Demonstration of Groundwater Containment Through the Use of Barrier Wall and Surface Cover Systems, and Natural Attenuation

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Abstract: Two years of groundwater monitoring data demonstrate that groundwater remedial objectives have been accomplished at a former coke and by-products facility through the integrated use of barrier wall and surface cover systems, and natural attenuation. The barrier wall system consists of a 4,500 foot long slurry wall bordering a river and enclosing the former process areas. The surface cover is processed dredge material which consists of sediments from the New York/New Jersey area waterways stabilized with Portland cement. No active groundwater pumping is required to achieve the containment. Potentiometric data validate that groundwater flow has been controlled and redirected away from the river and seepage velocities have been reduced. Groundwater chemistry data show that the dissolved plume has been controlled, not expanded and biodegradation is occurring. Inspections along the river indicate that discharges of DNAPL have been mitigated.

The Site was the location of a coke and coke by-products plant, which operated from the early 1900s until 1979. The Site is bordered to the north and east by a river, and industrial properties to the south and west. The majority of active plant operations occurred in the central and eastern portions of the Site, and included a coke plant and coke gas cleaning/conditioning plant, a coal tar plant, and cyanide/sulfuric acid plant. The western portion of the Site was used for disposal of coke by-product waste materials.

The shallow fill unit consists primarily of cinders, slag, coal and coke fragments, and ranges from four to 21 feet in thickness. Beneath the fill unit at most locations is a layer of peat (meadow mat) that ranges from three to 6 feet in thickness. Within the eastern portion of the Site where the peat layer is not present, the fill is underlain by an organic-rich silty clay unit ranging in thickness up to 45 feet. Combined, the organic silty-clay and peat layers serve as the basal confining layer for the shallow fill unit. Beneath the peat and/or organic silty clay, there is a fine to medium sand layer between three and 20 feet in thickness. Immediately below the sand layer is a reddish-brown varved clay layer, which has a maximum thickness of 60 feet, and is largely continuous across the Site. A glacial till layer, between five and 26 feet in thickness, underlies the varved clay and organic silty clay units. The bedrock surface (Brunswick Shale) is located between 58 and 102 feet below ground

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surface (bgs).

The pre-remedial groundwater flow direction in the shallow fill unit was generally toward the river. A variety of dissolved-phase Constituents of Interest (COI), including polynuclear aromatic hydrocarbons (PAHs), volatile organic compounds (VOC), and cyanide, were migrating toward the river at concentrations in excess of applicable standards. In addition, an Interim Remedial Measures treatment system was operated in the vicinity of the river to collect DNAPL.

The objective of the shallow groundwater barrier system was to prevent DNAPL migration into the river, and to promote natural attenuation of dissolved COI in the groundwater prior to flowing off Site. The objective of the surface cover system was to reduce stormwater infiltration to the shallow groundwater. Reduced infiltration would further enhance natural attenuation processes by reducing hydraulic gradients and increasing COI retention time in the shallow fill unit at the Site.

A conservative fate and transport model was used to evaluate the effect of the shallow barrier and surface cover systems on dissolved COI in Site groundwater. The fate and transport model was completed to predict worst case constituent migration following installation of the slurry wall and sheet pile barrier wall, with the assumption that low permeability surface cover would be installed at the Site. Two constituents, benzene and naphthalene, were modeled because these two compounds are the most mobile constituents representative of volatile and semi-volatile organic classes of COI. A combination of Site data supported with literature derived data were used to generate the model input parameters. The model included a sensitivity analysis which assessed the effect of potential variations of several key transport parameters on constituent migration and attenuation.

The fate and transport modeling predicted that the COI on Site would not migrate rapidly due to low predicted groundwater velocities and the nature of the Site soils, which are predicted to retard constituent migration considerably. The model results included isoconcentration plots of predicted benzene and naphthalene migration over various time periods including initial conditions, 0.5 years, two years, 10 years, and 50 years following implementation of the proposed remedy. The model predicted that virtually no migration of benzene and naphthalene would occur for a period of 10 years following remedy implementation.

The remedy for the Site consists of a low-permeability surface cover across the Site, and a shallow groundwater barrier system. The surface cover is dredged material from the Port of New York and New Jersey harbors that is stabilized with a minimum of 8% by weight cement. The completed barrier system consists of a soil-bentonite slurry wall enclosing most of the eastern area of the Site (4,500 LF) and, where needed for structural support, a steel sheet pile (SSP) wall (6,100 LF). The soil-bentonite slurry wall was designed to provide a maximum permeability of 1×10^{-7} cm/sec, compatibility with Site COI, and a minimum design entrance pressure of 4.33 pounds per square inch to resist DNAPL migration. The slurry wall was constructed to a minimum width of 3 feet, and into the shallow confining unit a minimum depth of 3 feet. The SSP wall was constructed of welded steel sheet pile pairs, and installed a minimum of 3 feet into the deeper confining unit. Each SSP wall joint was sealed using a hydrophilic material, which resulted in the SSP wall having an effective permeability equivalent to that of the slurry wall.

Eight quarters of groundwater data were collected following implementation of the Site remedy. The data indicates that the post-remedial groundwater flow regime is consistent with the model predictions. Groundwater flow has been redirected away from the river, and the retention time and flow distance of groundwater originating from the Coal Tar Plant area have been greatly increased. The average pre-remediation groundwater elevation gradients have been reduced from approximately 0.01 ft/ft to approximately 0.0005 ft/ft. This reduction in groundwater elevation gradients has also prevented the DNAPL source from expanding. The eight quarters of analytical data confirm that natural attenuation processes are occurring and have prevented the COI plume from migrating. Evidence of active biodegradation (i.e., increased carbon dioxide and methane levels, decreased oxidation-reduction potential, decreased concentrations of alternate electron acceptors) has also been observed. This finding is significant because the fate and transport model assumed that little to no biodegradation would be needed in order COI to naturally attenuate. Although not needed, active biodegradation will help ensure continued success of the natural attenuation remedy for the Site.