Oxygen Release Compound Stimulation of Biodegradation Following Landfill Excavation

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Abstract: An interim measure (IM), initiated May 2000 and completed August 2000, was conducted at a former landfill at Moody Air Force Base, Valdosta Georgia, in order to prevent migration of shallow groundwater contamination to off Base property and into deeper groundwater intervals. The IM selected was limited source removal with in situ treatment of the dissolved plume using Oxygen Release Compound® (ORC), landfill grading, drainage improvements, and effectiveness monitoring of the landfill. The landfill covers approximately 1.5 acres, and is located in an open grass field approximately 75 feet north of the Base boundary. The landfill was operated from 1941 to 1946 and from 1951 to 1953 using the cut and fill method. Historic aerial photographs and a geophysical survey showed six trench locations and their dimensions. Surface topography was irregular with drainage channels caused by the depressions from the cut and fill methods used to operate the landfill. This topography allowed for the infiltration of surface water. A groundwater investigation indicated the primary constituent of concern, benzene, had migrated off Base at this location. The most elevated level of benzene was detected less than 40 feet bgs. A complete vertical and horizontal delineation of the benzene plume emanating from the landfill was achieved and showed an elongated off Base plume with concentrations exceeding 1000 ug/L. Based on the results of the RFI investigation, an IM was developed that would eliminate the potential source of benzene contamination and enhance bioremediation by supplying oxygen to zones that have already depleted their natural oxygen content.

Interim measure objectives included the following: 1) remove materials within the landfill that were identified as potential sources of benzene contamination in the shallow groundwater, 2) reduce the continued migration of the groundwater plume through mass removal, not hydraulic control, 3) accelerate the ongoing in situ aerobic biodegradation processes that were remediating the groundwater plume by the addition of dissolved oxygen using ORC, 4) improve the existing drainage pattern over the landfill to ensure positive drainage away from the site to minimize infiltration and erosion, and 5) continue groundwater monitoring to ensure that the contaminant plume is not migrating to groundwater receptors.

Landfill excavation resulted in the removal of 15,040 tons of soil (1,062 yd^3 of compacted soil) from two locations (northern and southern pits). Small quantities of crushed drums and miscellaneous metallic debris were removed. All excavated soil was disposed as non-hazardous.

ORC was added to the impacted media using two methods. The first method for ORC application was through a mixture of ORC powder with excavation backfill materials. Approximately 312 pounds of ORC powder was added to the first 12-inch lift of backfill material placed in the landfill excavations. Two hundred pounds of ORC were backfilled into the southern pit and 60 pounds of ORC were backfilled into the northern pit. Backfill material consisted of a fine grained uniformed sand that would allow for the infiltration of groundwater to

the excavated areas in order to assist in the releasing of the oxygen to the shallow surficial aquifer. An ORC and sand mixture of 0.1 percent ORC weight-to-sand ration was placed in the landfill excavations. Approximately 5,200 yd^3 loose fill were placed in order to achieve the required grade, and 1,024 yd^3 of topsoil to reach the desired final grade.

The second method for ORC application was through slurry injection using a Geoprobe® Model 66-DT track-mounted rig to groundwater downgradient of the plume source area. Forty-one depth-to-product injection points were installed along two transverse lines perpendicular to the plume, downgradient from the source area. Twenty-one points were installed on the downgradient line, and twenty points were installed on the upgradient line; points were placed approximately 10-feet apart. Injection was completed using a stainless-steal none expendable tip connected to an inlet or screen to allow for horizontal injection of the slurry, and a top cap. Each injection point was installed to a depth between 40 to 43 feet bgs, pre-determined by geology. Fifteen pounds of ORC to 2.7 gallons of water was injected per point, over a ten-foot interval. A total of 615 pounds of ORC were injection into the surficial aquifer. Injection was completed May, 2000.

To monitor the effectiveness of the ORC application, eleven monitoring wells were sampled in June 2000 to establish baseline conditions prior to full implementation of the IM. Additional monitoring wells were installed during implementation of the IM and sampled quarterly.

As part of the monitoring process, dissolved oxygen (DO) readings were collected routinely following the application of ORC. Dissolved oxygen is an important indicator of the effectiveness of the ORC application in terms of the radius of influence as well as showing a source for dissolved oxygen. Dissolved oxygen readings reached an average high in September of 3.63 mg/L, with an average individual DO readings increase of over 1.0 mg/L from August to September. Although dissolved oxygen increased in September, concentrations subsequently decreased to approximately baseline conditions by January 2000. There are two potential causes for this decrease; 1) the high oxygen demand of the site depleted the applied oxygen, or 2) the ORC did not effectively release dissolved oxygen into the matrix.

Groundwater sampling results showed an initial reduction in benzene concentration in November 2000 following application of ORC in May 2000. Specifically, of the 15 wells sampled, 8 demonstrated a reduction in benzene concentration or remained stable around the detection limit of 1 ug/L. Five of the 15 wells were sampled for the first time and, therefore, had no baseline condition for comparison. Two of the 15 wells demonstrated an increase in concentration. Two upgradient wells showed notable reductions in concentration, where concentrations decreased from 130 to 1.5 ug/L and from 138 to 100 ug/L between June and November 2000. Two downgradient wells showed an increase in concentration from 2 to 260 ug/L and 417 to 450 ug/L, compared to baseline from first quarterly sampling event. These two wells are located downgradient of the most highly contaminated plume core. Dissolved oxygen concentrations in these wells peaked in August immediately following application. Results to date indicate wells which maintained high dissolved oxygen readings up to November 2000 demonstrated a reduction in benzene concentration, whereas, those wells in which the initial release of dissolved oxygen was depleted by demand maintained higher benzene concentrations.

Additional results showed electron acceptor concentrations were high along the plume fringe but depleted at monitoring wells with the highest concentrations of benzene. This condition results in the narrowing and elongation of the contaminant plume in the direction of groundwater flow (southwest) in plumes undergoing in situ biodegradation or natural attenuation.

Bioplume modeling using electron acceptor concentrations obtained in January 2001 indicated plume attenuation to the state of Georgia maximum contaminant level (MCL) within 16 years with minimal downgradient migration. The Bioplume model was rerun assuming dissolved oxygen concentrations within the plume core could be increased to 10 mg/L; this is recognized as the optimal result of ORC application. Results of this optimal condition model run indicated attenuation of the benzene plume to MCL within 9 years with minimal downgradient migration.

In summary, results indicate that benzene reductions through in situ aerobic biodegradation can be obtained given the presence of required electron acceptors (preferentially dissolved oxygen). ORC application can increase groundwater dissolved oxygen concentrations too greater than 10 mg/L. Model predictions assuming sustained maintenance of this optimal dissolved oxygen concentration indicate biodegradation of the benzene plume to the MCL (5 µ/L) within 9 years. Therefore, the primary objective of the on going IM is to sustain increased concentrations of dissolved oxygen through the effective application of ORC.

In order to accomplish this objective, reinjection of ORC and hydration of the ORC backfilled into the excavation trenches are a priority. A 6-inch piezometer will be installed into the southern excavation pit in order to hydrate the backfilled ORC and increase the release of dissolved oxygen into the impacted soils and groundwater. In addition, a reinjection of ORC is recommended in 2 parallel 200-foot injection lines. A total of 42 DPT points will be placed 10 feet apart to facilitate reinjection. The original injection lines ran northwest, southeast, perpendicular to the plume. The second set of injection lines may run northeast, southwest, parallel to and down the center of the plume to focus the attack on the plume core (greater than 1,000 µg/L) and highest area of oxygen demand.

Upon completion of the installation of the hydration piezometer and the reinjection of ORC, an additional 6 months of monitoring will occur. With the completion of the second phase of the IM, a potential final remedy will be determined.