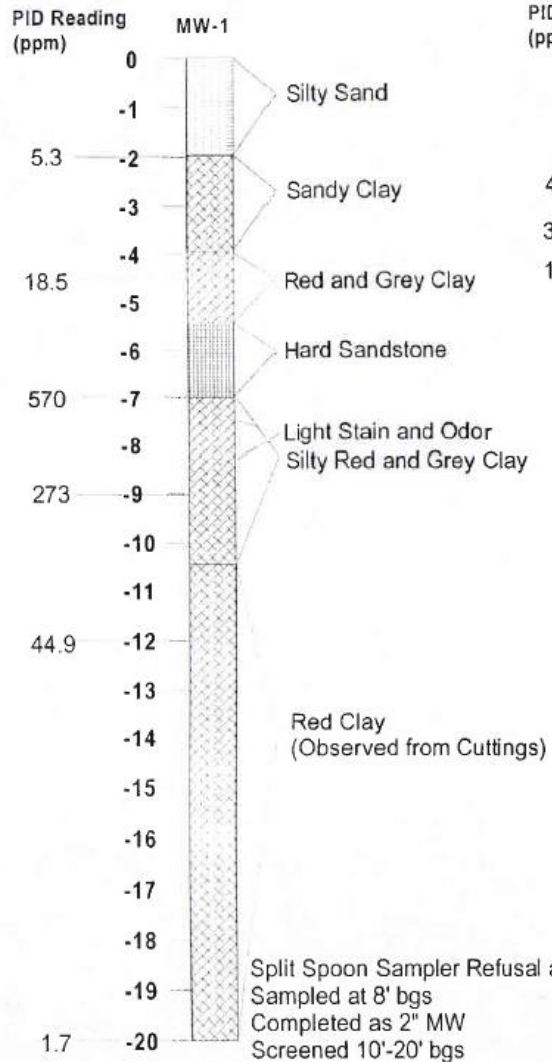
- Preparation for Extraction
- Well Installation
- Discharge Authorization
- Pilot Study and Extraction
- Methods and Procedures
- Results
- CalClean and GWM
- Future Event
- Scheduled Spring 2020

# Hydrogeology



**Table 2.1 - Groundwater Elevations - Kernaghan's Pik & Pump**

Sample ID	Date	Casing Elevation	Well Depth	Depth to Groundwater	GW Elevation	Free Product
MW-1	May 11	140.51	10.71	8.07	140.54	ND
	July 13			8.07	140.54	ND
	Nov 13			10.28	130.23	ND
	Dec 17			0.68	130.83	ND
MW-2	May 11	140.35	20.50	0.05	130.70	ND
	July 13			10.01	130.34	ND
	Nov 13			10.57	138.78	ND
	Dec 17			8.08	140.07	ND
MW-3	May 11	---	10.52	8.00	---	ND
	July 13	---		0.50	---	ND
	Nov 13	---		11.23	---	ND
	Dec 17	---		10.57	---	ND
MW-12	May 11	140.43	18.22	5.00	143.74	ND
	July 13			11.28	138.15	ND
	Nov 13			11.84	137.50	ND
	Dec 17			11.38	138.05	ND
MW-13	May 11	150.10	17.01	0.00	140.50	ND
	July 13			10.08	140.08	ND
	Nov 13			11.12	130.04	ND
	Dec 17			10.57	130.50	ND
MW-14	May 11	140.21	17.01	5.00	143.55	ND
	July 13			0.55	142.00	ND
	Nov 13			0.00	142.22	ND
	Dec 17			7.51	141.70	ND
MW-15	May 11	140.00	10.07	8.70	140.00	ND
	July 13			8.85	140.84	ND
	Nov 13			10.30	130.30	ND
	Dec 17			0.64	143.05	ND
MW-16	May 11	140.57	17.18	13.21	130.30	ND
	July 13			8.32	141.25	ND
	Nov 13			0.07	140.50	ND
	Dec 17			0.03	140.54	ND
MW-17	May 11	150.53	20.13	8.01	141.02	ND
	July 13			0.41	141.12	ND
	Nov 13			11.13	130.40	ND
	Dec 17			10.51	140.02	ND



**TITLE:**  
SOIL BORING LOGS - FEB '04

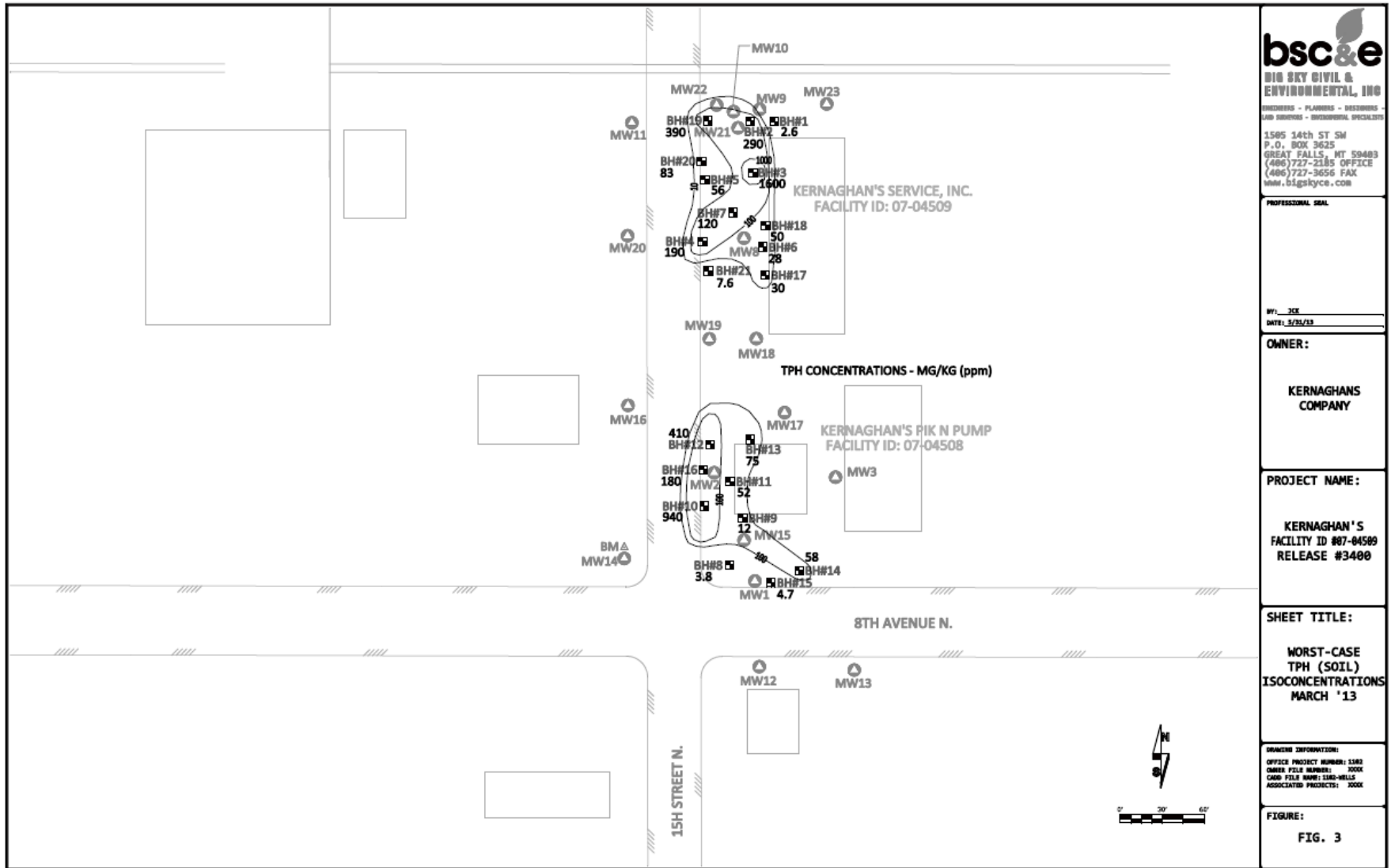
**PROJECT:**  
KERNAGHAN'S PIK & PUMP

**bsc&e**  
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# 2013 Soil Boring Investigation



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PROFESSIONAL SEAL

BY: JK  
DATE: 3/25/13

OWNER:  
KERNAGHAN'S COMPANY

PROJECT NAME:  
KERNAGHAN'S FACILITY ID 07-04509  
RELEASE #3400

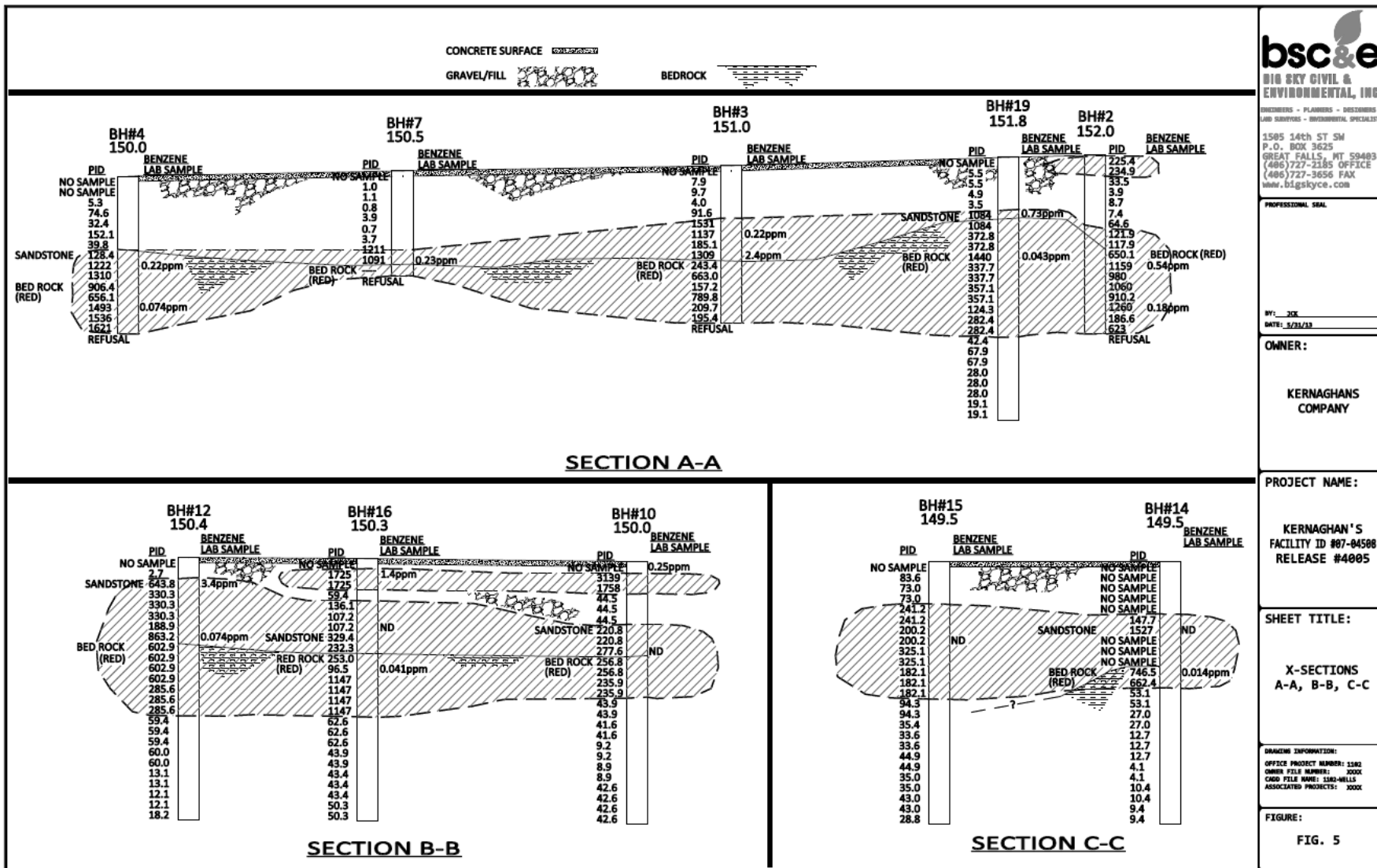
SHEET TITLE:  
WORST-CASE  
TPH (SOIL)  
ISOCONCENTRATIONS  
MARCH '13

DRAWING INFORMATION:  
OFFICE PROJECT NUMBER: 1582  
OWNER FILE NUMBER: 700K  
CADD FILE NAME: 1582-HELLO  
ASSOCIATED PRODUCTS: 700K

FIGURE:  
FIG. 3



# 2013 Soil Boring Cross Sections



**bsc&e**  
**BIG SKY CIVIL & ENVIRONMENTAL, INC**  
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PROFESSIONAL SEAL  
 BY: JOK  
 DATE: 5/21/13

OWNER:  
**KERNAGHAN'S COMPANY**

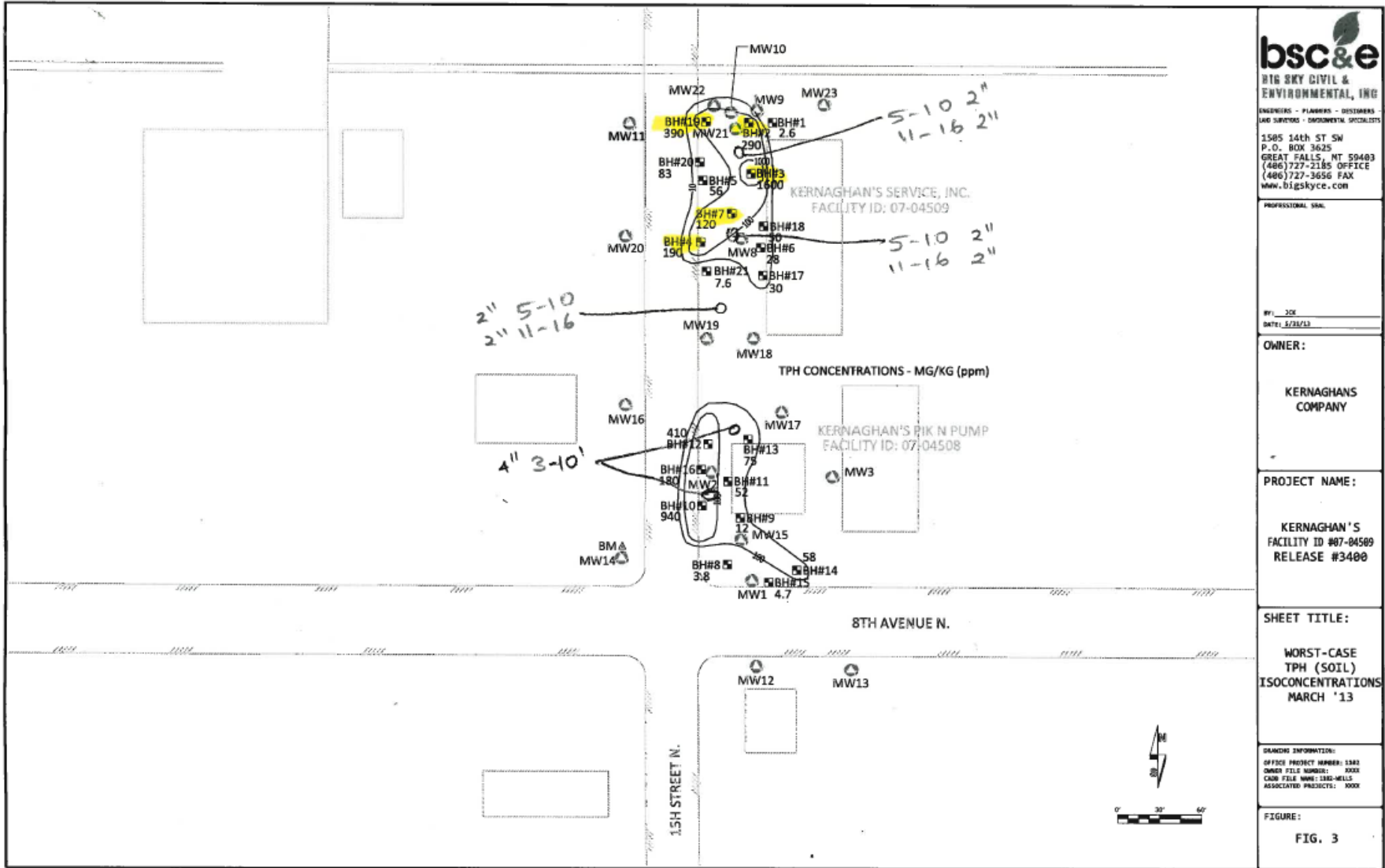
PROJECT NAME:  
**KERNAGHAN'S FACILITY ID #07-04508 RELEASE #4005**

SHEET TITLE:  
**X-SECTIONS A-A, B-B, C-C**

DRAWING INFORMATION:  
 OFFICE PROJECT NUMBER: 1502  
 OWNER FILE NUMBER: 1000  
 CAD FILE NAME: 1502-HELLS  
 ASSOCIATED PROJECTS: 1000

FIGURE:  
**FIG. 5**

# Monitoring Well Installation



**bsc&e**  
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PROFESSIONAL SEAL  
BY: JCK  
DATE: 3/28/13

OWNER:  
KERNAGHAN'S COMPANY

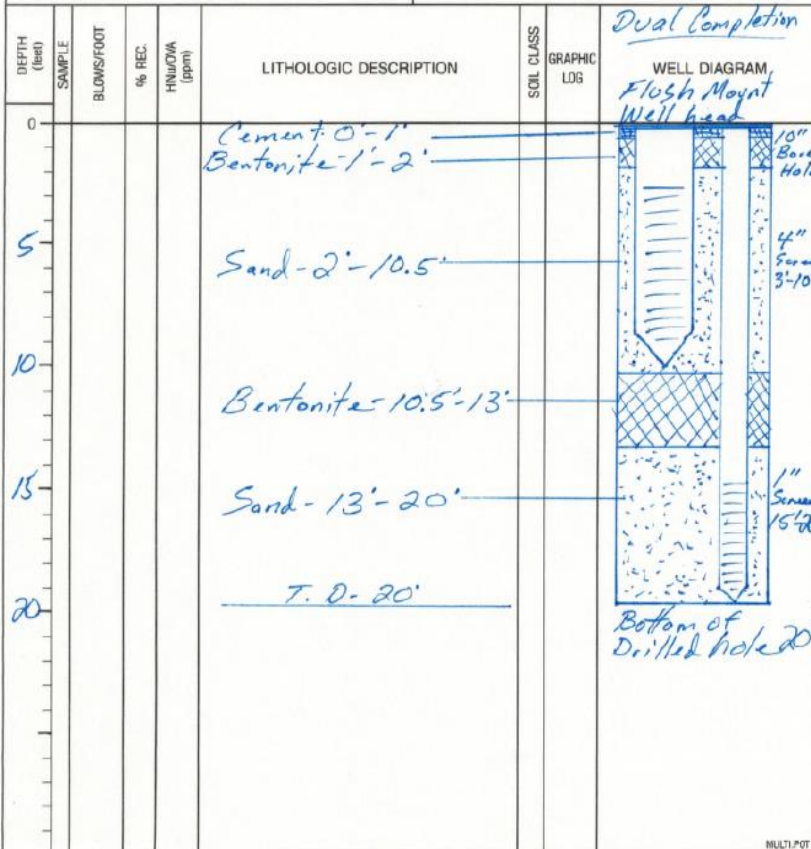
PROJECT NAME:  
KERNAGHAN'S FACILITY ID #07-04509  
RELEASE #3400

SHEET TITLE:  
WORST-CASE TPH (SOIL) ISOCONCENTRATIONS MARCH '13

DRAWING INFORMATION:  
OFFICE PROJECT NUMBER: 1382  
DRAW FILE NUMBER: 1382  
CAD FILE NAME: 1382-HELLS  
ASSOCIATED PROJECTS: 1382  
FIGURE:  
FIG. 3

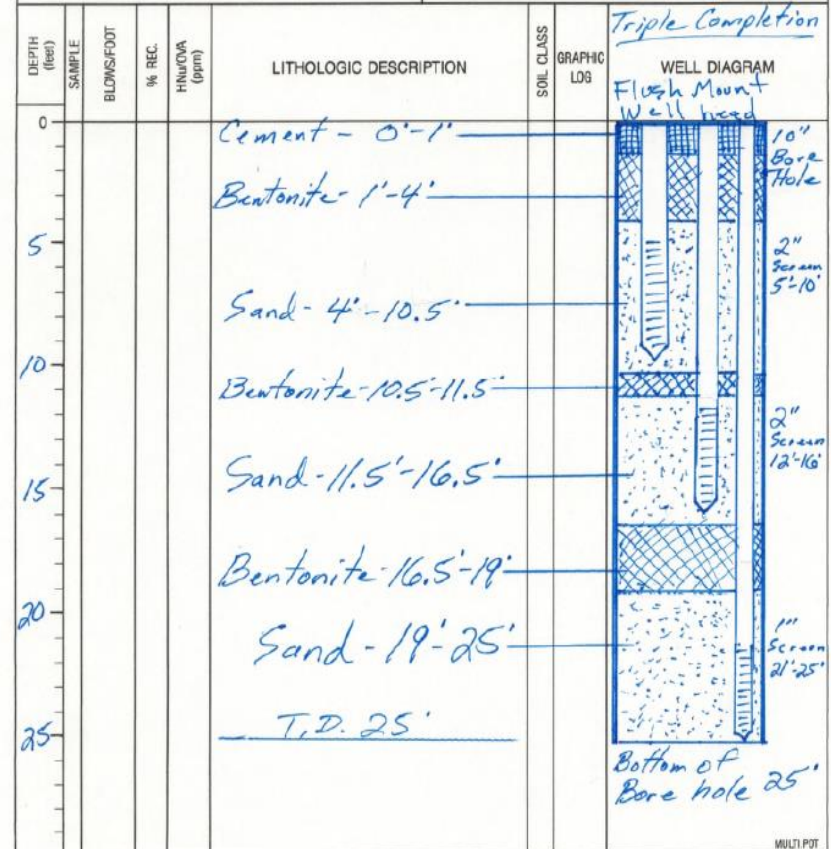
**BOLAND DRILLING COMPANY**  
SOIL BORING LOG AND WELL CONSTRUCTION RECORD

Client <u>Kernaghans P.K.-N-Pump</u>	Project I.D. _____	Page 1 of 1
Site _____	Well I.D. _____	
Boring I.D. _____	Date Installed _____	
Geologist/Engineer _____	Date Grouted _____	
Drilling Method _____	Casing Material _____	
Sampling Method _____	Screen Material _____	
Date Started _____	Casing Interval _____	
Date Completed _____	Screened Interval <u>1" - 15'-20" (4" - 3'-10")</u>	
Driller _____	Sump Installed? _____	
Borehole Diameter (in.) <u>10"</u>	Well Depth (ft) <u>(20')</u> , <u>(10')</u>	
Depth Drilled (ft) <u>20'</u>	TOC Elevation (ft) _____	
Ground Elevation (ft) _____	Water Level (ft) _____	
Depth to Water (ft) _____	Date Measured _____	
Date Measured _____		



**BOLAND DRILLING COMPANY**  
SOIL BORING LOG AND WELL CONSTRUCTION RECORD

Client <u>Kernaghans Service</u>	Project I.D. _____	Page 1 of 1
Site _____	Well I.D. _____	
Boring I.D. _____	Date Installed _____	
Geologist/Engineer _____	Date Grouted _____	
Drilling Method <u>Air Rotary</u>	Casing Material _____	
Sampling Method _____	Screen Material _____	
Date Started _____	Casing Interval _____	
Date Completed _____	Screened Interval <u>(5'-10') / (12'-16') / (21'-25') - 1"</u>	
Driller _____	Sump Installed? _____	
Borehole Diameter (in.) <u>10"</u>	Well Depth (ft) <u>(10')</u> , <u>(16')</u> , <u>(25')</u>	
Depth Drilled (ft) <u>25'</u>	TOC Elevation (ft) _____	
Ground Elevation (ft) _____	Water Level (ft) _____	
Depth to Water (ft) _____	Date Measured _____	
Date Measured _____		



Sanitary Sewer Main  
Manhole Locations



Sanitary Sewer Main Manhole  
Discharge Location



6. Discharge shall not exceed the following limitations

Client Sample ID: MW-2

Analyses	Result	Units	Qualifiers	RL
<b>METALS, TOTAL RECOVERABLE</b>				
Antimony	ND	ug/L		0.5
Arsenic	8	ug/L		1
Cadmium	0.22	ug/L		0.03
Chromium	ND	ug/L		10
Copper	188	ug/L		2
Lead	15.9	ug/L		0.3
Mercury	0.087	ug/L		0.005
Nickel	7	ug/L		2
Selenium	ND	ug/L		1
Silver	ND	ug/L		0.2
Thallium	ND	ug/L		0.2
Zinc	176	ug/L		8

Client Sample ID: MW-8

Analyses	Result	Units	Qualifiers	RL
<b>METALS, TOTAL RECOVERABLE</b>				
Antimony	ND	ug/L		0.5
Arsenic	39	ug/L		1
Cadmium	ND	ug/L		0.03
Chromium	ND	ug/L		10
Copper	ND	ug/L		2
Lead	5.2	ug/L		0.3
Mercury	0.009	ug/L		0.005
Nickel	ND	ug/L		2
Selenium	ND	ug/L		1
Silver	ND	ug/L		0.2
Thallium	ND	ug/L		0.2
Zinc	ND	ug/L		8

Parameter	Daily Maximum Discharge Limitation
Benzene	50 ug/L
Toluene	1,000 ug/L
Ethylbenzene	700 ug/L
Xylenes	10,000 ug/L
Naphthalene	100 ug/L
MTBE	60 ug/L
Acenaphthene	70 ug/L
Anthracene	2,100 ug/L
Benz(a)anthracene	5 ug/L
Benzo(a)pyrene	5 ug/L
Benzo(b)fluoranthene	5 ug/L
Benzo(k)fluoranthene	50 ug/L
Chrysene	100 ug/L
Dibenzo(a,h)anthracene	5 ug/L
Fluoranthene	40 ug/L
Indeno(1, 2, 3-cd)pyrene	5 ug/L
Pyrene	40 ug/L
1-Methylnaphthalene	22 ug/L
2-Methylnaphthalene	72 ug/L
Total Arsenic	0.0025 lb/day
Total Cadmium	3.51 mg/L
Total Chromium	5.92 mg/L
Total Copper	0.0035 lb/day
Total Lead	0.14 mg/L
Total Mercury	0.02 mg/L
Total Nickel	0.59 mg/L
Total Selenium	4.5 x 10 <sup>-5</sup> lb/day
Total Silver	0.62 mg/L
Total Zinc	2.13 mg/L
Total Sulfide	3608 mg/L

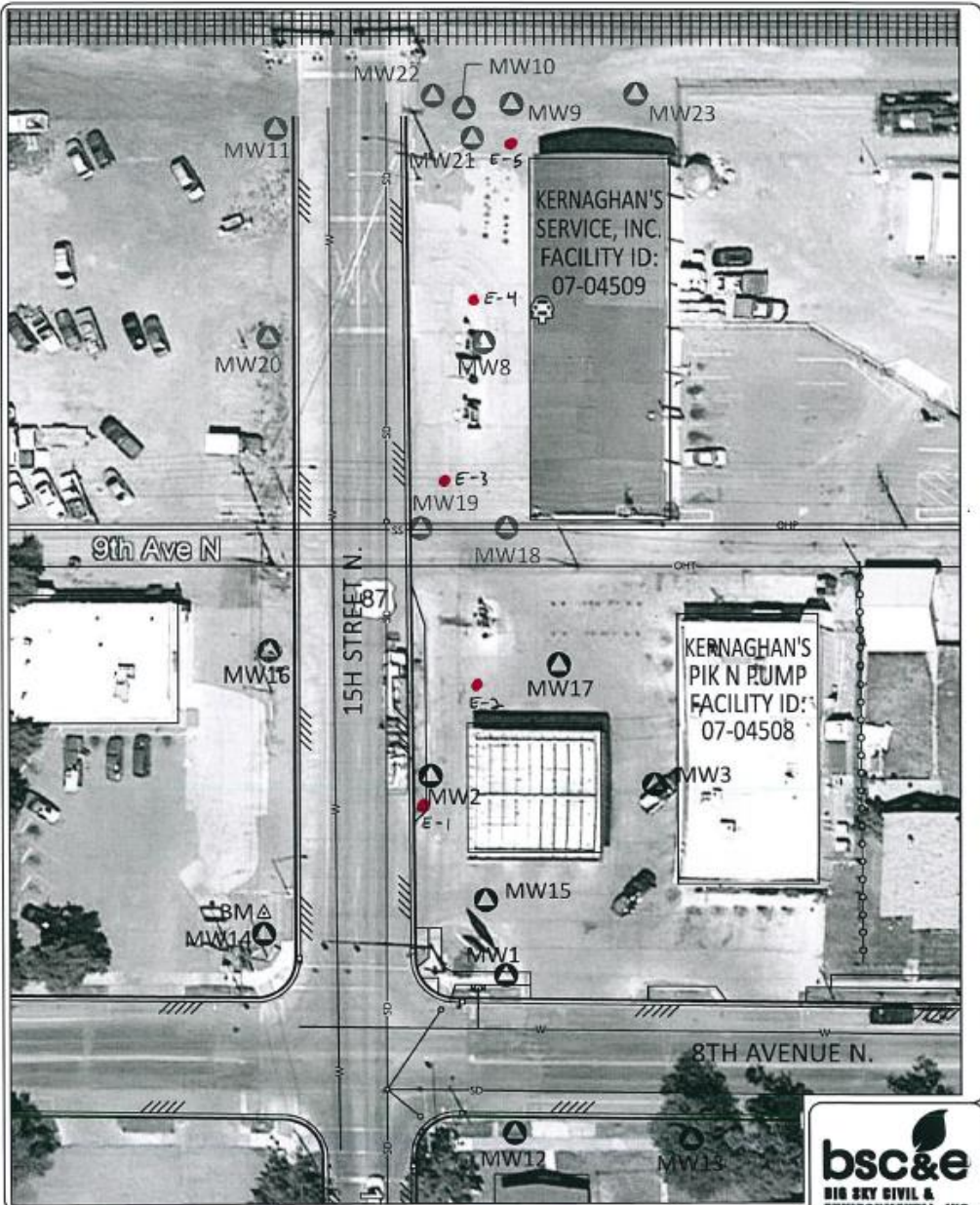
7. Discharge shall be monitored for flow daily and sampled for quality every two weeks. Samples shall be 24 hour composite samples consisting of a minimum of 4, flow paced aliquots. The samples shall be analyzed for the parameters listed in item 6 above using 40 CFR 136 methods and modified Massachusetts Methods for Volatile Petroleum Hydrocarbons and Extractable Petroleum Hydrocarbons.



# Selection of Extraction Wells

Well ID	Max Inlet Concentration (ppmv)	Start Time	Date
MW-17	16,500	15:20	3-Sep
MW-2	199	10:30	4-Sep
E-1	2,530	14:30	4-Sep
E-2	204	8:00	5-Sep
MW-15	788	13:20	5-Sep
MW-1	315	8:00	6-Sep
MW-3	4,700	10:00	6-Sep

# Observation Wells



HIGH VACUUM  SVE or  DPE      FIELD DATA SHEET


Project Location: 1507 8TH AVENUE N      City: GREAT FALLS, MT      Site #: KERNAGHAN'S PIK N PUMP      Date: 9/27/2019

Client: BIG SKY ENV.      Operator (s): *Severin*

CALCLEAN INC.  
(714) 938-2706  
Page 2 of 2

WELL SCREEN DTW (ft)	OBSERVATION WELLS																							
	MW-1		MW-19		MW-16		MW-12		MW-11		E-2		E-11		MW-15		MW-13							
	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)	Vacuum %40	DTW (ft)		
7-07																								
0800	0.00	9.52	0.00	10.05	0.00	8.89																		
1200							0.00	10.99	0.00	8.91	0.00	9.60			0.00	9.50	0.00	9.72	0.00	10.20				
1600																								
7-09																								
0800	0.00	9.55	0.00	10.05	0.00	9.01																		
1200							0.00	11.01	0.00	8.24	0.00	9.35												
1600																								
7-9																								
0800	0.00	9.55	0.00	10.05	0.00	9.02																		
1200							0.00	11.02	0.00	8.19	0.00	9.25			0.00	10.45	0.00	9.74	0.00	10.45				
1600																								
0800	0.00	9.50	0.00	10.52	0.00	8.79																		
1200							0.00	11.05	0.00	8.00	0.00	9.09			0.00	10.12	0.00	9.60	0.00	10.46				
1600																								
7-11																								
0800	0.00	9.06	0.00	10.50	0.00	9.50																		
1200							0.00	11.04	0.00	7.35	0.00	9.01			0.00	10.15	0.00	9.60	0.00	10.45				
1600																								

Comments:

TITLE: <b>SITE MAP</b>	PROJECT: <b>KERNAGHAN'S SERVICE RELEASE #3400</b>	EXHIBIT: <b>FIG. 1</b>	 <b>BIG SKY CIVIL &amp; ENVIRONMENTAL, INC</b> <small>ENGINEERS - PLUMBERS - DESIGNERS - LAB SERVICES - ENVIRONMENTAL SPECIALISTS</small> <small>1500 21ST AVE. SW P.O. BOX 3678 GREAT FALLS, MT 59403 (406) 727-2185 OFFICE (406) 727-2658 FAX www.bskenv.com</small>
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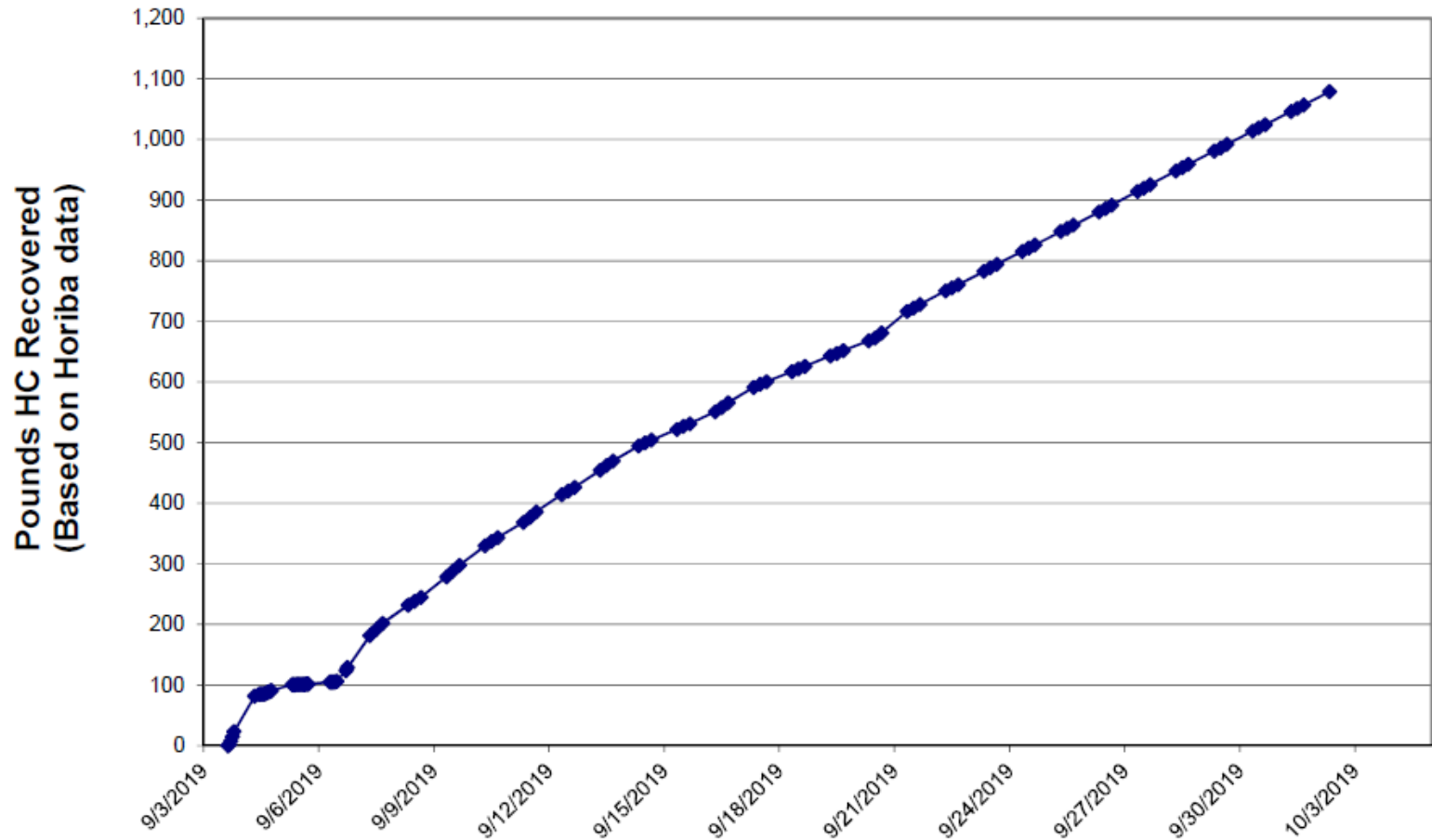
**BIG SKY CIVIL & ENVIRONMENTAL, INC**





**CalClean Inc.**

**Figure 4**  
**Cumulative HC Recovered Over 30 Days**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-10/3/19**

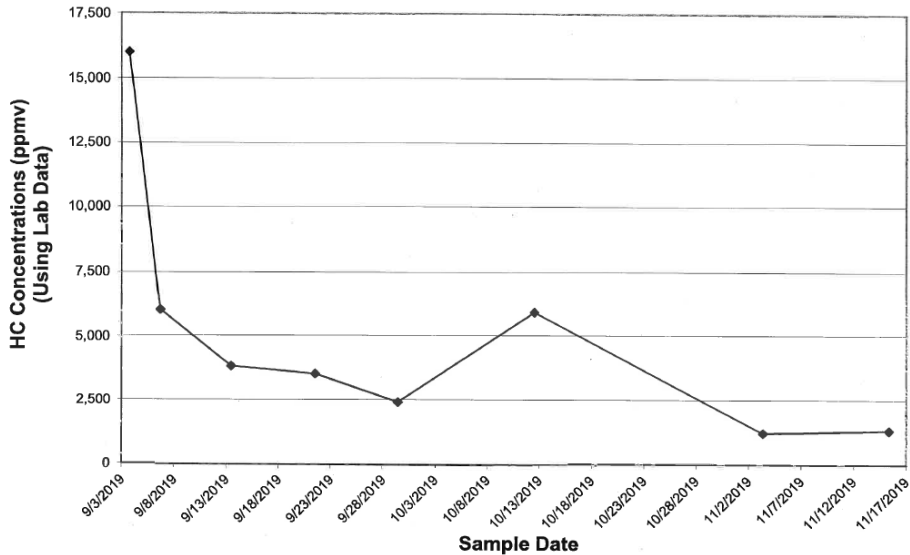


CalClean Inc.

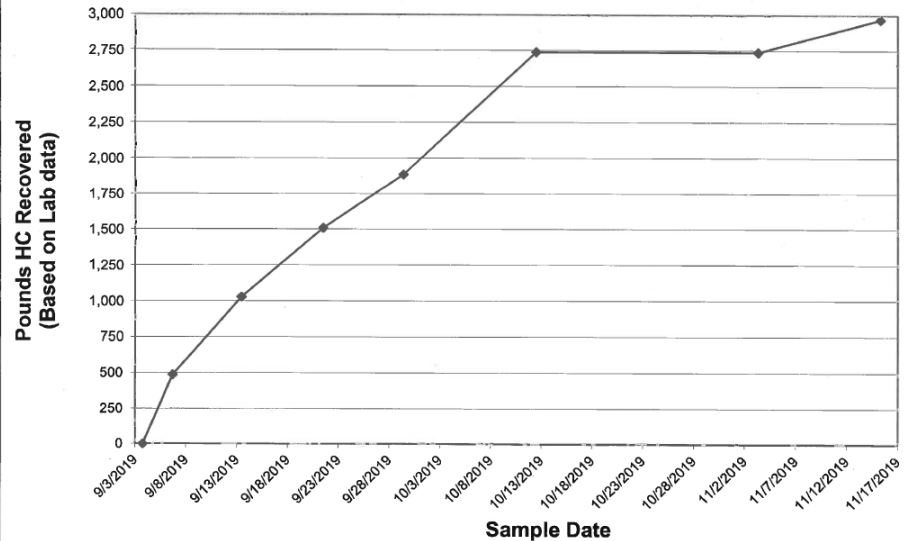
**Table 2**  
**HYDROCARBON MASS REMOVAL (Using Lab Data)**  
**Kernaghan's Pik N Pump, Great Falls, MT**

TIME	SYSTEM PARAMETERS			Hydrocarbon Recovery		
	Average System Vacuum (in of Hg)	Average Total System Inlet Flow (scfm)	Influent Concentrations* (ppmv)	(lbs)	(gal)	(Cumul. lbs)
9/3/2019 18:00	22	42	16,000	0.00	0.00	0.00
9/6/2019 16:40	21	50	6,000	486.84	77.92	486.84
9/13/2019 11:00	19	50	3,800	541.49	86.67	1,028.33
9/21/2019 12:00	20	50	3,500	479.55	76.76	1,507.88
9/29/2019 10:00	20	49	2,400	377.74	60.46	1,885.63
10/12/2019 12:00	20	47	5,900	851.60	136.31	2,737.23
11/3/2019 8:00	20	47	1,200	0.00	0.00	2,737.23
11/15/2019 8:00	20	47	1,300	230.37	36.87	2,967.59
<b>TOTAL HC RECOVERED* - LAB DATA</b>				<b>2,967.59</b>	<b>475.00</b>	
<b>TOTAL HC RECOVERED** - FIELD ANALYZER DATA</b>				<b>2,092.00</b>	<b>334.85</b>	
<b>Average HC Recovered*** (Field Analyzer/Lab Data)</b>				<b>2,529.80</b>	<b>404.93</b>	
<b>TOTAL GROUNDWATER EXTRACTED</b>					<b>63,791</b>	

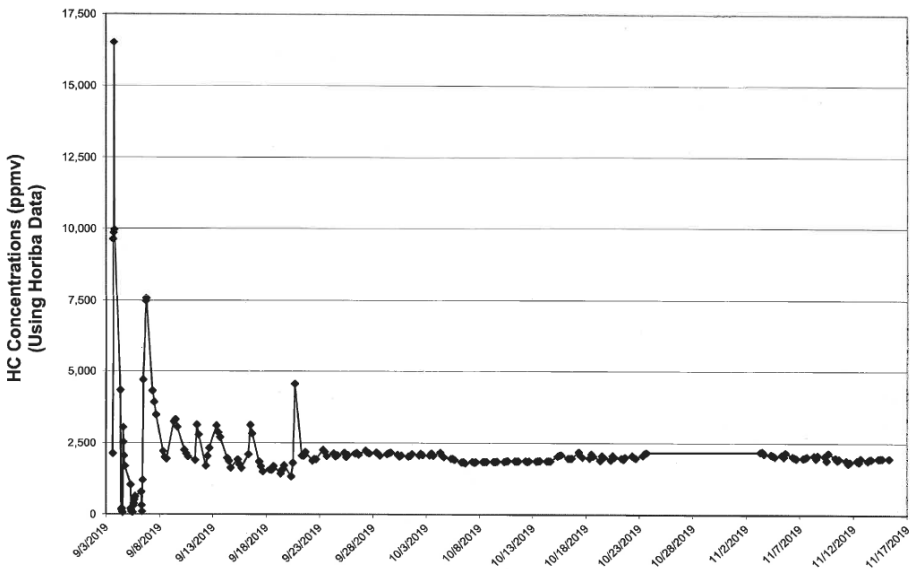
**Figure 1**  
**Total Inlet HC Concentrations vs Time (60 Days)**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-11/15/19**



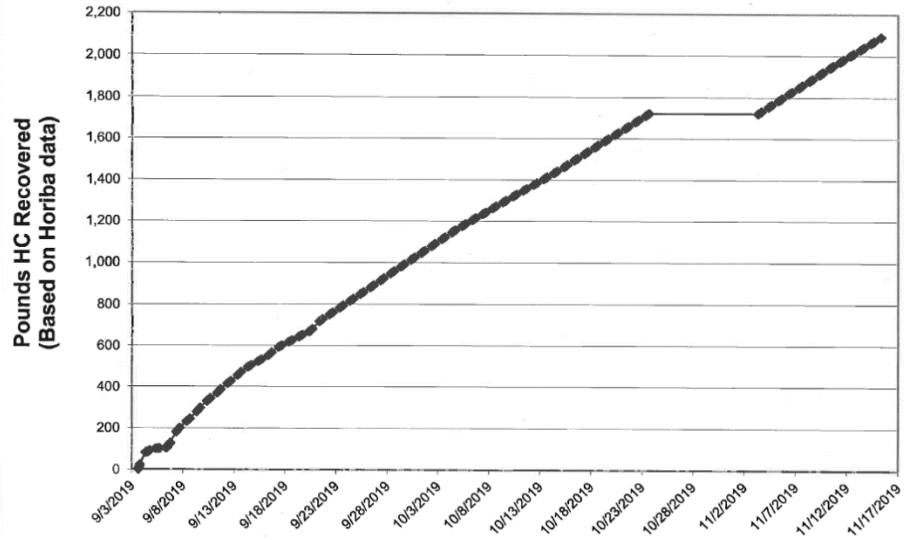
**Figure 2**  
**Cumulative HC Recovered Over 60 Days**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-11/15/19**



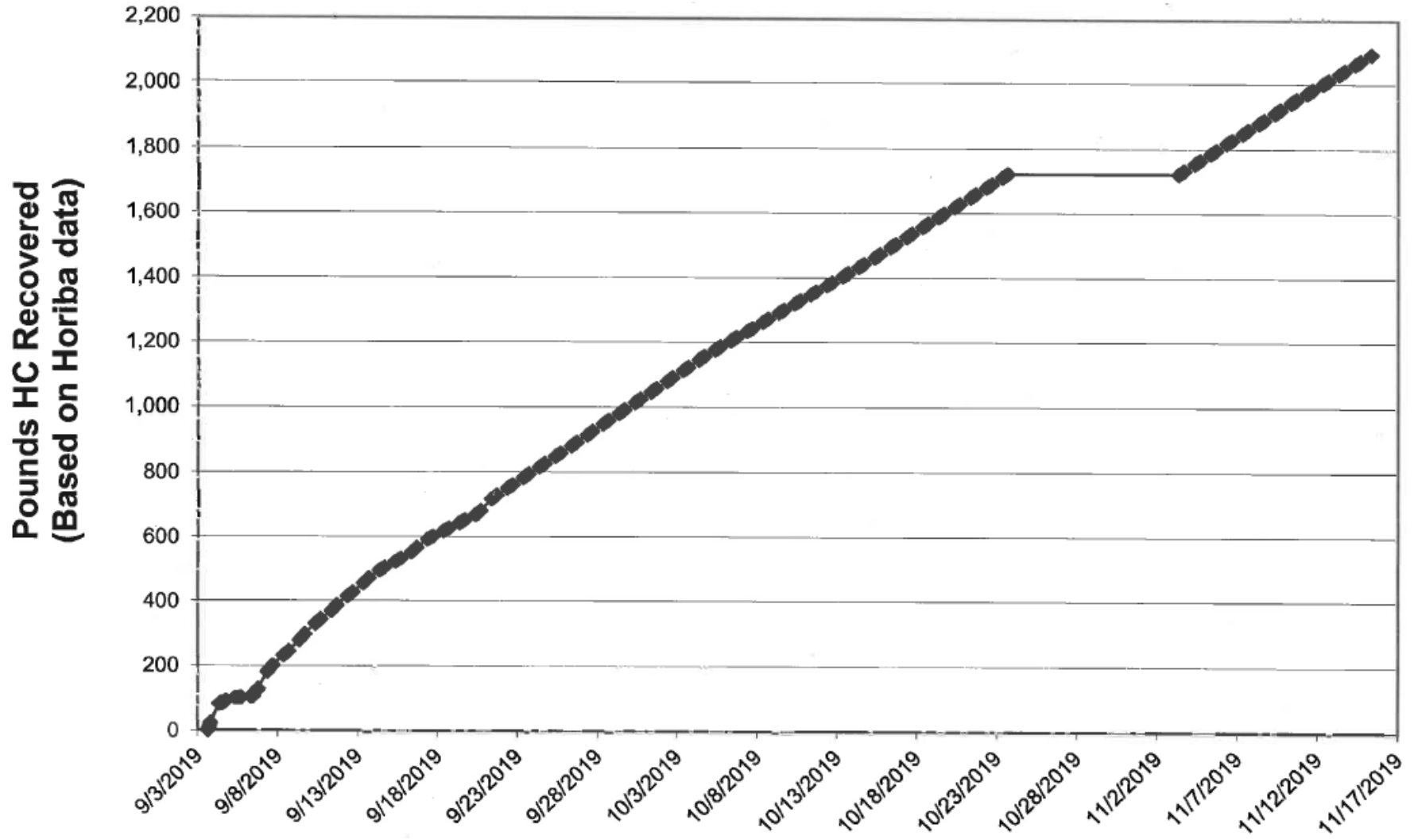
**Figure 3**  
**Total Inlet HC Concentrations vs Time (60 Days)**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-11/15/19**



**Figure 4**  
**Cumulative HC Recovered Over 60 Days**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-11/15/19**



**Figure 4**  
**Cumulative HC Recovered Over 60 Days**  
**Kernaghan's Pik N Pump, Great Falls, MT - 9/3-11/15/19**





# Authorization to Discharge

- Notice of Violation Letters
- Response Letters
- Spring Extraction Event
- All four (4) sampling events
- Due within five (5) business days
- On hold due to violations

**Table 3.1 - Historic Groundwater Analytical Results - Kernaghan's Pik & Pump**

Sample ID	Date	VPH												EPH				
		MTBE	Benzene	Toluene	Ethylbenzene	m+p-Xylenes	o-Xylenes	Total Xylenes	Naphthalene	C9-C10 Aromatics	C5-C8 Aliphatics	C9-C12 Aliphatics	TPH	EPH Screen	C9-C18 Aliphatics	C19-C36 Aliphatics	C11-C22 Aromatics	TEH
MW-1	Sept 11	46	1340	36.9	310	ND	ND	ND	ND	311	1550	ND	3380	2310	ND	ND	248	ND
	Nov 13	8	1800	7.7	220	ND	ND	---	12	500	2500	200	5600	4600	ND	ND	0.31	0.35
	Dec 17	11	190	3.4	66	7.9	ND	7.9	12	350	1100	500	1700	1300	ND	ND	130	180
	Aug 19	7.9	150	4.5	89	---	---	16	28	260 B	770	380 B	1100 B	1100	61	ND	58	120
	Nov 19	2.8	13	0.93	4.9	---	---	<1.0	2.9	27	150	50	200	ND	---	---	---	---
MW-2	Sept 11	1770	9110	5850	1780	4620	1730	6340	281	3700	12100	1840	34100	5730	ND	ND	855	861
	Nov 13	17	17000	17000	1400	7600	3300	---	280	4500	41000	2500	94000	17000	ND	ND	1.1	1.3
	Dec 17	1600	18000	18000	1900	7900	3400	---	360	5800	47000	28000	110000	10000	270	ND	870	1200
	Aug 19	230	16000	14000	1400	---	---	11000	350	4200 B	69000	9800 B	80000	9400	700	ND	400	1100
	Nov 19	210 H	16000 H	21000 H	3400 H	---	---	18000 H	660 H	12000 H	86000 HB	24000 HB	110000 HB	19000	2300	ND	1200	3400
MW-3	Sept 11	ND	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Nov 13	ND	0.83	ND	ND	ND	ND	---	ND	ND	ND	ND	ND	370	---	---	---	---
	Dec 17	ND	ND	ND	ND	ND	ND	ND	ND	23	ND	100	ND	ND	---	---	---	---
	Aug 19	<0.15	0.7	0.24 J	1.2	---	---	2.8	3.2	1.4 JB	29	1.4 JB	47 B	480	---	---	---	---
	Nov 19	0.5 J	2.1 H	11	4.7	---	---	0.52 JH	9.3	39	140	90	230	ND	---	---	---	---
MW-12	Sept 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Nov 13	ND	ND	ND	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	---	---	---	---
	Dec 17	ND	ND	ND	ND	ND	ND	---	ND	ND	ND	94	ND	ND	---	---	---	---
	Aug 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Nov 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-13	Sept 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Nov 13	ND	ND	ND	ND	ND	ND	---	ND	ND	ND	ND	ND	ND	---	---	---	---
	Dec 17	ND	ND	ND	ND	ND	ND	---	ND	23	ND	81	100	ND	---	---	---	---
	Aug 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Nov 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-14	Sept 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Nov 13	ND	1.4	3.3	0.49	2.7	0.74	---	ND	ND	ND	66	ND	ND	---	---	---	---
	Dec 17	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	92	ND	ND	---	---	---	---
	Aug 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Nov 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-15	Sept 11	ND	278	26.5	256	451	23.5	474	106	723	909	646	3500	1370	ND	ND	ND	ND
	Nov 13	20	430	23	120	130	18	---	53	530	830	200	2200	2300	ND	ND	0.29	0.51
	Dec 17	78	770	79	410	320	59	379	130	1300	4600	3300	7900	2400	340	ND	370	2400
	Aug 19	80	860	160	530	---	---	550	130	970 B	7900	1600 B	9500	4000	290	770	130	1200
	Nov 19	5.1	80	23	32	---	---	80	17	140	490	81	720	1500	140	370	49	560
MW-16	Sept 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Nov 13	ND	1.4	2.7	0.38	2.1	0.58	---	ND	ND	ND	62	ND	ND	---	---	---	---
	Dec 17	0.61	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	---	---	---
	Aug 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Nov 19	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
MW-17	Sept 11	ND	388	71.8	93.3	213	117	330	58.5	524	622	368	3490	ND	---	---	---	---
	Nov 13	9.0	650	13	22	30	7	---	33	340	1200	ND	2300	840	---	---	---	---
	Dec 17	30.0	2400	240	260	440	130	570	52	870	5800	1700	7500	1700	ND	ND	110	150
	Aug 19	44	2400	580	880	---	---	2000	94	2000 B	9700	1100 B	13000 B	8300	240	1300	180	1800
	Nov 19	2.6	300	110	100	---	---	320	20	300 B	1400	510	1900	2300	240	170	62	240
MT DEQ Tier 1 RBLS for Groundwater (May 2018)		30	5	1000	700	10000	10000	100	1100	650	1400	NE	1000*	1400	1000	1100	NE	

**Table 3.1 - Historic Groundwater Analytical Results - Kernaghan's Pik & Pump**

Sample ID	Date	VPH								
		MTBE	Benzene	Toluene	Ethylbenzene	Naphthalene	C9-C10 Aromatics	C5-C8 Aliphatics	C9-C12 Aliphatics	TPH
MW-1	Sept 11	46	1340	36.9	310	ND	311	1550	ND	3380
	Nov 13	8	1800	7.7	220	12	500	2500	200	5600
	Dec 17	11	190	3.4	66	12	350	1100	590	1700
	Aug 19	7.9	150	4.5	89	28	260 B	770	380 B	1100 B
	Nov 19	2.8	13	0.93	4.9	2.9	27	150	50	200
MW-2	Sept 11	1770	9110	5850	1780	281	3700	12100	1840	34100
	Nov 13	17	17000	17000	1400	280	4500	41000	2500	94000
	Dec 17	1600	18000	18000	1900	360	5800	47000	28000	110000
	Aug 19	230	16000	14000	1400	350	4200 B	69000	9800 B	80000
	Nov 19	210 H	16000 H	21000 H	3400 H	660 H	12000 H	86000 HB	24000 HB	110000 HB
MW-15	Sept 11	ND	278	26.5	256	106	723	909	646	3500
	Nov 13	20	430	23	120	53	530	830	200	2200
	Dec 17	78	770	79	410	130	1300	4600	3300	7900
	Aug 19	89	860	160	530	130	970 B	7900	1600 B	9500
	Nov 19	5.1	80	23	32	17	140	490	81	720
MW-17	Sept 11	ND	388	71.8	93.3	58.5	524	622	368	3490
	Nov 13	9.0	650	13	22	33	340	1200	ND	2300
	Dec 17	30.0	2400	240	260	52	870	5800	1700	7500
	Aug 19	44	2400	580	880	94	2000 B	9700	1100 B	13000 B
	Nov 19	2.6	300	110	100	20	300 B	1400	510	1900
MT DEQ Tier 1 RBSLs for Groundwater (May 2018)		30	5	1000	700	100	1100	650	1400	NE

All units: ppb - parts per billion

ND - Non-detectable Concentrations

Shading indicates an exceedence of MDEQ RBSL or HHS



# High Vacuum Dual Phase Extraction

- Considerations
  - Monitoring Well Construction vs Lithology
  - Extraction Equipment Location
  - Groundwater Disposal
    - Sanitary Sewer Manhole
    - COGF POTW
- Pilot Study
  - Extraction Well Selection
  - Event length
  - Groundwater Monitoring

# Questions?