



In Situ Soil Stabilization of a Former MGP Site

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Soil mixing is a well-established technology used in the improvement of the strength of soil as well as the remediation of chemical contaminants in soil. This process is typically referred to as in situ solidification/stabilization (S/S). In situ S/S involves mixing a binding reagent into the contaminated media or waste using soil augers and has been used to treat both organic and inorganic hazardous waste constituents. Cement-based mix designs are most commonly used for S/S treatment of hazardous waste, however, a variety of additives such as fly ash, hydrated lime, bentonite can also be used to meet specific project requirements.

Several technologies can be used for the in situ S/S of soils, however, a specific focus will be placed on the use of the Shallow Soil Mixing (SSM) technique. SSM consists of using a single large diameter auger, generally on the range of 5 to 10 ft in diameter, capable of mixing to depths up to 30 or 40 feet deep. The mixing shaft, known as the kelly bar, is hollow stemmed and is attached to a single flight auger which breaks the soil loose and lifts it slightly to six beater bars on the mixing shaft. As the auger penetrates the soil, a slurried reagent is pumped through the mixing shaft and exits through jets located on the auger flighting.

The SSM technique was selected as the method for the in situ stabilization of approximately 103,500 cubic yards of non-aqueous phase liquid (NAPL) impacted soils at the Cambridge Research Park Site. This site consists of a ten-acre property that was the location of a former Manufactured Gas Plant (MGP) where past operations resulted in the release of hazardous chemicals to the soil and groundwater. The hazardous chemicals that are present in the soil and groundwater, in a 2.82 acre area of the property, exceed the Upper Concentration Limit (UCL) established by the Massachusetts Contingency Plan (310 CMR 40.0996).

The site was divided into zones in which dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) or both were present. Site investigations showed that the DNAPL was consistent with coal combustion products (coal tar) and LNAPL was similar to weathered diesel oil of #2 fuel oil. The downward migration of the DNAPL was restricted by the clay layer located at approximately 22 feet below the existing ground surface. The LNAPL was found present on top of water table and exceeded a thickness of two feet in some monitoring wells. Stabilization in zones containing DNAPL only or DNAPL and LNAPL was performed by mixing to a depth of 2 feet below the clay layer. The LNAPL zones were stabilized to a depth of 12 ft below ground surface.

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Prior to stabilization, demolition of subsurface structures and obstructions was completed. This was performed by excavating to a depth of approximately 15 ft below ground surface. The majority of demolition debris consisted of concrete and steel piping left in-place after demolition of the former MGP. In some cases, an excavator equipped with a hoe ram was required to demolish existing concrete foundations. All demolition debris was separated and classified for offsite disposal. The remaining soil material was placed back into the excavation area.

The most difficult challenge of the subsurface demolition work was the control of odors and volatile organic compounds (VOC) emissions. Two successful methods were used at the site for odor control during the subsurface demolition. The first method used an odor controlling foam material, which was sprayed over open excavation areas, temporary stockpile areas, and demolition debris to suppress odors from newly excavated material. This proved to be the most effective method for controlling odors, because the release of odors could be controlled immediately at the source. This method also aided in the reduction of VOC emissions. As an additional backup measure, a mist unit was also set up along the perimeter of the excavation area. This unit operated by releasing an engineered odor reducing mist into the air. In addition to these two active controls various passive odor reduction measures were implemented. Perimeter fencing with a wind screen/vapor barrier also helped to elevate and disperse vapors. As a final control, excavation was limited to favorable wind and temperature conditions to minimize the impact to offsite receptors.

During the soil-mixing phase, odors were controlled by a specialized Soil Vapor Extraction (SVE) unit. This unit consisted of a metal shroud or hood which was placed over the area being mixed to trap potentially hazardous vapors and fugitive dust released from the soils. During the stabilization process, vapors and fugitive dust were drawn through a vacuum hose attached to an opening in the side of the shroud. The vapors were then drawn through the treatment unit, which included an air separator, HEPA filter, and activated carbon unit(s). Upon completion of the treatment process, the air is then released through a discharge pipe.

The initial phase of stabilization involved performing a field test program to determine proper reagent addition and equipment operation necessary to produce a homogeneous mix. The total reagent addition was based on the dry weight of reagent in the grout mix to a percent weight of the soil. This also made it necessary to determine a workable grout mix ratio (water to solids ratio) that would satisfy the project requirements. Upon completion of the test program, it was determined that a 7% cement to soil and 2% to cement mixture would be used (grout mixed using a 1.25:1 W:C ratio). The test program also determined specific equipment operations such as auger advancement rate through the soil, grout injection rate, and number of strokes (i.e. one complete advancement of the auger from the ground surface to bottom depth and back to ground surface) necessary to produce a homogeneous mixture.

In reference to the limits of stabilization, a specific SSM column layout was determined using overlapping of adjacent columns to effectively stabilize 100% of the mixing area. Each column was individually labeled for identification purposes. The stabilization column layout and dimensions are provided in Figure 1 below. Columns were identified and marked in the field by surveying methods. The surveying data for each column was recorded and used to relocate columns for compliance sampling. This method was used exclusively throughout the project duration.

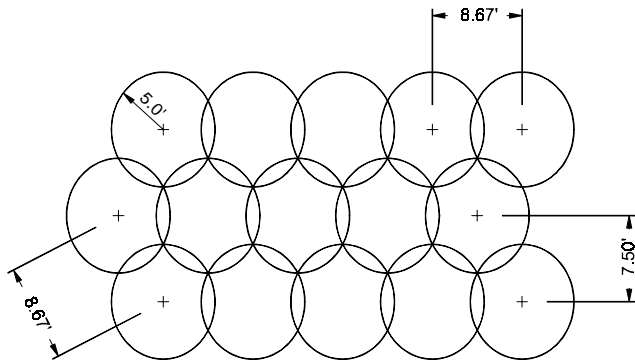


Figure 1 – SSM Column Detail for 10 ft diameter columns.

Samples collected were photographed and visually inspected for homogeneity and the presence of NAPL. In addition, the samples were analyzed for physical parameters including hydraulic conductivity, bulk density, as-treated NAPL saturation and post-centrifuge residual saturation. Sample collection was performed at a frequency of once per every 1,000 cubic yards of stabilized soil for the first 10,000 cubic yards for testing at curing times of seven and 28 days. Upon completion of the first 10,000 cubic yards of stabilized material, the sampling frequency was reduced to one sample for each 2,500 cubic yards.

Samples were also analyzed for TCLP volatiles (BTEX) and TCLP semi-volatiles. These samples were collected from wet samples collected at the time of mixing. Additionally, the sample for TCLP analysis was collected from the post-28 day cured sample to assess the effects of curing on the TCLP results. The physical and chemical data supports and demonstrates that the stabilization activities were performed in accordance with the project requirements and achieved the desired results.

References

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