Insitu Flushing
Gold Crew Release (GC-165)
Rocky Mountain Oil Test Center (RMOTC)
BP/Amoco Treatability Testing
May 2003

Insitu Treatability Testing: Rocky Mountain Oil Test Center (RMOTC)

Gold Crew Release (165) was tested for efficacy for use on a major soil-flushing project. The site's profile characteristic includes groundwater at 12 to 15 feet, smear zone 2 to 5 feet from groundwater with up to 3 foot of free-floating product on top of groundwater.

A test procedure was developed to determine the product's efficacy in releasing the entrained contaminant in the smear and capillary zone while reducing the total TPH in the soil. The entire protocol can be found in Experimental Procedure B.

In setting up the procedure it was determined to construct the model to mimic the site conditions. Tanks were set up with 4 inches of water on the bottom of each tank. A pre assembled bridge device was placed inside each tank to suspend the soil above the groundwater allowing the soil to come into contact with the groundwater. A fine layer of gravel was placed on top of the bridging material and 8 inches of soil removed from the site was placed in each tank. One tank utilized only water as a control while the other tank utilized a 2% solution of Gold Crew Release (165)

The injection flow rate was established to reproduce retention and flow rates experienced on the site. The solution tanks were pumping at the rate of 20-23ml/minute allowing a 1 to 2 day retention time. Total daily volume of 8.8 gallons was sustained to assure this rate and retention time was maintained. Flow rates can be seen in the table below. The HRT (hydraulic retention time) is the average flow rate measured by the volume pumped from each tank.

Table 1

Soil Volume	Flow (CM^3/min)	HRT	HRT (hours)	HRT (days)
Control				
IN - 33,406.06	**11.08**	**3014.98**	**50.24**	**2.09**
OUT- 33,406.06	**13.33**	**2506.08**	**41.76**	**1.74**
Gold Crew				
IN - 33,406.06	**12.33**	**2709.33**	**45.15**	**1.88**
OUT- 33,406.06	**14.46**	**2310.23**	**38.50**	**1.60**

The second set of HRT is based on the average flow rate measured by the volume of liquid discharged into the receiving drum. The retention time held consistent at 1 to 2 days while the test vessels were completely saturated (approximately 7 gallons) which represents pore volume.

Testing
Testing included sampling events on day 1, 15 & 22.

Testing included:

a. TPH-DRO, 8015 modified - 6
b. BTEX, 8260 - 6
c. Trimethylbenzene-1,2,4 - 6
d. Benzene - 6
e. Soil particle size – 2

Results
Complete results can be seen in attachment B.
The results are broken down into two matrixes, soil & water. The soil was measured as to the total removal of contaminant. This could include flushing or biodegradation or both. The water matrix was measured to quantify contaminant removal from flush action only.

Discussion
Review of the results indicates an effective removal of contaminant from the soil matrix. The reduction of overall contamination averages a 97% reduction in a 30-day period. There were some instances of increased volume of specific contaminants. This can be attributed to the flushing of contaminant to the specific point of sampling. Since there are no bacteria in the Gold Crew Release (165), the specific degraders may not have had time to acclimate and establish quantifiable mass to effectively remove the target contaminant.

Attachment B

	Baseline Sampling Event 3/25/03			Mid-test Sampling Event 4/3/03		Final Sampling Event 4/17/03		
Matrix: Soil								
Parameter	**Results**	**Units**	**Report Limit**	**Results**	**% Change**	**Results**	**% Change Mid-test**	**% Change Overall**
GC Semivolatiles								
Total Extractable Hydrocarbons OA2								
Disel Fuel	2900	mg/kg	11	690	76.21	210	69.57	92.76
n-Tetracosane (S)	102	%	11	105	(2.94)	128	(21.90)	(25.49)
p-Terphenyl (S)	97	%	11	103	(6.19)	146	(41.75)	(50.52)
Organics Prep								
% Moisture								
Method: SM 2540G								
% Moisture	6.20	%	NA	4.40	29.03	5.60	(27.27)	9.68
GS/MS Volatiles								
GC/MS VOCs in Soil by 8260								
Method: EPA 8260								
1,2,4-Trimethylbenzene	180000	ug/kg	6700	23000	87.22	5	99.98	100.00
1,3,5-Trimethylbenzene	21000	ug/kg	670	4000	80.95	19	99.53	99.91
Ethylbenzene	40000	ug/kg	6700	5100	87.25	5	99.90	99.99
Isoproprylbenzene (Cumene)	9200	ug/kg	670	1600	82.61	5	99.68	99.94
m&p xylene	40000	ug/kg	670	6000	85.00	5	99.91	99.99
Napthalene	32000	ug/kg	13000	2700	91.56	11	99.60	99.97
n-Butylbenzene	23000	ug/kg	670	3900	83.04	5	99.87	99.98
n-Propylbenzene	39000	ug/kg	6700	5200	86.67	5	99.90	99.99
p-Isopropyltoluene	4000	ug/kg	670	770	80.75	5	99.32	99.87
sec-Butylbenzene	7000	ug/kg	670	1400	80.00	5	99.63	99.93
Xylene (Total)	41000	ug/kg	690	6000	85.37	5	99.91	99.99
Dibromofluormethane (S)	95	%	NA	96	(1.05)	97	(1.04)	(2.11)
Toluene-d8 (S)	96	%	NA	95	1.04	92	3.16	4.17
4-Bromofluorobenzene (S)	87	%	NA	93	(6.90)	87	6.45	0.00
1,2-Dichloroethane-d4 (S)	110	%	NA	97.00	11.82	99	(2.06)	10.00
				Mid-test Sampling Event 4/3/03		Final Sampling Event 4/17/03		
Matrix: Water								
Parameter				**Results**	**Units**	**Results**	**Units**	**% Change Overall**
GC Semivolatiles								
Total Extractable Hydrocarbons OA2								
Disel Fuel				79.00	mg/l	130.00	mg/l	(64.56)
Total Petroleum Hydrocarbons				590.00	mg/l	0.00	mg/l	100.00
n-Tetracosane (S)				124.00	%	74.00	%	40.32
p-Terphenyl (S)				128.00	%	63.00	%	50.78
Organics Prep								
% Moisture								
Method: SM 2540G								
% Moisture				NA	%	NA	%	NA
GS/MS Volatiles								
GC/MS VOCs in Soil by 8260								
Method: EPA 8260								
1,2,4-Trimethylbenzene		ug/l	5.00	13000.00		1500.00	ug/l	88.46
1,3,5-Trimethylbenzene		ug/l	5.00	1800.00		740.00	ug/l	58.89
Benzene		ug/l	5.00	190.00		24.90	ug/l	86.89
Ethylbenzene		ug/l	5.00	1700.00		24.90	ug/l	98.54

Materials

2-Long 40-gallon treatment tank (48”x12”x16”)
mesh screen
2-variable speed pumps (low pressure/high volume)
Glass sample jars (provided by the laboratory)
250 milliliter glass jars (provided by the laboratory)
Measuring beakers
Digital timer
Thermometer
2-Collection drums
Soil sampler
Water sampler (bailer)
Notebook
Vendor product
Potable water (enough volume to achieve 2” depth per tank)
BP Amoco contaminated soil (enough volume to achieve 12” per tank)
Electrical source to support 220 volts (3-phase) with breaker protection.

Experimental Method

Pre-Test Procedure

1. Perform bulk density test on soil to determine percent sand and percent clay values, and soil porosity.
2. Pretreat potable water with vendor product according to procedure provided by individual vendor prior to introducing to treatment tank.
3. Using a soil sampler, pull composite samples of contaminated soil from control tank and treatment tank(s). Homogenize soil and fill sample containers. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1,
    b. Diesel Range Organics, EPA Method 8015 Modified.
    c. BTEX, EPA Method 8260B,
    d. Benzene,
    e. Trimethlybenzene Method E524.2
    f. soil particle size analysis.

Tank Set-up Procedure

Prepare two tanks. One tank is control set; the second tank is test set.

1. Place volume of water in bottom of each tank to achieve a 4” water depth.
2. Place pre-assembled bridge device inside of each tank to suspend soil above groundwater. Allow soil and water contact.
3. Place fine layer of gravel on top of bridging screen material in each tank.
4. Place 8” of soil mixture in each tank.
5. Allow soil-filled tanks to reach ambient room temperature.

Water Injection Set-up Procedure

The steps below describe assembly of the water injection system for the control system and test system. Only potable water will be introduced to the control tank. A solution of potable water and vendor product will be introduced to the treatment tank.

1. Place one drum of potable water on the side of the control tank by which the influent will be introduced to the tank.
2. Place one drum of vendor solution on the side of the test tank by which the influent will be introduced to the test tank.
3. Run outlet tubing into collection drum for test tank. Repeat this step for control tank.
4. Using a digital timer and a beaker marked in milliliter increments, pump water from the influent drum into the beaker for one minute. Using this information calculate the hourly volume rate. Adjust the pump speed as necessary. Repeat this step for the test tank.

Control Tank Operation and Data Collection Procedure (21 days)

The steps below describe flow rates, leachate collection procedures, and sampling procedures relating to the operation of the control tank.

Daily

1. Record pump rates in hourly increments for control tank.
2. Record hourly rate and cumulative rate of leachate collected from each tank.

Mid-Test Sampling Procedure (day 15)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drum. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
   a. Total Petroleum Hydrocarbon EPA Method 418.1
   b. Diesel Range Organics, EPA Method 8015 Modified
   c. BTEX, EPA Method 8260
   d. Benzene
   e. Trimethlybenzene, Method E524.2
2. Using a soil sampler, pull composite samples of soil from the control tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
   a. Total Petroleum Hydrocarbon EPA Method 418.1
   b. Diesel Range Organics, EPA Method 8015 Modified
   c. BTEX, EPA Method 8260
   d. Benzene
   e. Trimethlybenzene, Method E524.2
   f. soil particle size analysis.

Post-Test Sampling Procedure (day 22)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1,
    b. Diesel Range Organics, EPA Method 8015 Modified.,
    c. BTEX, EPA Method 8260,
    d. Benzene,
    e. Trimethlybenzene
2. Using a soil sampler, pull composite samples of soil from the control tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
    f. soil particle size analysis.

Test Tank Operation and Data Collection Procedure (21 days)

The steps below describe flow rates, leachate collection procedures, and sampling procedures relating to the operation of the test tank.

Daily

1. Pump vendor product solution at a rate of _____gal/hr (ml/min) water to test tank.
2. Record pump rates in hourly increments for control tank.
3. Record hourly rate and cumulative rate of leachate collected from each tank.

Mid-Test Sampling Procedure (day 15)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
2. Using a soil sampler, pull composite samples of soil from the test tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.5
    f. soil particle size analysis.

Post-Test Sampling Procedure (day 22)

1. Using a water bailer, collect six (6) bailer volumes from the leachate collection drums. Homogenize liquid and fill appropriate sample containers for mid-treatment water analyses. Samples will be analyzed for:
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
2. Using a soil sampler, pull composite samples of soil from the test tank. Homogenize this soil and fill sample containers. Samples will be analyzed for
    a. Total Petroleum Hydrocarbon EPA Method 418.1
    b. Diesel Range Organics, EPA Method 8015 Modified
    c. BTEX, EPA Method 8260
    d. Benzene
    e. Trimethlybenzene, Method E524.2
    f. soil particle size analysis.