RADIAN INTERNATIONAL
A DAMES & MOORE GROUP COMPANY

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November 8, 1999

Mr. David Crosby
Environmental Remediation
New York State Department of Environmental Conservation
50 Wolf Road, Room 267
Albany, NY 12233-70

Subject: **Pilot Test Work Plan for the former Miller Container Site located in Fulton, NY**

Dear Mr. Crosby:

At Miller Brewing Company's request, Radian conducted an in depth review of the applicability of innovative technologies at the former Miller Container Site in Fulton, NY. Radian's review determined that an iron permeable reactive wall (PRW) would be effective at this site. Innovative technologies such as PRWs provide an opportunity to improve the effectiveness of remediation, and replace older less effective systems such as the pump and treat system used at the Fulton site. PRWs are proven effective for the contaminants of concern at this site, and will effectively address subsurface heterogeneity at this site by placing a continuous wall across zones of contamination. We anticipate the PRW will significantly reduce or stop the migration of contaminants to the Fulton municipal well field, and will better meet the objectives of the Record of Decision for this site.

During our meeting with the New York State Department of Environmental Conservation (NYSDEC) on October 15, 1999, Radian, on behalf of Miller Brewing Company, proposed a pilot test to demonstrate the effectiveness of a PRW at the Fulton site. The Pilot Test Work Plan you requested for the PRW pilot test at the site is attached. A table summarizing Radian's experience using similar innovative technologies is provided for your review.

We look forward to working with you on this project. If you have any questions, please call me at (414) 327-8246.

Sincerely,

James Imbrie

James Imbrie, PE
Senior Engineer

Cc Mr. Tom Eplett, Miller Brewing Company
Ms. Henrietta Hamel, New York State Department of Health
Mr. David Hawthorn, City of Fulton
Mr. Charles Branaugh and Mr. John May, NYSDEC

Pilot Test Work Plan

Former Miller Container Plant
Fulton, NY

Prepared for:

Miller Brewing Company
3939 W. Highland Avenue
Milwaukee, WI 53201-8322

Prepared by:

Radian Remediation and Operating Services
10150 W. National Avenue
Milwaukee, WI 53227

November 8, 1999

Objectives

Radian will conduct a site-specific pilot test to evaluate the effectiveness of a PRW for the remediation of this site. We will prepare a full scale PRW design based on the outcome of the pilot test. The pilot test and design has six (6) objectives:

1. Determine iron reductive dechlorination rates for contaminants in groundwater at the site;
2. Identify byproducts generated by the wall;
3. Make recommendations regarding the type of iron to use;
4. Estimate groundwater velocity through the wall;
5. Estimate wall formation and shape; and
6. Determine optimal reactive wall configuration.

We will achieve these objectives in three (3) phases: Bench Scale Testing, Permeable Reactive Wall Installation, and Performance Monitoring and Design. Each phase is described below.

Scope of Work

The scope of the PRW pilot test includes:

- Bench-scale testing using groundwater from the site and different types of iron;
- Installing a zero valent iron filing test wall;
- Collecting and analyzing groundwater samples from monitoring wells; and
- Designing a full scale PRW system.

Phased Approach

Phase 1 – Bench Scale Testing
Laboratory bench scale studies will be conducted to determine the effectiveness of iron filings in treating contaminated groundwater at the site. As a part of the studies different types of iron filings will be tested to determine the best media to be used at the site for the test wall. The bench scale studies will consist of batch and column tests.

Batch Tests
Batch tests will compare the reactivity of different types of iron. Groundwater collected from the site will be treated with iron (and guar), and placed in serum bottles with zero headspace. The analyte (i.e., 1,1,1 TCA, PCE, and their daughter products) levels will be measured periodically, over a one to three-day period. Tests will be performed for a control and up to four (4) types of iron. The iron tested will be based on grain size analysis, and installation considerations. The most cost-effective iron for the pilot test wall will be selected based on the results. We will also conduct batch tests to identify guar and breaker mix designs. We currently plan on using an enzyme breaker that most closely suits site conditions, either Rantec LEB-4 or LEB-H (see attachment).

Column Tests
Column tests will consist of passing groundwater through columns of iron and soil that approximate test wall and site conditions. Samples will be collected periodically from influent, effluent and intermediate sample ports in the column. Samples will be analyzed for the following organic and inorganic parameters:

- BOD_5 (SM 5210B)
- Calcium, Magnesium, Manganese, Iron (EPA 200.7)
- Alkalinity (EPA 310.1)
- TDS (EPA 160.1)
- VOC (SW 846 Method 8021)

Sample results will be evaluated to identify half-lives of the contaminants of concern, the potential for precipitation; degradation products generated, and estimate the amount of iron required.

Phase 2 – Permeable Reactive Test Wall Installation
A full-scale zero valent iron test wall will be constructed as shown in Figures 1 and 2. The test wall will be about 80-feet long and extend to a depth of about 80 feet. The test wall will be installed directly up-gradient of groundwater recovery well RW-2. This location was selected based on the following:

- Recovery well RW-2, and the wells surrounding RW-2 have the highest concentrations of PCE and 111 TCA at site, and will provide a worst case scenario with regard to contaminant levels;
- The high groundwater recovery rate at RW-2 will increase groundwater velocities in the vicinity of test wall and will provide a worst case scenario for groundwater velocities;
- The higher groundwater velocities near RW-2 will allow for reasonable duration for the pilot test;
- The higher velocities near RW-2 are similar to those near the municipal well field where we are considering placing a PRW; and
- The test wall is located so it can be incorporated into the full scale PRW.

The depth of contamination, up to 80 feet, complicates the construction of a PRW at the site. Because of the difficulty associated with traditional construction techniques at an 80-foot depth, Radian will use high pressure jetting to install the PRW. This approach has minimal disruption to the ground surface, and also eliminates the generation of waste soils associated with standard trenching techniques. We conducted preliminary sampling at the site using some of the jetting equipment. The preliminary test was successful and suggests this alternative for PRW installation can be used at this site. At this time, we anticipate the test wall would be constructed by jetting iron into about ten vertical panels with a "Y" configuration. The panels would extend upward about 20-feet from the till that acts as a lower confining layer at the site.

Geophysical testing using radiowave imaging (RIM) will be conducted before and after construction of the test wall. The testing will be used to confirm that the test wall generally meets requirements for panel height and thickness.

Following the wall installation Radian will install temporary monitoring wells at the locations shown in Figure 1 using a direct push rig. Three 2-inch wells will be placed in each of two locations; up gradient, and down gradient of the PRW test wall, two 1-inch monitoring wells will also be placed in the test wall (8 wells total). The wells would be screened over a 20-foot interval from about 60 to 80 feet below ground surface. In addition we would place a 1-inch well down gradient and just above the PRW test wall to monitor the potential for groundwater mound up and go over the top of the wall. This well would be screened from about 60 to 65 feet bgs. Wells would be constructed of Schedule 40 PVC. We would use existing monitoring wells when possible.

At this time we would also packer off the shallow screen at RW-2, to stop groundwater flow over the wall that might be induced by pumping from the shallow screen.

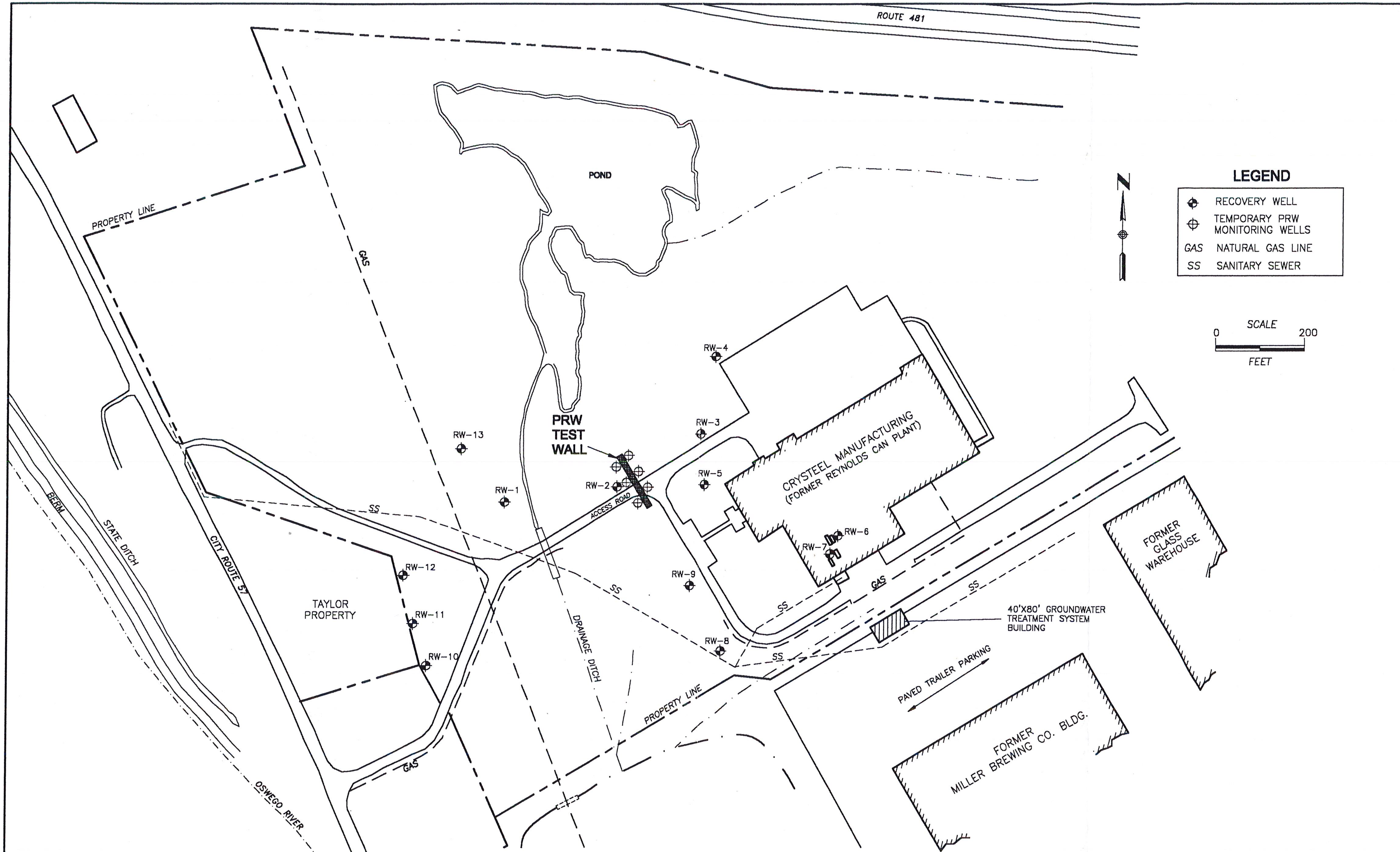
Phase 3 – Performance Monitoring and Design
Performance monitoring includes the collection of groundwater samples from the PRW monitoring wells to identify changes in contaminant levels at the test wall. We will collect baseline samples from the up gradient, in wall, and down gradient wells. Thereafter, samples will be collected periodically for up to a six-month period. The samples will be analyzed for the following organic and inorganic parameters:

- BOD_5 (SM 5210B)
- Calcium, Magnesium, Manganese, Iron (EPA 200.7)
- Alkalinity (EPA 310.1)
- TDS (EPA 160.1)
- VOC (SW 846 Method 8021)

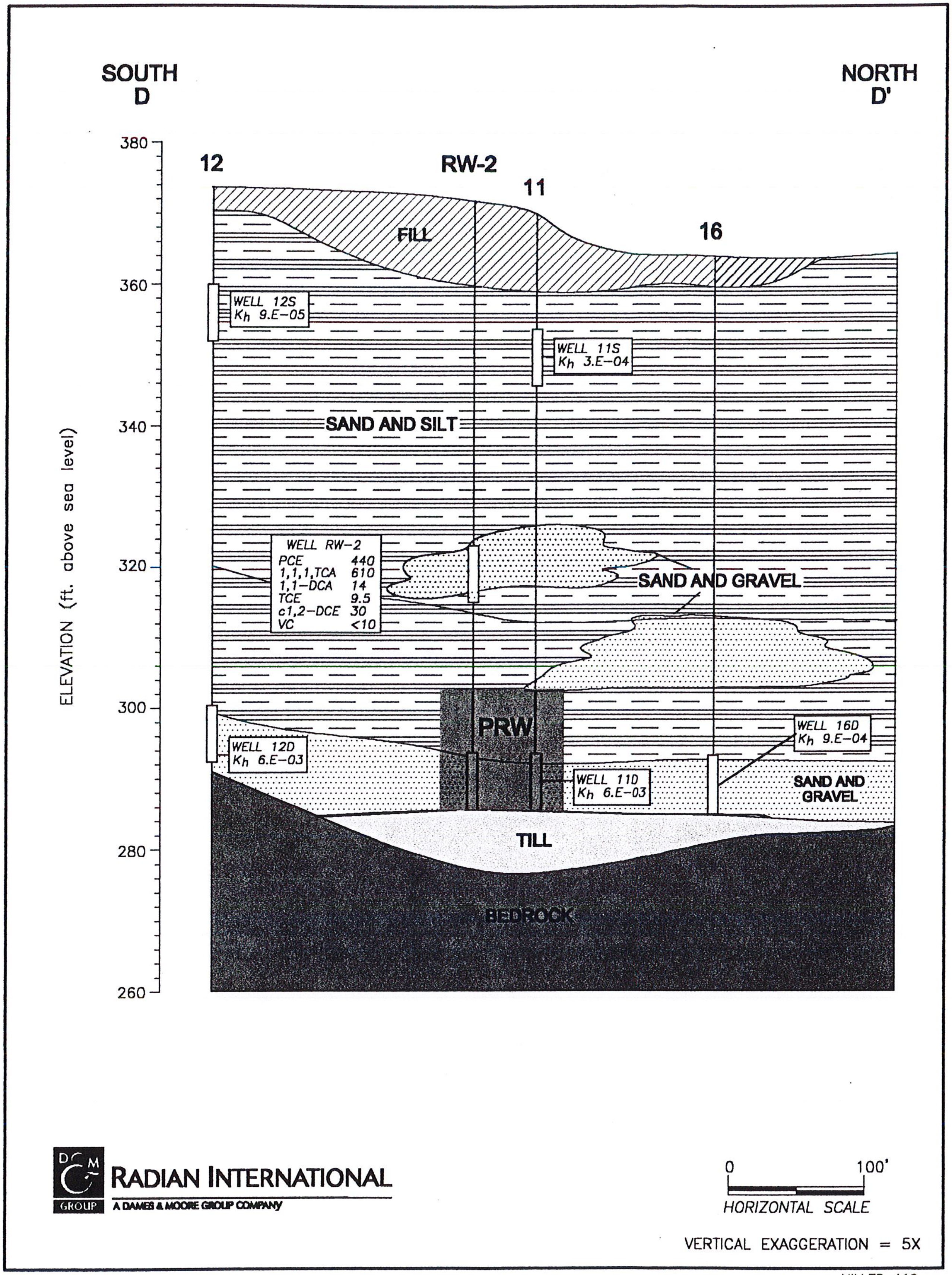
Analysis for VOCs would include QA/QC duplicate and trip blanks. The results will then be evaluated and presented in a pilot study and design report. The report will discuss the pilot test results, quantify design parameters, address design issues, and present a final design.

Schedule

A schedule for the pilot study is presented in Figure 3. If we initiate the bench scale testing phase in November 1999, we should be able to complete the field injection, this fall, and complete the performance monitoring and design by the spring of 2000. Construction of the full-scale permeable treatment wall system would begin in the summer of 2000.



PREPARED FOR **MILLER BREWING COMPANY MILWAUKEE, WISCONSIN**	CONFIDENTIAL–ALL RIGHTS RESERVED–PROPERTY OF **RADIAN INTERNATIONAL** A DAMES & MOORE GROUP COMPANY MILWAUKEE, WISCONSIN 53227	SCALE AS SHOWN DRAWN BY RFW / DATE 10/22/99 CHECKED BY JI / DATE 10/22/99	DRAWING TITLE **FIGURE 1 PRW TEST WALL LOCATIONS** CAD DRAWING FILE: MILLER/B3 PROJECT NO. 80374901 DRAWING NO. B-3

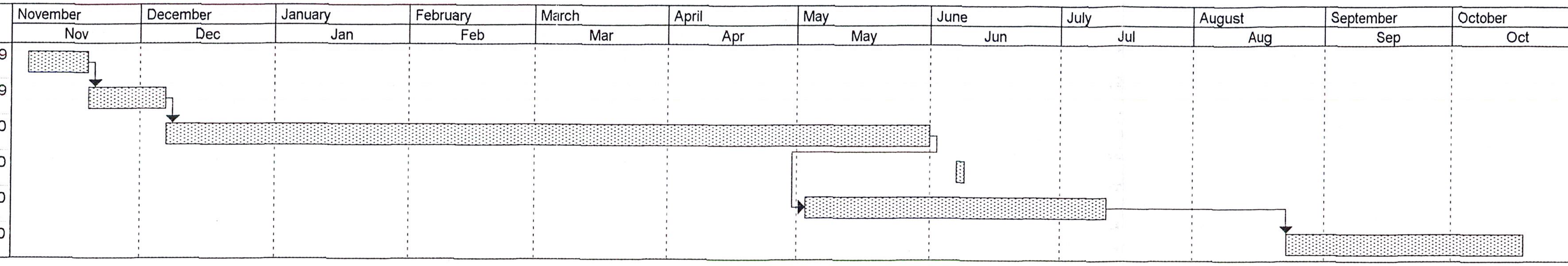


MILLER-A10

FIGURE 2. PRW TEST WALL

Figure 3
Pilot Test Schedule
Former Miller Container Site, Fulton, NY

ID	Task Name	Start	Finish
1	Bench Scale Testing	Fri 11/5/99	Thu 11/18/99
2	PRW Test Wall Installation	Fri 11/19/99	Mon 12/6/99
3	Performance Monitoring	Tue 12/7/99	Wed 5/31/00
4	Presentation to NYDEC	Wed 6/7/00	Thu 6/8/00
5	Pilot Study and Design Report	Wed 5/3/00	Tue 7/11/00
6	System Installation	Wed 8/23/00	Tue 10/17/00



Project: Miller Brewing Co. - Fulton NY :
Date: Tue 10/26/99

Task | Split | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Split | Rolled Up Milestone | Rolled Up Progress | External Tasks | Project Summary

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BREAKING BIOPOLYMER LIQUID SHORING SYSTEMS

COMPONENT BREAKDOWN

THIS INFORMATION IS CONFIDENTIAL AND PROPRIETARY TO RANTEC CORPORATION AND MAY BE USED ONLY WITH EXPRESS PERMISSION.

BACKGROUND

Biopolymer liquid shoring systems typically are made up using a fresh water solution of guar gum. This fluid has viscosity, rheological and cake-building characteristics, which aid in maintaining stability of open excavations. It is used in lieu of clay based fluids because it is bio-degradable and does not reduce permeability of the surrounding formations nor gravel packs installed in the excavation. During the course of construction of a trench system using liquid shoring it is necessary to prevent loss of viscosity and other essential characteristics of the biopolymer solution with appropriate additives for preservation of the solution against microbial attack.

Following completion of the construction sequence, biopolymer solution that is leftover will require disposal. Remaining fluid may come from the last panel, may be extracted or may remain in the gravel or sand pack. Disposal means will be varied. Pre-treatment of the remaining fluid may include break of viscosity and destruction of the preservative additives. There are a number of means for accomplishing these degradation steps and are chosen to suit the local circumstances.

Optimizing Biopolymer Breakdown

The breakdown of Biopolymer (guar gum) liquid shoring fluid or grouting gel is an important, but often overlooked part of the construction sequence. Breakdown can be greatly enhanced by proactive measures. Recent research has developed a series of steps to assure complete breakdown.

<u>BACKGROUND</u>
Rantec G150 biopolymer, guar gum, is used to assist in the placement of a wide variety of granular materials. Solutions of G150 are used in oil and gas well stimulation to carry proppant sand, in jet grouting to carry sand or reactive iron, in soil mixing to carry reactive iron and in trenches as liquid shoring to stabilize excavations prior to placement of drain rock or reactive iron. In each case fluid flow through the granular media after placement is essential.

Permeability of the granular medium determines full performance of the installed system. Production of oil or gas is permeability dependent. Recovery of contaminated groundwater requires good permeability. Full reactivity of iron is dependent on even and full groundwater flow through the bed.

Final permeability of each type of granular medium depends upon the reduction of polymer (guar gum) molecular weight. Earlier experience dictated that breakdown of G150 fluid viscosity to near that of water would be adequate. Recent research by major oil service companies, however, shows that improvements in permeability can be obtained by further reductions in molecular weight, beyond those observable on the macroscopic level using viscosity alone as an indication.

Molecular weight of guar gum has recently been measured as 1,500,000 or greater. Because viscosity production is an exponential function of molecular weight (m.w.), low viscosity fluids can still contain large portions of polymer at 300,000 m.w. This level of m.w. is sufficient to reduce permeability of granular packs.

BREAKDOWN TECHNIQUES

A number of techniques and products are available to improve the reduction of molecular weight (as breakdown is better named). These include maintaining optimum conditions for enzyme activity, specifically pH and temperature; proper enzyme choice; adequate enzyme dosage; multiple enzyme additions and optimizing conditions for biological consumption.

Conditions

Temperature and pH conditions strongly control the ability and rate of enzyme bond breaking activity. Enzyme activity increases with temperature up to approximately 140°F. Enzymes have optimum activity that is pH dependent. **Figure 13 Break Activity vs pH** shows the ideal pH ranges for Rantec LEB-4 and LEB-H. The use of acid or alkali to adjust pH to the optimum range will greatly increase the ability of the enzyme to reduce molecular weight. In situations where adjustment of pH is difficult or not possible, proper enzyme choice can be made to most closely suit the conditions.

Dosage and Additions

Enzymes are macro molecules consisting of amino acids (proteins) that act like fitted keys to unlock polymer bonds. They continue to break bonds but are eventually destroyed by natural forces. Adequate dosage of enzyme is required to assure that enzymes continue to be present until the polymer is broken. Multiple additions of enzyme assist in continued molecular weight reduction by replacing those molecules of protein that have been lost or destroyed.

Biological Breakdown

Under proper conditions biological activity can produce the greatest destruction of polymer molecules. Many microbes are able to metabolize the guar molecule and in doing so first must reduce the molecule to simple sugars. Subsequent metabolic activities use the simple sugars for cellular activity, producing CO2, water and cell bodies. Ideal biological conditions for polymer breakdown are warm temperature (70 to 110°F), pH 5 to 7, adequate dissolved oxygen and prior removal of biostats such as T142.

Good distribution of the breaker into the liquid shoring is important. LEB-4 and LEB-H are first diluted 100:1 and placed evenly in the fluid. Circulation with pumps will assist in mixing the enzyme with the fluid.

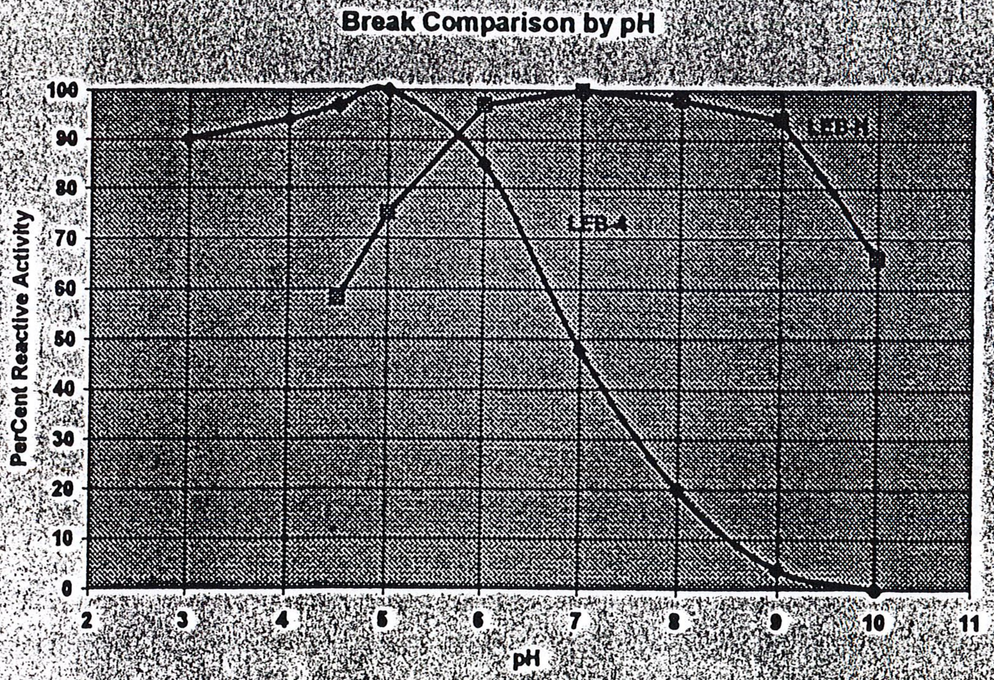

Figure 13 Break Activity vs pH

Chlorine Break

Introduction of free chlorine into the liquid shoring fluid begins destruction of the guar molecule by an oxidation reaction. During this process bonds between sugars within the guar molecules are broken, thus reducing the viscosity of the fluid. Free chlorine is consumed, combining with cations in the fluid. Free chlorine may be produced safely from dry calcium hypochlorite or liquid sodium hypochlorite. A level of 500 ppm free chlorine will rapidly break the guar molecules.

Optimum pH for chlorine break is less than 5.5. Good distribution of the hypochlorite is essential for efficient breaking action. Calcium hypochlorite is mixed in a water solution prior to use.

Following break of the viscosity of the fluid there will remain oligosaccharides from the guar molecules. The fluid will be sterile due to the action of chlorine against any microorganisms in the fluid. Any further breakdown of the soluble oligosaccharides will require bio-reduction.

Other Break Systems

Other specialized systems may be used for breaking G150 slurry and for breaking synthetic slurry. Please contact Rantec engineers for assistance in special applications.

PRESERVATIVE BREAKDOWN

Troysan 142:

T142 (3,5-dimethyltetrahydro 1,3,5 2H-thiadiazine-2-thione) may be broken with oxidizers. Two systems have been developed to offer alternatives.
Chlorine - Addition of free chlorine from calcium or sodium hypochlorite at a level of 500 ppm will quickly destroy T142.
Hydrogen Peroxide at 100 ppm will also quickly destroy T142.

T142 is reduced to ammonia and sulfate compounds due to the action of the oxidizer system used. Specific compounds will depend upon other ions present in the fluid and should be determined by empirical testing.

Dimet:

Buckman Laboratories' Dimet (Potassium Dimethyldithio-carbamate) is a naturally unstable preservative. In use, Dimet must be maintained at a pH level of greater than 9.0. Reduction of the pH to less than neutral will de-stabilize the compound dropping its half life to a few hours. Simple sulfate salts, carbon dioxide and water result.

DISCLAIMER

Due to the complex and variable nature of liquid shoring fluids thickened with Rantec G150, it is not possible to predict the final composition of fluids used for this purpose. Variability sources are water source contaminants, ground water contamination and soil contamination. Each site and excavation must be evaluated empirically to determine the exact nature of remaining liquid shoring fluid. Rantec Corporation provides the above information as general guidelines only and makes no warranty or representation as to the exact nature of fluids used in the liquid shoring process or processed or broken with any of the above techniques nor the suitability of any fluid or process for any particular application.

PRW Related In Situ Groundwater Treatment Projects

Site Description	Treatment Description	Treatment Effectiveness	Installation Technology	Consultant/Contractor
A site in Alabama has TCE and PCE as the contaminants of concern. The aquifer consists of a fine-grained sand with approximately 15% silt at the depth of contamination and a has groundwater velocity of 25 - 58 ft/yr.	Permeable reactive wall composed of iron filings and guar gum was installed 75' below ground surface. The wall consists of panels measuring approximately 20' high and 10' to 20' long with thickness varying from 1" to 3".	Concentrations were reduced from 700 ppb to 40 ppb 10 months after installation.	High pressure injection	Radian with subcontractor for construction
Contaminated aquifer is in Ontario, Canada with a groundwater gradient approximately equal to zero. Contaminants of concern are hexachlorobutadiene, carbontetrachloride, TCE, PCE, DCA, DCE, and vinyl chloride.	Injection of fine iron filings, guar gum, oxygen release compound, and live bacteria in a saturated area 80' wide x 180' long x 16' deep.	A reduction of 50% in concentration over a period of two months, and the project is currently on-going.	High pressure injection	Radian (Mobile Field Services)
A site in Utah has groundwater contamination with chloroform, bromodichloromethane, bromoform, and dibromochloromethane as contaminants of concern. Virtually no groundwater gradient is present at the site.	Injection of fine iron filings and guar gum directly into a plume measuring 25' wide x 85' long x 8' deep.	Concentrations were reduced in three months and the regulatory agency has accepted the site for closure.	High pressure injection	Radian (Mobile Field Services)
A site in Colorado has TCE and PCE as the contaminants of concern. The aquifer present at the site is a tight clayey sandy silt with virtually no groundwater gradient.	Three permeable reactive walls composed of iron filings and guar gum were installed with dimensions of 25' wide x 8' tall. The walls were installed 20' below ground surface. HRC was also injected at a later date.	Project is currently on-going. Low flow system containment with wall, additional in situ enhancement.	High pressure injection	Radian (Mobile Field Services)
A site in Utah has groundwater contamination with TCE, PCE and related compounds as the contaminants of concern.	A 400' permeable wall was constructed from a depth of 30' up to the ground surface. The wall is 3' wide and is composed with pea gravel and guar gum. Air is being injected to remove contaminants.	Project is currently on-going. Results to date are 99% removal after two years of operation.	Open trench construction	Radian with subcontractor for construction
A site in Colorado has groundwater contamination with TCE, PCE, and other chlorinated hydrocarbons as the contaminants of concern.	A permeable reactive wall in a funnel and gate configuration was constructed to a depth of approximately 18' below ground surface. The permeable reactive wall was composed of iron filings.	Concentrations of chlorinated hydrocarbons were reduced to below detection levels.	Open trench construction	Dames & Moore with Envirometal Technologies