# Bio-Polymer Construction and Testing of a Zero-Valent Iron PRB at the Somersworth Landfill Superfund Site

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Abstract: This paper describes the construction and subsequent quality assurance testing of a 915 foot long zero-valent iron (ZVI) permeable reactive barrier (PRB) at the Somersworth, NH Sanitary Landfill Superfund Site. The PRB was installed along the downgradient perimeter of the landfill to degrade chlorinated organic compounds in overburden groundwater as part of the Preferred Remedial Action Plan for the Site. The application of a ZVI PRB at this Site is unique because: (1) the PRB was installed immediately downgradient of a landfill; (2) the PRB extends over 40 feet into highly permeable sand with cobbles; and (3) the installation was conducted using an open trench supported by a bio-polymer or BP slurry. The ZVI PRB was installed in 30 to 50 foot long sections separated by metal I-beams, which allowed individual sections to be excavated and backfilled without impacting activities in adjacent sections. The placement of the ZVI was complicated by: (1) the large quantity of ZVI used (over 3,500 tons); (2) the use of different ZVI/sand mixtures along the length of the PRB; and (3) the placement of ZVI/sand mixtures through a BP slurry. Following construction, core samples were obtained from the PRB using a modified Shelby tube method to verify lateral and vertical consistency of the ZVI throughout the PRB.

## INTRODUCTION

The Somersworth Sanitary Landfill Superfund Site (the "Site") is located near the City of Somersworth in southern New Hampshire and received municipal and industrial wastes from the 1930s to the early 1980s. The Site was added to the National Priorities List (NPL) in 1985 as a result of the discovery of chlorinated solvents (tetrachloroethene {PCE} and trichloroethene {TCE}) and their degradation products (dichloroethene and vinyl chloride) in groundwater downgradient of the landfill. Various remedial actions were considered for the Site and in 1995 a Record of Decision (ROD) was issued based on the use of a zero-valent iron (ZVI) permeable reactive barrier (PRB) to degrade chlorinated solvents in overburden groundwater moving from the landfill. The ROD allows for natural attenuation to degrade chlorinated solvents in groundwater already beyond the edge of the landfill.

## PERMEABLE REACTIVE BARRIER DESIGN

Design investigations at the Site found that the concentrations of solvents in groundwater along the downgradient edge of the landfill varied considerably. The PRB was designed with 8 sections, each approximately 100 feet in length, with differing amounts of ZVI corresponding to the ZVI required to treat the specific concentration of VOCs entering each section of the PRB. The construction method (excavation of an open trench using a biodegradable polymer or bio-polymer (BP) slurry to maintain trench stability) dictated that the PRB have a minimum thickness of 30 inches, corresponding to the width of the excavator bucket. Inert coarse washed sand was mixed with the ZVI before being placed in the trench. The different sections of the PRB contained ZVI/sand mixtures with between 40% and 100% ZVI by weight.

The application of a ZVI PRB at this Site was unique because: (1) the PRB was installed immediately downgradient of a landfill (prior to this installation no other large ZVI PRBs had been installed at landfills); (2) the PRB extends to a depth of over 40 feet into highly permeable sand with cobbles (the significant depth and geological and hydrogeological conditions pose problems for construction methods used at other sites in the past); and (3) the installation was conducted using an open trench supported by a BP slurry (this was one of the first and by far the largest PRB installed using BP). The PRB was installed in 23 separate panels each 30 to 50 feet long and separated by metal I-beams. This method allowed individual panels to be excavated and backfilled without impacting activities in adjacent panels.

## PERMEABLE REACTIVE BARRIER CONSTRUCTION

The PRB was installed by excavating a 30-inch wide trench from the ground surface to the top of bedrock using a large excavator. The stability of the trench was maintained using a BP slurry. After each panel was excavated, the ZVI/sand mixture was added to the trench using a tremie pipe extending to the bottom of the trench. Clean water was added to the ZVI/sand mixture as it entered the top of the tremie pipe to displace the BP from the bottom of the trench as the ZVI/sand mixture was added and reduce the potential for entrapment of air in the PRB. Excess BP slurry was displaced as the ZVI/sand mixture was added to the trench and overflowed to a collection basin.

The contractor initially installed alternating panels (primary panels) along the length of the PRB then installed secondary panels between the primary panels. Typically, primary panels were excavated in one day. The following morning, the excavator was used to remove a small amount of material from bottom of the trench that either settled out of the BP slurry or was lost from the sides of the trench and the trench was backfilled with the ZVI/sand mixture. During the installation of the primary panels, the BP remained stable (i.e., maintained sufficient viscosity to support the trench) overnight or in some cases for several days. During the installation of the first 2 secondary panels, the contractor had difficulties maintaining the stability of the BP. Following these difficulties the contractor excavated and backfilled secondary panels in a single day to reduce the potential for instability of the trench. Following construction of the PRB, samples were collected from a number of panels as part of the post construction testing described below.

## POST CONSTRUCTION TESTING

Sampling of the installed ZVI/sand mixture was conducted as part of construction QA/QC to verify lateral and vertical consistency of the ZVI throughout the PRB. The objective of the sampling was to collect continuous cores and sub-sample these cores for gravimetric ZVI content measurements. Obtaining continuous samples of ZVI was difficult because the material is non-cohesive. Previous attempts to sample with a Geoprobe and split-spoon sampler had not been entirely successful. Several tools were tried in the field including: large-diameter split-spoon, split spoon with a basket retainer, split-spoon with a flap valve, and a thin-walled fixed piston sampler, with limited success. Eventually nearly continuous samples were obtained by lowering a Shelby tube down a cased borehole that had been cleaned and washed using a roller-bit. An electric jackhammer was then placed on the end of the drill rod (using a sling and cable from the drill-rig for balance), and the self-weight and vibration of the jackhammer was used to push the Shelby tube into the ZVI/sand mixture. The Shelby tube was vibrated approximately 10% more than the length of the tube into the ZVI/sand mixture. After removing the jackhammer, the sample was withdrawn as quickly as possible to the ground surface. The end of the Shelby tube was capped immediately upon retrieval as material tended to fall from the tube once above the water table. Sample recoveries using this method were typically greater than 90%, and occasionally nearly 100%.

It is believed that the vibration of the jackhammer was necessary during sampling as a result of the flat finger like shape of the ZVI particles. Attempts to sample the ZVI/sand using a split-spoon revealed that pushing or driving a tool into ZVI is typically unsuccessful because the particle readily interlock and form a plug in the end of the tube. The vibration from the jackhammer is believed to allow the Shelby tube to cut through the ZVI because it prevents iron particles from developing the necessary shear strength to form a plug. Conversely, once the Shelby-tube was been driven to depth, the cessation of vibration allows particles to interlock inside the tube and develop sufficient strength to bind to the sides of the Shelby-tube during removal. However, once above the water table, combined seepage and gravitational forces tended to overcome the friction between the sample and Shelby-tube walls; thus, fast retrieval is essential to the success of this method.

The result of the core samples collected from the installed PRB demonstrated that the ZVI content was within acceptable ranges with the exception of the bottom few feet of the 2 panels where difficulties had been encountered with the stability of the BP. Retrofit work is planned to install additional ZVI in the bottom few feet of these panels.

## CONCLUSIONS

This work provided a successful demonstration of the design and construction of a large scale ZVI PRB under unique and challenging conditions. Some difficulties were encountered during construction, but the problems affect only very small portions of the PRB and retrofit work is being planned to address the small deficiencies.

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