BIO-POLYMER SLURRY TRENCH METHOD FOR INSTALLATION OF IN-SITU AIR SPARGING SYSTEM

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Introduction

An investigation was conducted at a site in Greenville County, South Carolina which detected contaminants in the groundwater. It was then decided that remedial action was required. The contaminants and their location in the groundwater led to the selection of an in-situ air sparging system to be installed at approximately thirty-four feet deep. Due to design depth requirements and other site conditions, the bio-polymer slurry trench (B-P drain) Method was utilized in the air sparging system installation.

The two trenches were installed using a biodegradable slurry in lieu of the bentonite slurry commonly utilized in the more traditional slurry trench technique. The slurry temporarily supported the trench walls while the air sparging components were submerged and set at the proper elevations. Once backfilled with stone, the slurry in both trenches was broken by introducing a breaker solution which reduced the slurry to sugar water. The trenching, air sparging piping installation, and backfilling operations were completed in about six weeks.

Site history

The site was once used for the disposal of various wastes, including various powder materials and adhesives for packaging. The initial remediation of the site included the excavation, removal, and disposal of the waste at a hazardous waste landfill. After the completion of the initial remediation, monitoring wells detected three contaminants of concern in the groundwater, including bis (2-ethylhexyl) phthalate, manganese, and trichloroethane (TCE). With the likelihood of the land use being residential in the future and that any exposure to these contaminants would be through the ingestion of the contaminated groundwater in the existing nearby wells, a groundwater remediation plan was developed and implemented by the consultant, RMT, Inc.

Site description and layout

The four and half acre site is located in a residential area of Greenville County, South Carolina. It is located on a hill surrounded by woods and a couple of small streams. The soil encountered during excavation was a stiff, non-plastic silt.

The groundwater table was 10 to 15 feet deep. The remediation plan called for two sparging trenches to be installed on the down gradient side of the contaminated area. Trench No. 1 is 160 feet long and Trench No. 2 is 220 feet long. Both trenches are 3 feet wide and approximately 34 feet deep. The two trenches are between 50 and 70 feet apart. Located at the northern end of the trenches is an equipment building which houses the hot air generating system. A piping system connects the generating system to the trenches. See Figure 1.

Air sparging design

The air sparging system works by blowing air approximately twenty feet below groundwater into the two permeable gravel backfilled trenches. The volatile organics in the water are then transported by the air up to the ground surface and released to the atmosphere. The concentrations of the released volatiles are small enough that point source release permits are not required. Additionally, some of the oxygen from the air dissolves and reacts with the manganese in the groundwater. The manganese then precipitates lowering its concentration in the groundwater.

The results of this air sparging process will lower the contaminants concentrations to acceptable levels and provide a good drinking water source.

The portion of the air sparging system in the trenches consists primarily of inverted "T" sections made of 4-inch stainless steel pipe. See Figure 2. Trench No. 1 has three sections, two are 60 feet long and the other 40 feet long. Trench No. 2 has five sections, four are 40 feet long and the other 60 feet long. All eight sections have a solid riser of approximately 30 feet. The horizontal pipe along the bottom of the trench has a series of one eighth of an inch diameter holes on its underside, each protected from clogging by its own piece of angle iron. All of the risers are connected to the hot air generating system in the equipment building via individual four inch stainless steel solid pipe which run underground and adjacent to each trench.

The two air sparging trenches are backfilled with SCDOT 89-M stone to within 3 feet of finished grade. The upper portion of each trench is comprised of a 2½ foot compacted clay layer and 6 inches of topsoil.

Just below the top of the gravel backfill is a 6 inch slotted corrugated high density polyethylene (CHDPE) pipe which runs along the entire length of the trenches. Each trench has two vents attached to this pipe which extend through the clay and topsoil layers to about 4 feet above the ground surface. The trenches also contain five 2 inch stainless steel peizometers. See Figure 3.

Attached to each stainless steel inverted "T" section is a similar shaped piping structure for trench development. These structures consist of a 6 inch perforated CHDPE pipe horizontal section the same length as its stainless steel counterpart and a 6 inch solid HDPE riser which extends to just a few inches below finish grade. Each trench also has two inch stainless steel trench wells to assist in trench development.

B-P slurry trench method

B-P drains are narrow, vertical trenches filled with permeable materials. They are typically used as extraction or interceptor trenches for the collection and/or removal of groundwater or as dewatering devices. For this particular project, the trenches function as an interceptor trench by intercepting the contaminate groundwater plume and allowing the air sparging system to remove the groundwater-borne pollutants.

B-P drains are constructed utilizing the slurry trench technique. A natural, organic polymer called guar gum is used during excavation in lieu of the more commonly used bentonite. In contrast to the bentonite slurry, the guar does not seal the trench walls. When the guar powder is thoroughly mixed with water a biodegradable, highly viscous, pseudo-plastic fluid is produced. The high gel strength of this guar slurry behaves similarly to a drilling fluid by transferring the hydrostatic pressure from the slurry to the trench walls.

Typically the slurry will last a day or two, depending on the groundwater and source water characteristics, soil properties, and temperature. There are additives available that when properly introduced and maintained may increase slurry life to as many as two weeks.

Once a trench has been backfilled, the trench development process begins as slurry in the trench begins to break down. The breaking process occurs by natural enzymes in the soil consuming the bio-polymer. The process may be expedited by introducing a breaker solution. Once the slurry has been broken, the trench becomes permeable and allows for the restoration of the site’s original hydraulic conductivity.

The B-P drain method is an excellent choice for trench construction, especially when compared with conventional techniques. The practice of dewatering a site and then using sheeting and shoring to support the trench walls is no longer advantageous for many reasons. The cost and duration of trench construction by the B-P drain are significantly less since no dewatering or sheeting and shoring installation are necessary. The B-P drain method also addresses the increasing importance of job safety in that no one ever enters the excavation. Another important factor in considering trenching methods is environmental impact. The B-P drain method allows for a much narrower trench construction than conventional techniques. This becomes especially important on contaminated sites, since much lower quantities of excavated spoils are created. Also, there are no water storage and/or disposal problems which arise from temporary dewatering systems.

Slurry production

The bio-polymer slurry for this project was produced by mixing fifty pound bags of dry guar gum and water in a 5 cubic yard, high speed, colloidal mixer. Once the mixture became fully hydrated, it was sent directly to the trench through a temporary hose. Throughout its production and use, the slurry was frequently monitored by a quality control engineer both in the mixer and the trench. Since the work was performed in the winter with low temperatures, the enzymes in the slurry were less active and therefore slowed the decomposition of the slurry and the need for any preservatives. Therefore, the design criteria for a workable slurry were easily maintained and/or exceeded throughout the entire project.

Trench excavation

A hydraulic excavator with a 3 foot wide bucket was utilized for the excavation of the 0% grade trenches. The slurry level was maintained at the ground surface and at not time allowed to fall below 3 feet from the top of the trench. Soils excavated from the trenches were temporarily stockpiled on visqueen on one side of the trench in such a fashion to allow any free liquid to drain back in to the open trench.

After setting a section of the air sparging system in the trench and progressively backfilling with stone, the slurry was displaced and flowed forward along with the ongoing excavation. This allowed for amore efficient excavation operation, as slurry production from the mixplant became less of a controlling factor.

Fabrication and installation

Once a portion of trench was excavated and verified at the design depth, an air sparging section could be placed. Each section was set using steel cables, I-beams and a spreader bar. The stainless steel riser of the inverted “T” section was first attached to the center of the spreader bar. An I-beam was then positioned, not attached, between the ends of the spreader bar and the ends of the horizontal stainless steel pipe of the ‘T” section. At the same locations, steel cable was wrapped around the spreader bar and horizontal pipe and tied off. The steel cable kept the bottom of the “T” section horizontal, preventing sagging. The I-beams were utilized to maintain rigidity in the structure.

The HDPE development pipe was then attached to the stainless steel “T” section using plastic tie straps. Trench wells and piezometers were attached at the specified stations in a similar fashion.

An important concern in the installation and final placement of the sections was keeping them from resting against the trench walls. After being instructed to keep the sections a minimum of 6 inches from the trench walls, this concern was eliminated by wrapping 6 inch diameter CHDPE pipe around the sparge and development piping in several locations. These devices acted as spacers, insuring that the sections would be set at a minimum of 6 inches from either side of the trench walls.

After verifying all the dimensions of the piping structure, it was now ready to be placed in the trench. Placement was achieved through the utilization of a truck crane. The structure was attached to the crane's lifting hook using slings which had been installed along the spreader bar.

The section was lifted by the crane and carefully moved until its bottom was within a couple of feet of the trench slurry. At this time, water was pumped into the opening on top of the sparge pipe riser and allowed to fill up the sparge pipe. As the water continued to feed the pipe, it began to simultaneously run out the holes along the bottom of the horizontal pipe. The holes were then inspected to insure they were all unobstructed. After a final inspection, the section was slowly guided and submerged into the slurry filled trench. The section was lowered until the specified elevation was obtained and approved. The section was then secured by placing wood beams across the trench under the spreader bar. Additional beams were added until the entire section was blocked off and fully supported. The crane was then unhooked and trench construction continued.

Backfilling

After setting the first piping section, excavation for the next section proceeded. Once another portion of trench was excavated to design depth, the trench backfilling operation began. The backfill specified was a washed SCDOT 89-M stone. The stone was first placed at the beginning of the trench using a front end loader. It was slowly sifted from the loader bucket into the top of the trench and allowed to fall like a gentle rain to the bottom of the trench. Once the trench was full, backfilling was able to proceed more quickly by letting the stone flow down its naturally formed slope. Once a piping section was fully bedded in the stone, the spreader bar was removed and used to fabricate another section.

Trench development

Upon completion of the stone backfilling operation, the slurry in the trenches was ready to be broken. Slurry degradation was achieved by pumping the slurry through the HDPE development piping to a series of frac tanks, where it was circulated and then returned to the top of the trench. The slurry would then flow down through the stone to the trench bottom, where it would be drawn up through the development piping and start the process all over again.

Due to the low temperatures which retarded slurry breakdown, an enzyme breaker solution was introduced to the trench slurry via the development piping and trench wells. A minimum of three pore volumes was circulated for each trench. By examining water samples and monitoring the water level in the trenches, proof was obtained that the slurry had been turned into simple sugar water and that the groundwater table at the trenches had returned to pre-construction levels. All slurry used during construction was broken in about four days. No off site disposal was necessary.

Project completion

Upon completion of the gravel backfill placement and development of the system, 6 inch slotted CHDPE pipe was placed just below the top of the gravel layer along the entire length of each trench. Two vertical, vent pipes were then connected with tees to this pipe in each trench. After the gravel backfill was hand graded to an elevation 3 feet below final grade, a layer of filter fabric was place over the top in both trenches. Next a 2½ foot compacted clay cap was installed in 6 inch lifts. The remaining 6 inches was filled with topsoil in order to facilitate future seeding. Trench construction was completed by setting the trench well covers and constructing concrete pads for both the trench wells and vent pipes.

The stockpiled spoils from the trenches were hauled to the designated on-site disposal area. This area was then compacted and fine graded. All disturbed areas were restored and thoroughly cleaned up prior to the final removal of equipment, materials and personnel.

Conclusion

The installation of an in-situ air sparging system may be effectively installed through the utilization of the bio-polymer slurry trench method. The use of a biodegradable slurry allowed for the temporary support of the trench walls during the backhoe trenching operation. Upon reaching design depth, the air sparging components were submerged in the trench and then backfilled with stone. Through natural enzyme action, the slurry was broken down into a simple sugar water. The development process was expedited by introducing a breaker solution to the slurry and then subjecting it to circulation. Groundwater sampling and measurements confirmed that the water had been returned to its preconstruction characteristics and elevations. No off site disposal was necessary.

Clearly, the bio-polymer slurry trenching technique offers viable alternative to more traditional methods by offering a shorter project duration, cost savings, and safe working environment. The successful completion of this project demands that the B-P drain method receive more consideration in future civil and environmental applications.

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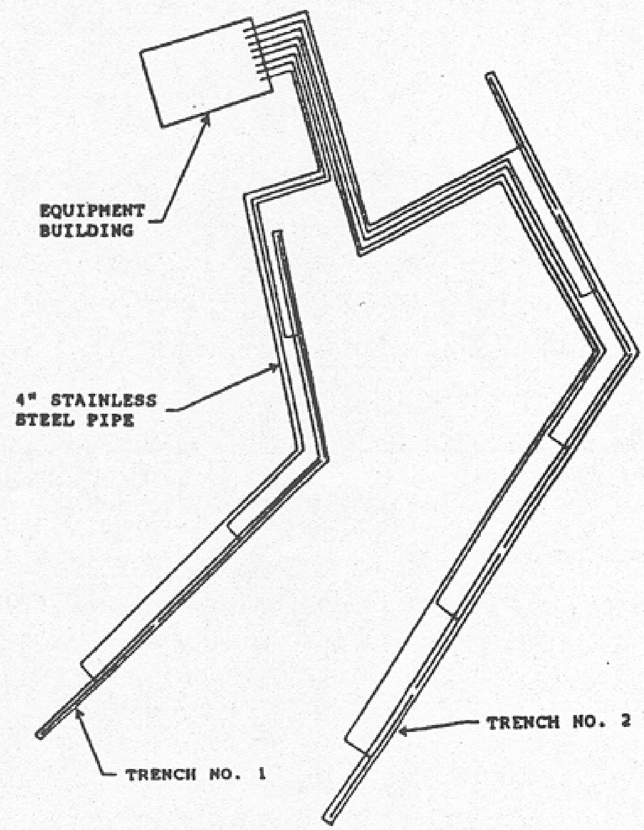

Figure 1: Site layout

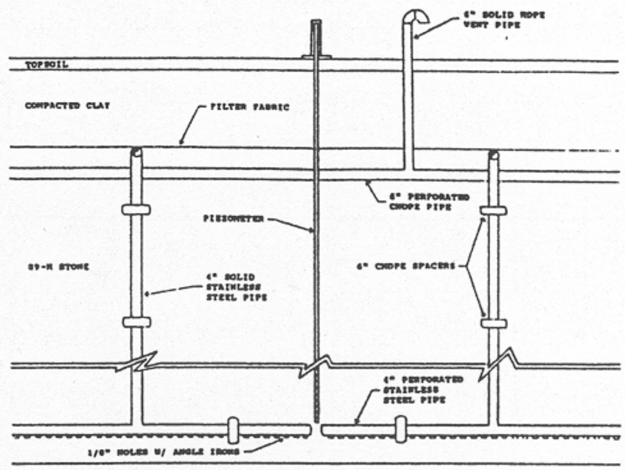

Figure 2: Typical trench section

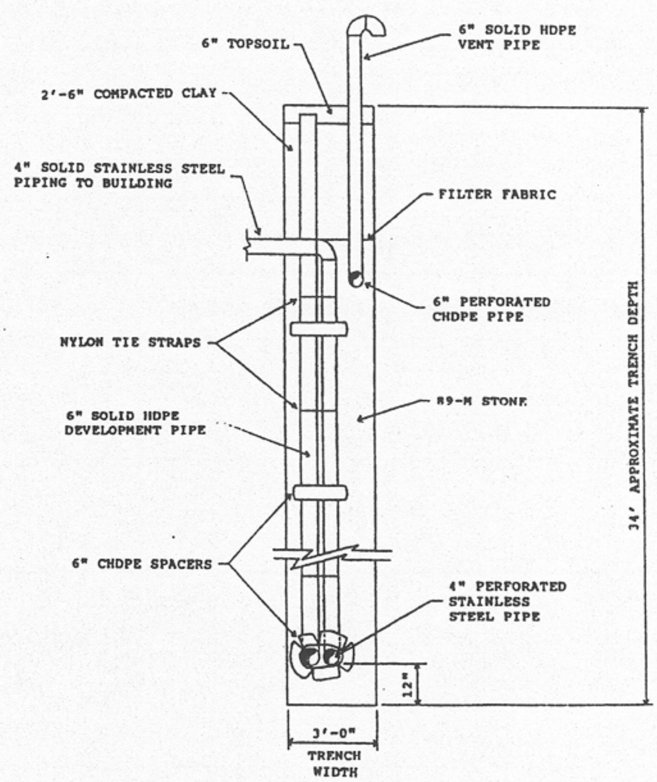

Figure 3: Typical trench cross section