Remediation of 25,000 Pounds of Hydrocarbons in One Month

1991 Aerial Photograph of Halliburton Geophysical Services (HGS) Pad in Prudhoe Bay, Alaska

INTRODUCTION

Pre-construction view of HGS pad

From October 1989 to August 1999, ***Halliburton*** of Houston, Texas made several attempts to characterize and remediate petroleum hydrocarbon contaminated soil and water within a 9 acre man-made gravel pad in Prudhoe Bay, Alaska. On September 16, 1999, **URS** conducted a site-wide characterization of diesel range organics (DRO) and benzene soil contamination at the gravel pad/tundra interface. A total of 53 test pits were excavated and field screened. Thirteen soil samples were collected for chemical analysis. Based on the analytical results, six areas of the pad totaling approximately 7,400 cubic yards were estimated to be contaminated above Alaska Department of Environmental Conservation (ADEC) cleanup levels. The highest concentrations of DRO contamination were reported in the center of the pad. Approximately 900 cubic yards of benzene contaminated soil with concentrations as high as 37 milligrams per kilogram (mg/Kg) were identified in the northeast portion of the gravel pad. In early 2000, the site was accepted into ADEC's Voluntary Cleanup Program. At that time, ADEC designated a 200 mg/Kg DRO cleanup level for the site based on the presence of benzene in soil. **URS** prepared a Cleanup/Corrective Action Plan to remediate the DRO contaminated soil by in-situ bioremediation/landfarming. The intra-pad water was to be remediated by dewatering and bioremediation.

Mitigation measures in place along perimeter of pad

During July 2000, **URS** and its subcontractor constructed six biocells with french-drain catch basins to remediate the soil and remove the intra-pad water for treatment in temporary holding tanks. The biocells were designed to treat the lower 3 feet of the pad with proprietary enzymes and nutrient inoculations and tilling in place. Prior to beginning the remediation activities, baseline sampling of the biocells and surrounding tundra ponds were conducted by **URS**. The benzene contaminated soil in the northeast portion of the pad was removed by excavation and thermally treated. Following the removal of the benzene contaminated soil, ADEC revised the site-specific DRO cleanup level to 500 mg/Kg.

On July 24, 2000, in-situ bioremediation landfarming utilizing ***Enzyme Technologies, Inc. (ETEC)*** proprietary enzyme and nutrient enchancers began at the site. Simultaneous with landfarming activities, **URS** removed approximately 63,000 gallons of hydrocarbon contaminated water from the catch basins and placed it in temporary holding tanks equipped with low flow aeration manifolds.

French drain and catch basin construction

The water in the holding tanks was sampled then treated with the same ***ETEC*** products used on the biocells. After two-days of aeration and treatment, the water within the tanks was sampled a second time to evaluate degradation rates of contaminants. The results showed non-detect concentrations of benzene, toluene, ethylbenzene, xylenes (BTEX) and polynuclear aromatic hydrocarbons (PAHs) compounds. The water was then used in the biocells to maintain moisture levels.

The biocells were tilled with a tractor developed by ***ETEC***. The biocells were tilled daily the first week, then three times a week during the second, third, and fourth weeks of landfarming. After 30 days of biocell landfarming, **URS** collected confirmation samples to determine the degradation rates of contaminants in the soil. The biocells were backfilled and the site was returned to its original appearance on September 2, 2000. After 30 days of in-situ landfarming, DRO concentrations had decreased from a high of 2,600 mg/Kg to below the 500 mg/Kg site-specific cleanup level.

Benzene contaminated soil excavation

On September 14, 2000, ADEC informed ***Halliburton*** that no further remedial action was required at this site.

Halliburton Company

IN-SITU LANDFARMING: A COST EFFECTIVE SOLUTION

In January 2000, **URS** conducted a remedial alternatives cost analysis for the petroleum hydrocarbon contaminated soil at the former ***Halliburton*** HGS pad site. Five alternatives were considered: excavation and thermal treatment; site encapsulation; soil venting; ex-situ landfarming, and in-situ landfarming.

ETEC tractor tilling Biocell No. 3

URS estimated approximately 7,400 cubic yards of soil within the HGS pad was contaminated above ADEC cleanup levels. The contamination was within the lower 3 feet of the pad which also had sunk approximately 1 foot into the underlying tundra. The thermal treatment option included stripping off the top three feet of clean gravel (overburden) and excavating and transporting the contaminated soil to an off-site treatment facility 2 miles away. Treated soil would be returned to the site. The time required to conduct the thermal treatment was 3 months. The encapsulation option included construction costs to place a 20-mil HDPE liner and leave the contamination in place. Monitoring of the surrounding surface waters would have been necessary for a period of 2 to 3 years. However, this option would not allow use of the pad, and the contamination would remain a liability for the foreseeable future.

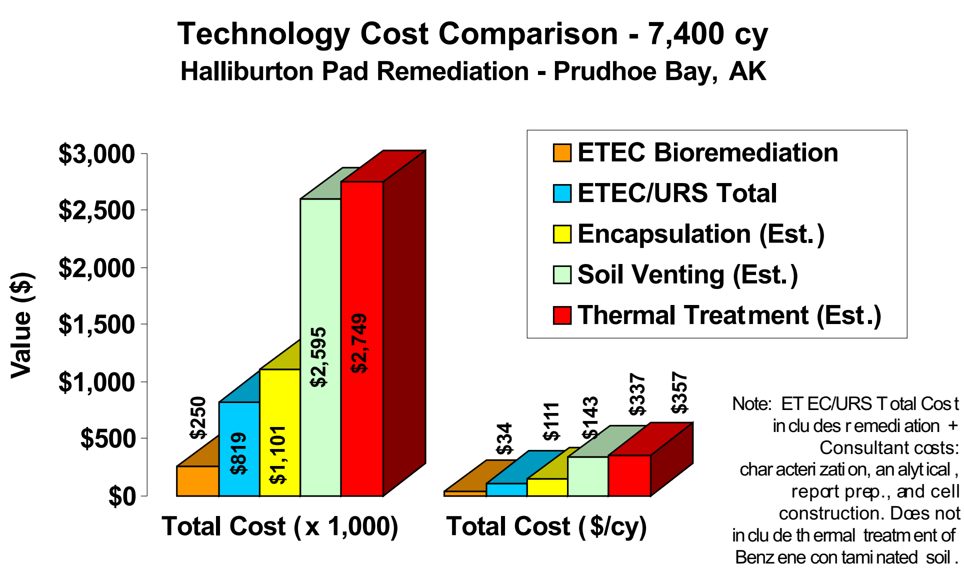
The soil venting option included construction of a treatment system and 2 to 3 years of operation, maintenance, and sampling. The fourth option was ex-situ landfarming. This option would include stripping off the overburden and building off-site treatment cells. The cells would be dismantled at the conclusion of the estimated 2 year treatment period. The fifth option was in-situ landfarming using bioremediation. This option would include stripping off the overburden and building in-place treatment biocells for soil mixing. The cells would be backfilled and the pad would be regraded at the conclusion of the proposed 60-day treatment period and become available for further use.

The results of the cost analysis showed that in-situ landfarming was the most cost effective method for remediating the soil (Figure 1) and provided usage of the property after completion of the treatment activities. The estimated cost for in-situ landfarming, including site construction, plan and report preparation, analytical testing, and project management, was approximately $600,000 or $81.00 per cubic yard. The thermal treatment option was the most expensive.

Since the water within the pad was determined by ADEC as the most probable transport mechanism for the soil contamination, a dewatering program was added to the in-situ landfarming option. The biocells were built with french-drain catch basins to remove the intra-pad water for treatment in temporary holding tanks. The water in the holding tanks was treated with the same product used for the soil biocells. After the water was treated, it was recycled back onto the biocells. The additional cost for dewatering was approximately $184,000.

The final total project cost including characterization activities (sampling, analytical testing, report preparation), remedial alternative cost analysis, Voluntary Cleanup Program application, cleanup/corrective action plan preparation, site construction and remediation activities, thermal treatment of benzene contaminated soil, sampling and analysis, and cleanup action final report preparation was approximately $975,000. The cost to thermally treat 900 cubic yards (cy) of benzene contaminated soil was $156,000. The cost to bioremediate 7,400 cy of DRO contaminated soilwas $250,000.

Figure 1. Cost Comparison Chart for Remedial Options



URS

REMEDIAL METHODOLOGY

Five of the biocells (Cells #1 through #5) were designed to treat 2,800 cy 1,130 cy, 870 cy, 2,375 cy, and 225 cy, respectively. The five perimeter biocells had one french drain catch basin constructed along one edge to remove the intra-pad water. Cell #1 in the central portion of the pad had four catch basins (Figure 2). Each catch basin containing intra-pad water was pumped several times until approximately 2% of the calculated "pad-volume" had been removed and placed into temporary holding tanks. One "pad volume" of water was calculated to be approximately 3.2 million gallons. In addition to the biocell and intra-pad water sampling and analysis, **URS** collected baseline samples of surface water from tundra ponds surrounding the pad. At the completion of all site activities, confirmation samples were collected from one tundra pond designated by ADEC. **URS** also collected baseline samples of intra-pad water placed in temporary holding tanks prior to treatment, and confirmation samples 48-hours following treatment. Soil samples were also collected from the stockpiles of overburden. All of the soil samples were analyzed for DRO, residual range organics (RRO) and BTEX compounds. All of the water samples were analyzed for BTEX and PAHs to assess the total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TaqH) concentrations for fresh water aquaculture restrictions per 18 AAC 70. Following the purging of intra-pad water and simultaneous with landfarming, samples were collected from the nine catch basins for further characterization.

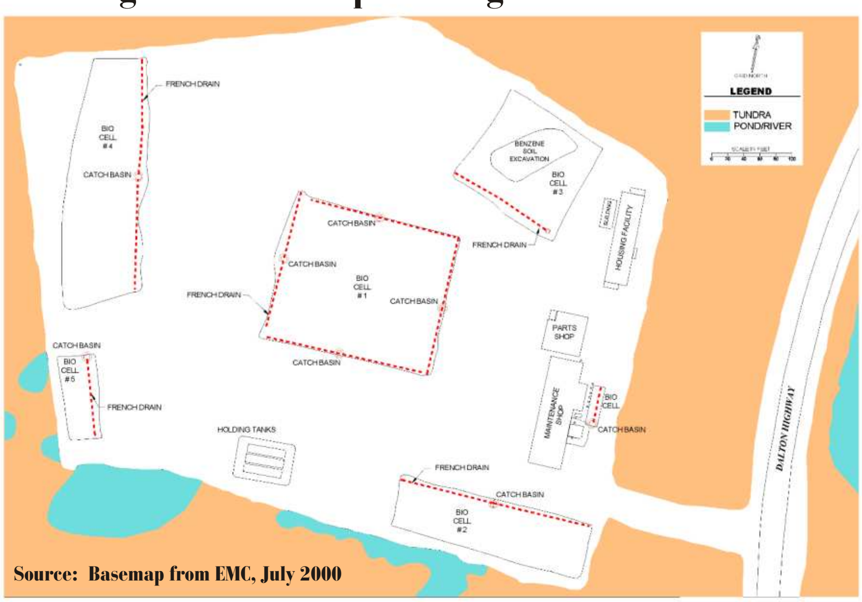
ETEC inoculation of Biocell No. 1

Prior to beginning landfarming activities, **URS** collected baseline samples from each biocell. A total of 25 soil samples were collected: eight samples from the central biocell (Cell #1); five samples from the southeast biocell (Cell #2); four samples from the northeast biocell (Cell #3); six samples from the northwest biocell (Cell #4); and two samples from the southwest biocell (Cell #5). At the completion of the landfarming activities and just prior to backfilling, **URS** collected confirmation samples from the same locations as the baseline samples and analyzed them for same constituents as before, plus PAHs. The biocells were also sampled by ***ETEC*** for nutrients (ammonia and phosphorous) and hydrocarbon plate counts at Day 0, Day 6, and Day 18 of the landfarming process.

On July 23, 2000 the biocells were inoculated with a combination of ***ETEC's Petroleum Consortium*** (EZT-A2), ***Enzyme Accelerator*** (EZT-EA) and ***Custom Blend Nutrients*** (EZT-CBN) bioremediation products. During the initiation of landfarming activities, **URS** removed approximately 63,000 gallons of intra-pad water from the catch basins and contained the water on-site in three temporary holding tanks. The holding tanks were within secondary containment cells. One baseline water sample was collected from each holding tank. Each holding tank had a low-flow aeration manifold to aid the treatment process. Following the baseline sampling of water in the holding tanks, each tank was inoculated with the same product used on the biocells. Once the results of the confirmation samples indicated non-detect concentrations, the water was re-used during the landfarming activities.

To prevent outward migration of hydrocarbons, **URS** encircled the pad with polypropylene absorbant booms. The absorbant booms were in place prior to biocell construction and monitored throughout the remediation activities. At the conclusion of the in-situ landfarming activities, the absorbant booms were retrieved and later incinerated.

Figure 2. Site Map Showing Biocell Locations



Source: Basemap from EMC, July 2000

ENZYME TECHNOLOGIES, INC.

TREATMENT RESULTS-25,000 LBS. OF CONTAMINATION REMEDIATED IN 30 DAYS

The range of baseline and confirmation concentrations of DRO and RRO for the five biocells are shown in Figure 3 and Figure 4, respectively. The average DRO baseline concentration was 1,388 mg/Kg. The average RRO baseline concentration was 182 mg/Kg. The average decrease in DRO and RRO concentration was 1,126 mg/Kg and 155 mg/Kg, respectively. After thirty days of landfarming using ***ETEC's*** proprietary enzyme and nutrient enhancers, all five biocells exhibited significant decrease in both DRO and RRO concentrations. **URS** estimated that on average approximately 23,300 pounds of DRO contamination and 3,200 pounds of RRO contamination were removed during the in-situ landfarming process.

The initial intra-pad water results showed total BTEX concentrations as high as 1.854 milligrams per liter (mg/L) from the northwest portion of the central cell and an average of 0.426 mg/L. The highest concentration of BTEX from the baseline holding tank samples was 0.206 mg/L with an average of 0.198 mg/L between the three tanks. Using the total between the cell catch basin samples and the holding tank samples the average total BTEX is 0.369 mg/L for the entire pad. The average amount of total BTEX contaminants removed from the holding tank water in 48 hours was 0.7 pounds.

Placement of temporary holding tanks

No PAHs were detected in the confirmation biocell and water samples. A total of approximately 25,000 pounds of petroleum hydrocarbon contamination was remediated from the six biocells following 30 days of in-situ landfarming. None of the surrounding tundra surface water samples contained concentrations of TAH and TaqH that exceed ADEC Arctic cleanup levels. In conclusion, the surface water results showed no complete path exists between the intra-pad waterand thesurrounding tundraponds.

Figure 3. In-Situ Landfarming Bioremediation Treatment Results for DRO in Soil

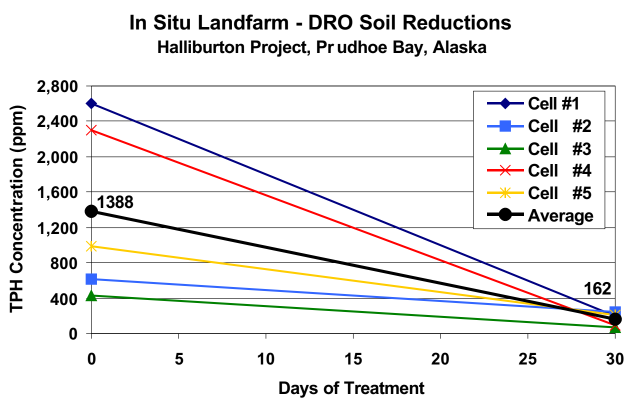
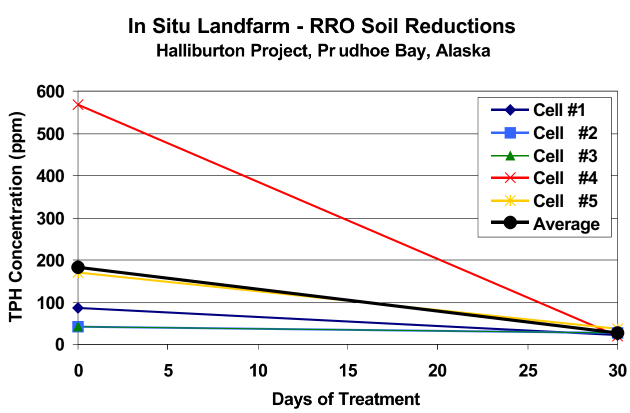


Figure 4. In-Situ Landfarming Bioremediation Treatment Results for RRO in Soil



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Biocell No. 2 with Sagavanirktok River in background

Transferring intrapad water to holding tanks

Post remediation view of HGS pad

Over the past 5 years, URS has brought together several world-class engineering companies, among which are some of the industry's leading environmental, engineering design, process engineering, and program/construction management firms. In Alaska, URS is manifested as the combination of three firms already known individually for their scientific and engineering excellence: Woodward-Clyde Consultants, Dames & Moore Group, and Radian International. Our Anchorage office has a staff of more than 90 professionals who have a wide range of environmental and engineering backgrounds and professional experience. We have satellite offices located in Fairbanks, Ketchikan, Juneau and Homer, which enable us to provide better service to clients throughout Alaska.

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