

Permeable Reactive Barrier Installation Using the Biopolymer Slurry Trench Method

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The Permeable Reactive Barrier (PRB) is a new form of technology involving emplacement of zero valent iron or other reactive media for the purpose of the *in situ* treatment of contaminated groundwater by intercepting contaminant plumes and transforming them into environmentally acceptable forms. The PRB can be used to treat several forms of contamination such as chlorinated solvents, dissolved metals, and petroleum hydrocarbons.

The PRB has several methods of installation that are currently used and are still being developed. Some methods tend to be more complicated than others, however the method of installation chosen should be dependent on the particular application and construction limitations. Aside from using conventional excavation techniques, PRB's have been installed using soil mixing, jet grouting, and slurry wall technologies.

One method of soil mixing is performed by first installing several steel casings into the ground. The casings are then gravity filled with the reactive media and the casing is pulled out of the ground. The media is mixed in place using a drilling rig or specialized soil mixing equipment, forming a homogeneous mixture with the *in situ* soils. Other applications may only require a reactive barrier at a specific depth (e.g. barrier located between 20 to 30 feet below ground surface). Clearly, the construction of a barrier that extended from the ground surface (e.g., from the ground surface to the confining layer limits) would be costly and unnecessary. Therefore, jet grouting can be used to drill to a specific depth and install iron as necessary, without excavation of overburden material.

Installation using the Biopolymer Slurry Trench method has proved to be very effective in most circumstances. This method allows construction of deep and narrow trenches supported only by an engineered fluid or slurry. The backfill material can be placed in the trench through the biopolymer slurry using a "tremie" type method. After trenching and backfill placement are complete, the bio-polymer slurry is degraded to a marsh funnel viscosity of less than 30 seconds and the trench flushed by pumping and circulating the fluids present in the trench.

One particular project, in which the Biopolymer Slurry method was used to install a PRB, was performed at the Somersworth Landfill in Somersworth, New Hampshire. The PRB was installed between August 1, 2000 and September 29, 2000. The trench was excavated using a Link-belt 7400 Excavator equipped with an extended stick and a 30" bucket with rock ripper teeth. The completed trench was approximately 915 linear ft and was excavated to the top of bedrock elevation (bedrock refusal). During construction, the PRB was divided into eight separate sections, each being 100' to 175' in length with each

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section having a different concentration of sand/iron mixture. These sections were divided into 2 or 3 individual panels, each approximately 33 to 50 feet in length. These sections were labeled by station number and identified as primary and secondary sections. Steel "I" beams of 30" and 36" were placed in the trench to segregate the primary and secondary panels. A temporary extraction well was placed in each 33 to 50 foot panel. The wells were slotted 6-inch PVC wells used to aid in the development of the trench.

The trench depth was verified by lowering a weighted plumb bob through the slurry to the bottom of the excavation and measuring the elevation of the bedrock surface. Elevations were surveyed with a Berger 200B transit level at an interval of once every 10 lineal feet of excavation. The level of the bucket on the LB7400 also was monitored with a 4-ft level on a daily basis to ensure the excavator was on level ground (i.e., ensure proper trench verticality).

The Biopolymer slurry for trench excavation was produced using an onsite slurry mixing plant consisting of a five cubic yard high-speed colloidal shear mixer, transfer pump, and electrical generator. The mixing process began by adding 50-60 lbs of G150 Bio-Polymer guar gum to approximately 1000 gallons of water to yield a viscous slurry. Slurry was pumped to the trench via a 6" trash pump.

The mixing of the iron/sand backfill was performed using an Elkin Mixer truck. This unit is designed to mix multiple materials, blending them into a homogeneous consistency. The iron and sand were added separately to the Elkin Mixer in separate bins. The rate/volume addition of each material was controlled by adjusting the gate heights of each bin of the mixer. All mixing was performed on the concrete iron/sand mixing pad. A front-end loader replenished the sand into its respective bin of the Elkin mixer and a forklift was used to place the bags of iron over the iron bin, which the bag was then broken and placed in the bin. The iron/sand mixture was then augured into the bucket of a front-end loader, or was allowed to spill onto the mixing pad, where the loader then transferred the material to the hopper of the conveyor system that was present at the trench. The conveyor system had a water source attached to it so the voids of the mixture would be thoroughly saturated as it entered the slurry. The conveyor system emptied into a 24" tremie pipe that was 40 feet in length. After the desired level of backfill was reached, the excess slurry was either pumped or bailed out of the trench and was placed in the slurry containment pond. When the surface of the iron/sand backfill was visible, temporary sacrificial geotextile cloth was placed on top of the backfill to ensure no sediment came into contact with the mixture. Once the geotextile was placed, the trench was capped with a temporary structural fill.

To verify a homogenous mixture was achieved during the initial mixing, samples were collected from the mix pad area and tested using the magnetic separation test. This test involves collecting a sample, drying the sample, weighing the total dry weight, separating the iron and sand using a magnet, and weighing the iron and sand individually. The final results can be expressed using a percent iron by weight or volume of the sample. If a percent volume is used, the unit weight of both sand and iron should be specified. This is

by far the most effective method of determining if the required iron mixes have been achieved.

The most critical aspect during the installation is the segregation of the iron and sand backfill during placement. It is anticipated that some segregation will occur during placement, however strict controls should be used to minimize this. Several methods can be used to minimize the amount of segregation during placement. The use of the tremie pipe can decrease the amount of segregation that occurs during placement. The tremie confines the mixture during placement to a smaller area, not allowing it to freely disperse throughout the slurry as it settles to the bottom. The tremie will also minimize or eliminate contact of the backfill with the trench side walls, minimizing the potential to displace native material from the walls into the trench.

Samples can also be collected during backfill placement to verify that the material has not segregated during placement or that minimal segregation has occurred. It is suggested that sampling occur during placement only. Sample retrieval after placement (i.e., coring or excavating) can be difficult and may not provide representative samples of the iron and sand mixture. One method for retrieving samples during placement is to lower an open top container into the trench where backfill placement is to occur. The container is held at a desired depth, which fills up with backfill as the material is placed in the trench. The container is then removed from the trench and the backfill tested using the magnetic separation test.

During trench development, it was anticipated that all slurry would be degraded in the trench to a viscosity of less than 30 seconds. Slurry was pumped out of three PVC extraction wells and the viscosity was measured to be less than 30 seconds and the pH was below 6.5. With this, all the PVC wells and I-beams were removed from the trench and low permeability clay cap was ready to be installed. The temporary structural fill was removed until the geotextile was located. The geotextile was peeled back and the top of the iron/sand elevations were surveyed with the transit level which was located adjacent to the trench. Once the top of iron/sand backfill was adjusted to the correct elevation, fresh geotextile was placed on top of the backfill, and clay was placed 12" high for the bridge lift. This bridge lift was compacted with the bucket of the excavator, and three eight-inch lifts were compacted with the walk-behind compactor. The remaining two feet were capped with structural fill. Density and moisture content of the clay were tested every 50-ft for every eight inch lift using a Troxler 3430.

This method of installation for this particular project proved to be very successful, however, other backfill mixing and placement procedures should be looked at on future installations. In the past, other projects have used ready mix trucks to perform the backfill mixing. This offers several advantages such as using a premeasured (by weight) amount of iron and sand. Trucks can be weighed and filled with a desired amount of sand. Since iron typically is supplied in pre-weighed bags (approximately 2000 lbs), exact weights of iron and sand can be used.