AnoX Enhanced Intrinsic Bioremediation

Case Study:
Former Gasoline and Petroleum Bulk Plant Located in the Coastal Plain of Virginia

1.2.1 Introduction

A petroleum release, resulting from leaking underground and aboveground petroleum storage tanks, was identified at the subject site in late 1991. The facility was formerly used as a retail operation for gasoline and diesel fuel distribution from several underground petroleum storage tanks (USTs). The facility also housed a wholesale and commercial bulk petroleum plant. The bulk petroleum plant consisted of several aboveground petroleum storage tanks (ASTs) containing two grades of gasoline, diesel fuel, number two heating oil, and kerosene located within an earthen dike. The ASTs served a bulk loading rack to load the various fuels onto home delivery trucks. Underground piping connected the ASTs and the bulk loading rack.

A suspected petroleum release was reported after site employees noted petroleum vapors inside the office building. Upon further investigation, it was determined that approximately 1 foot of separated phase gasoline had migrated into the drinking water well serving the office building. Initial abatement activities included removing the USTs, and excavating approximately 150 cubic yards of petroleum impacted soils form the UST basin.

During site assessment activities, approximately twenty-three monitoring wells were installed. Site assessment activities indicated that a significant dissolved phase petroleum plume was present, and that the plume had migrated off-site. There were also two separate phase-separated plumes located on the subject site. It was determined that the ASTs and/or the underground piping located at the bulk plant were leaking, and subsequently the entire bulk plant was removed. Initial abatement activities performed at the bulk plant area included removal of all ASTS, underground piping, bulk loading rack, and excavation of approximately 300 cubic yards of petroleum impacted soils. Although these soils were highly impacted with petroleum, these soils were used as fill for the initial excavation.

As a result, corrective actions included installation of a soil vapor extraction/air sparging system to provide limited remediation of the identified petroleum hydrocarbons. (The soil vapor extraction/air sparging system was installed in early 1992.) Based on a Risk Assessment developed for this site, the off-site dissolved phase plume was allowed to naturally attenuate. The adjacent properties included rural residences with drinking water wells. These wells included deep and shallow water wells used to provide domestic water service to the residences.

Quarterly ground water sampling and monthly maintenance has been performed on the subject site from 1992 until present. However, in April 2000 the owner of the subject site, based on analytical data and the continued migration of the off-site dissolved-phase plume, decided to provide a more aggressive remediation strategy at the site which included installation of permanently installed bioremediation treatment wells, and an infiltration gallery consisting of horizontal and vertical treatment wells in the “source area”. These bioremediation injection events were incorporated in conjunction with the soil vapor extraction/air sparging activities on-going at the subject site.

1.2.2 Bioremediation

Following the installation of seven permanently installed treatment wells, an

environmental contractor, began to treat the wells with VTX BioDegrader, a blend of petroleum degrading bacteria, and AnoX, an enhanced intrinsic bioremediation nutrient blend for anaerobic environments. Approximately 5,000 gallons of BioDegrader and AnoX solution were delivered to the subject site in a contractor's equipment and utilized to treat the wells completed in the petroleum-impacted uppermost aquifer. The vertical treatment points are comprised of four inch PVC well casing and 0.020 slotted screens to a depth of approximately fifty-five feet below ground surface (bgs). The screen and casing intervals differed based on subsurface geological and hydrogeological conditions, but generally consisted of twenty feet of well screen beginning approximately thirty-five feet bgs. Existing ground water depths are approximately thirty-five feet bgs over most of this site. All the treatment points were completed using a number three sand pack, bentonite seal, and neat cement grout to the surface. The treatment points were completed as flush mounts using a locking cap and eight inch access cover with bolted cover. Based on the hydrogeologic conditions, and analytical results of the soils sampled from the capillary fringe and vadose zone during treatment point installation, it was determined that treatment of the capillary fringe and vadose soils was not necessary.

1.2.3 Nutrient Addition

In order for the bacteria to successfully metabolize petroleum contaminants, it is critical that the groundwater contains all of the necessary nutrients to accommodate bacterial growth. The AnoX nutrients added to the groundwater are in the form of ammonia nitrogen, nitrate, and ortho-phosphate. Selected vitamins and micronutrients are also contained within the AnoX solution to stimulate growth.

The nutrient requirements are stoichiometrically balanced as follows:

The equation that demonstrates the chemical requirements for biological treatment is derived from the combination of the half reaction associated with bacteria systems. A balanced chemical reaction for the given biological conversion is useful in obtaining a mass balance. This equation is generally written as follows:

$$R=fsRc+fcRe-Rd$$

Where

Rc= the half reaction for the synthesis of bacteria cells
Re= the half reaction for the electron acceptor
Rd= the half reaction for the electron donor
fs= the portion of the electron donor used for the cell synthesis
fe= the portion of the electron donor used for the cell energy

Based on this equation, and the limits of the Underground Injection Permit (UIC) obtained for this remediation technology, nitrate addition is limited to ten parts per million (ppm). However, this consideration can be modified based upon varying regulatory situations.

1.2.4 Biotreatment Remediation Events

Biotreatment remediation events began in September 2000. These events consisted of the loading of approximately 5,000 gallons of Degrader at our facilities in Lexington, VA. The AnoX solution was tested for nitrate concentration to ensure compliance with the UIC permit. The BioDegrader and AnoX was then aerated overnight to ensure maximum oxygen concentrations, and to allow the consortium to acclimate and grow.

The remedial solution was then transported to the site and tested again to confirm nitrate levels prior to treatment. This test was performed with a Chemetrics portable nitrate test kit. Based on

analytical data received from the site, the Degrader was then used to treat the applicable wells.

Biotreatment events initially began on a monthly schedule. Monthly events were completed for one quarter. Monthly events were performed to obtain a net positive gain for the nitrate concentrations available to the bacteria consortium. As predicted, a net positive gain of nitrate was achieved during the first quarter. Biotreatment events were then - and are currently being - performed at the site on a once-per-quarter basis. Analytical data indicate that although once-per-quarter biotreatment events are effective at metabolizing the target contaminants, nitrate concentrations were very low to non-existent prior to the next biotreatment event. This data would indicate a more effective remediation could be achieved if biotreatment events were performed on a more frequent basis.

1.2.5 Analytical Data

Analytical data is collected quarterly according to the CAP. Additional samples are collected approximately 30 days following a treatment event. Following is a table of analytical results from various site monitoring wells showing the decrease in Total BTEX over time. (Table 2: Site Total BTEX Concentrations) Also following are three figures depicting the decrease in Total BTEX over time. (Figures 5-7) These Total BTEX Isoconcentration Contour Maps represent the Total BTEX concentrations prior to the bioinjection remediation events, mid way, and current concentrations at the site, respectively.

Table 1: Total BTEX Results for Enhanced Intrinsic (AnoX) Bioremediation

Monitoring Well I.D.	Date Sample Collected	Total BTEX Concentrations (ug/L)
MW1	Mar. 2000	916
	Dec. 2000	83.5
	Sept. 2001	0
MW2	Mar. 2000	110
	Mar. 2001	0
MW4	Mar. 2000	13.4
	Mar. 2001	0
MW6	Mar. 2000	51,960
	Dec. 2000	23,320
	Sept. 2001	29,920
MW7	June 2000	2,335.5
	Sept. 2000	170.7
	Mar. 2001	597.7
MW11	June 2000	200.6
	Dec. 2000	88.5
	Sept. 2001	25.3
MW13	Mar. 2000	163.9
	Mar. 2001	101.3
MW15	June 2000	7818
	Dec. 2000	2668
	Sept. 2001	0
MW16	June 2000	580.6
	Dec. 2000	300.1
	June 2001	173
MW17	June 2000	2020.6
	Dec. 2000	520.4
	Sept. 2001	151

MW18	Mar. 2000	1431
	Mar. 2000	287
	Sept. 2001	365.9
MW23	Mar. 2000	228
	Dec. 2000	137
	Sept. 2001	12.9