PERMEABLE TREATMENT WALL PILOT PROJECT AT THE WEST VALLEY DEMONSTRATION PROJECT

Herman R. Moore, U.S. Department of Energy;
Robert E. Steiner II, Beth A. Fallon, Craig L. Repp,
Mark R. Hemann, Erik W. Helffenstein
West Valley Nuclear Services Co.;
Dr. Alan J. Rabideau, University of Buffalo, New York

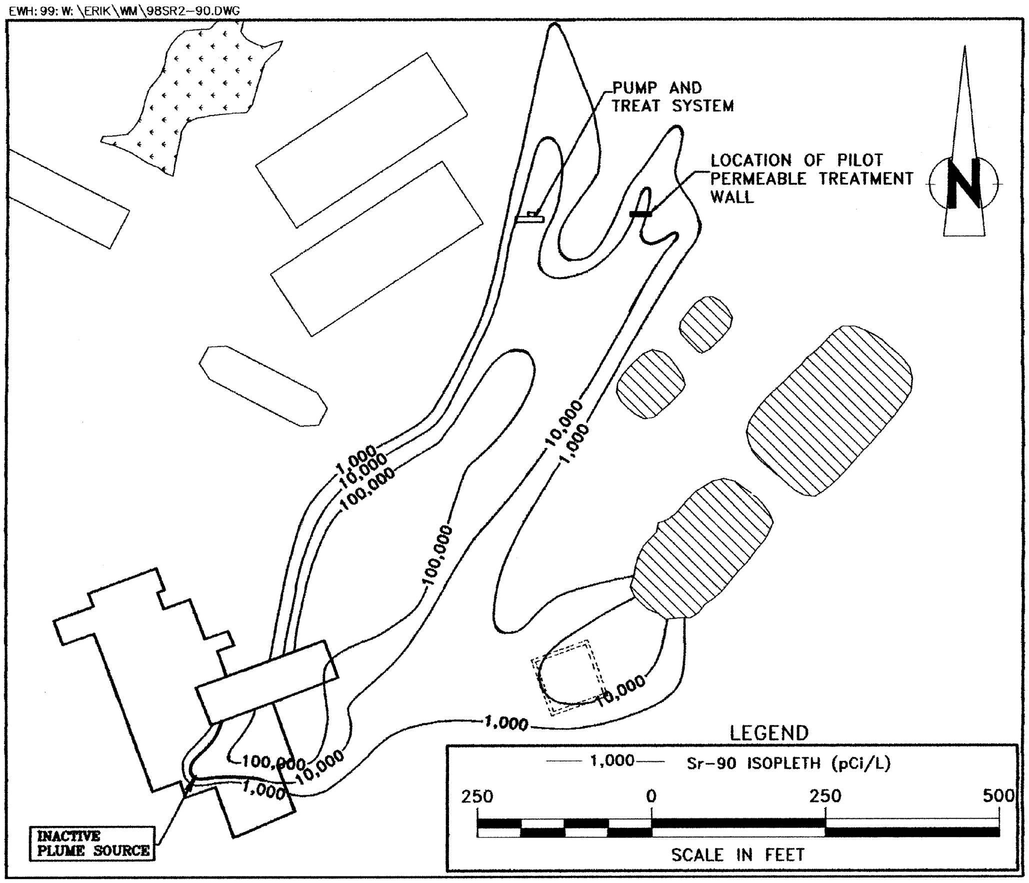
ABSTRACT

Treatment wall technology is increasingly being recognized as an effective means of mitigating groundwater contamination at sites worldwide. A pilot permeable treatment wall (PTW) project has been developed for mitigating strontium-90 (Sr-90) contaminated groundwater at the West Valley Demonstration Project (WVDP) in West Valley, New York. This PTW uses two technologies, ion exchange and in-situ treatment to remove Sr-90 as groundwater flows passively through the wall. Deployment of the pilot PTW project marks the culmination of a series of laboratory and bench-testing programs and conceptual design efforts. It also represents a collaborative effort among technical and scientific experts from industry, academia, the United States Department of Energy (DOE) and West Valley Nuclear Services (WVNS) to match an innovative technology with an existing remedial need.

The key elements of the design process are summarized to indicate how the 9 meters long by 2 meters wide by 8.5 meters deep excavated area was selected as the most effective size, location, and configuration for the pilot PTW. Additionally, the methodology used to select clinoptilolite (CH 14 x 50), a natural inorganic zeolite, as the in-situ treatment media is presented. Results from bench testing at a variety of laboratories indicates the wall design to have an effective operating lifetime of more than 25 years. The assessment program for confirming wall performance during its operational phase is outlined, followed by a discussion of potential future uses of this type of PTW at other locations at the WVDP site.

BACKGROUND AND HISTORY

The West Valley Demonstration Project (WVDP) is located at the site of the only commercial spent nuclear fuel reprocessing plant ever operated in the United States. The North Plateau refers to a geographic area within the WVDP site that includes the former reprocessing plant building. From a geologic standpoint, the North Plateau contains an upper sand and gravel water bearing unit isolated by surrounding stream valleys. Groundwater seepage occurs on the face of the plateau as the topography drops off, and in low lying areas. A radioactive groundwater plume emanates from beneath the former reprocessing plant building in a northeasterly direction on the plateau. The sand and gravel unit is underlain by a clay-silt till that inhibits any downward contaminant migration. The extent of the plume is shown in Figure 1. The plume's source has been traced to a leak in a process line that occurred during reprocessing operations (1968-1971), approximately ten years before the Department of Energy was authorized by Congress to begin the WVDP. Radioactive contamination from the leak has migrated very slowly in a northeasterly direction over the last 30 years. Extensive sampling and analysis identified strontium-90 (Sr-90) as the primary contaminant associated with the plume. The area of contamination southeast of the main body of the plume is associated with a former unlined retention basin.



Sr–90 Groundwater Plume at the West Valley Demonstration Project

Figure 1

In 1994, a field investigation was conducted to address increasing gross beta trends at a plateau surface water monitoring point. Following delineation of groundwater contamination, evaluations were undertaken to identify a treatment technology that could be applied relatively quickly and be effective while retaining the ability to implement other mitigative treatment technologies in the future. These evaluations led to the decision to install a groundwater pump and treat system across a preferential pathway near the western lobe of the plume's leading edge as an initial mitigative effort. This system uses three recovery wells to collect contaminated groundwater for ex-situ treatment with ion exchange resins. Pumping rates are weather dependent, ranging from several to more than 91 liters per minute during periods of heavy rainfall. Resin change out produces about 74 cubic meters of low-level radioactive waste per year. Although the system effectively mitigates Sr-90 surfacing near the plume's leading edge, maintaining optimum capture is both challenging and resource intensive. Extensive evaluations were undertaken to help identify an alternative technology that achieves more comprehensive Sr-90 mitigation with lower maintenance and operating costs. Through this process, treatment wall technology was selected as a technology that can better handle the seasonal fluctuations in groundwater hydrogeology and improve overall leading edge controls.

Beginning in August, 1999, a pilot PTW wall approximately 9 meters long by 2 meters wide by 8.5 meters deep was deployed on the North Plateau at a location where the Sr-90 plume narrows near its leading edge. This area is known as the 2nd Lobe of the plume. The pilot PTW installed at this location uses a natural inorganic zeolite, clinoptilolite (CH 14 x 50) as the treatment media.

METHODOLOGY

PTW technology has been demonstrated to be an effective method of groundwater remediation at several sites around the world. Most existing PTWs have been designed to remediate volatile organic contamination using zero valent iron for a treatment medium. The Chalk River site in Ontario, Canada is using a treatment wall with zeolite and a wall-and-curtain design to remove Sr-90 from groundwater. (1) PTW technology has been considered to be a potentially effective remedial tool for use at the WVDP.

In 1994, an initial round of bench-scale laboratory tests at Brookhaven National Laboratory (BNL) was conducted to identify what medium was best suited for strontium removal from WVDP groundwater. (2) Several natural zeolites and metal oxides were batch tested by placing the media in contact with WVDP groundwater spiked with Sr-85. The removal of Sr-85 was measured with respect to time. Five of the most promising results were further examined by column testing. WVDP groundwater was pumped through media-filled columns at in-situ groundwater velocity to determine the strontium sorption capacity (Kd) of the media. Column test data indicated that 20 x 50 mesh clinoptilolite, a natural zeolite, was the most effective and affordable treatment material, yielding an average Kd of 650 mL/g.

Column test Kd measurements were used to estimate the life span of the PTW. The Disposal Unit Source Term (DUST) model, a one-dimensional solute transport model developed at BNL, was used to determine Kd from column test data and to simulate Sr-90 transport and effluent concentrations through the PTW. An effluent concentration of 100 pCi/L was used as the life span endpoint. Based on bench-test Kd data and site hydrogeologic conditions, a PTW with a one meter wall thickness was estimated to have a 11.5-year life span.

Independent tests of clinoptilolite were also performed by the DOE Hanford site in 1996. (3) Hanford bench-test results were even more supportive of the ability of clinoptilolite to remove strontium from groundwater through PTW technology, with batch testing yielding an average estimated Kd of 2,650 mL/g.

In 1999, additional batch and column testing of 20 x 50 mesh clinoptilolite was performed by researchers at the State University of New York at Buffalo (UB) Department of Civil, Structural, and Environmental Engineering to provide confirmation of previous testing data. (4) WVDP groundwater was spiked with non-radioactive strontium prior to contact with the clinoptilolite. Batch test results yielded a Kd of 2,965 mL/g. A Kd of 2,030 mL/g was determined from four column tests run for 10, 20, 40 and 60 days. These Kd results were fairly similar to the Hanford tests.

A one-dimensional advective-dispersive-reactive model was used to determine column test Kds and estimate PTW life span. Column test Kd data and WVDP hydrogeologic information from the proposed pilot PTW location provided input to the model. Modeling results indicated a life span of more than 25 years for a 1.5 meter thick (in the direction of groundwater flow) clinoptilolite wall. The life span endpoint for these calculations was 1,000 pCi/L. Hydraulic conductivity testing indicated greater permeability of the 14 x 50 mesh than 20 x 50 mesh clinoptilolite. The 14 x 50 mesh clinoptilolite was used for pilot PTW construction.

Results from the UB testing program, a review of technical issues, regulatory requirements and stakeholder concerns were included in a deployment assessment report for the pilot PTW. This report was developed to help with the decision making process. No obstacles to deploying a pilot PTW were identified in the report. Based on this report, positive results from the UB testing, and concurrence from independent experts on the approach and design concept, the decision was made to move forward with the PTW pilot project.

A fairly simple design configuration was developed for wall installation that used a sheet pile cofferdam setup and conventional construction equipment. Figure 2 shows a typical cross section of the wall.

Installation involved placing clinoptilolite and pea gravel into an excavated area approximately 9 meters by 2 meters wide by 8.5 meters in depth with structural support from Type-48 sheet piling. Using this sheet piling eliminated the need for internal bracing (i.e., internal support within the cofferdam) allowing workers to stay out of the cofferdam and away from any radiologically contaminated soil.

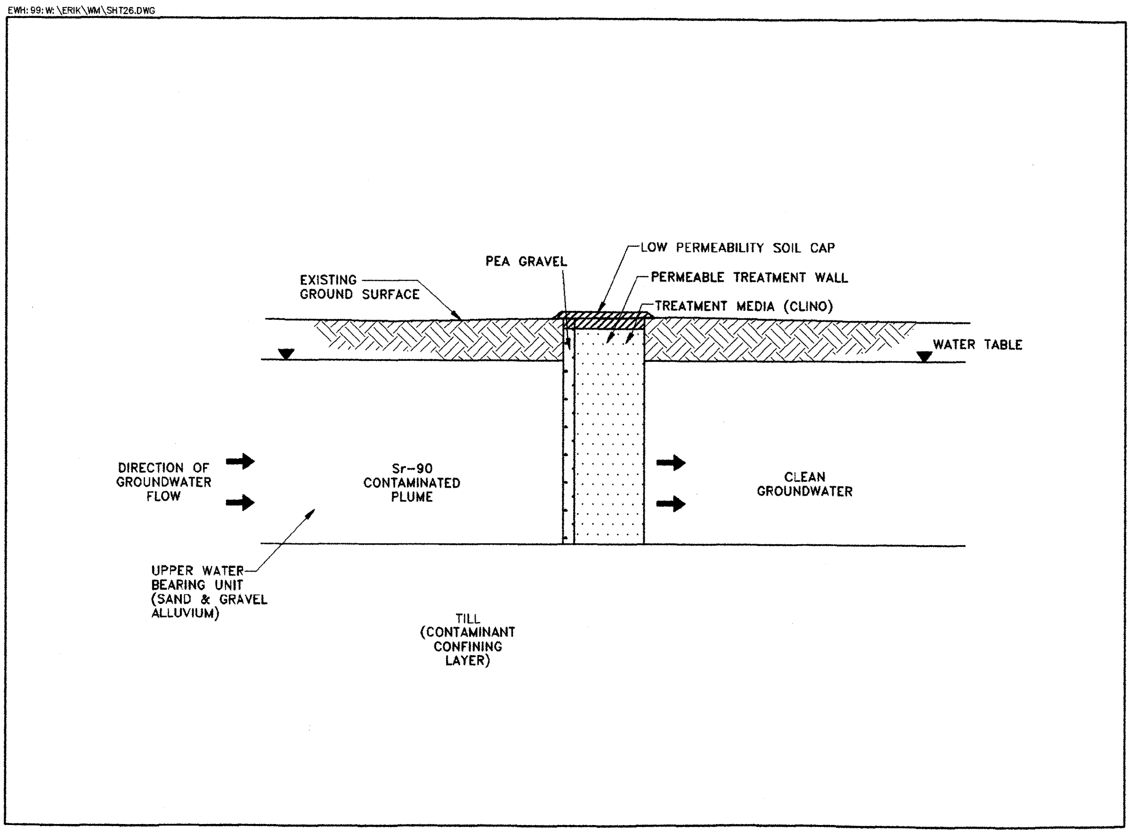


Figure 2 - PTW Cross Section

Once the cofferdam was in place, a dewatering system was used to dewater soils before excavation. This allowed for better handling of excavated soils and reduced the moisture content of the soil. The dewatering system consisted of four, 15 centimeter extraction wells located within the cofferdam. The dewatering system directed groundwater from the cofferdam to an on-site lagoon (Lagoon 2) for treatment in the site's Low-Level Waste Water Treatment Facility. Shallow soils were then excavated from the cofferdam. The shallow soils that were excavated did not have contamination at levels requiring radiological controls, and were therefore placed at a clean soil staging area on site. Soils excavated from greater depths required additional management and radiological controls. All radiologically contaminated soils were placed in intermodal containers and shipped to an off-site disposal facility.

Pea gravel was then placed in a 30 centimeter section at the front of the cofferdam to reduce clogging on the front face of the wall and provide a porous preferential inlet for groundwater entry into the clinoptilolite. Additionally, a sump was placed at the base of the pea gravel allowing a pump to be inserted for groundwater recovery should the PTW not perform as anticipated. A temporary grid structure was used to provide structural support and separate the gravel from the clinoptilolite during installation. After the clinoptilolite was placed in the excavated area, a layer of low permeable soil was placed over it and the sheet piles were removed to allow for operation. Once the sheet piles were removed from the excavation, they were decontaminated for potential later use. A decontamination pad with a synthetic liner was constructed before the start of field activities. Exposed or disturbed surface areas were seeded and vegetation reestablished to prevent erosion.

PROJECT TESTING AND MONITORING

The testing and monitoring program developed to assess operation of the pilot scale PTW focused on collecting data to: 1.) Confirm that groundwater flow has returned to preconstruction conditions, is flowing through the treatment media, and is not backing up or being diverted around the PTW; 2.) Confirm that Sr-90 activity is reduced as groundwater flows through the treatment wall; and 3.) Determine when Sr-90 activities in groundwater begin to decrease immediately downgradient of the PTW.

Since there is an abundance of laboratory data indicating that clinoptilolite will remove Sr-90 from WVDP groundwater, the assessment program's primary focus was on hydraulic monitoring of groundwater elevations in and around the pilot PTW. This approach was developed with input from independent technical experts on the design plans for the pilot scale PTW, including the monitoring program to assess operation.

Data Quality Objectives (DQOs) for the operational assessment program were developed to systematically define the questions or decisions that would be supported by the testing performed and to determine what data would need to be collected. The DQOs identified three periods when groundwater data would be collected and used for making an assessment of treatment wall operation. The first period was prior to construction, during which time groundwater elevation and groundwater quality samples were collected to establish baseline conditions in the PTW area. The second period was during construction, to evaluate the extent that the installation of sheet piles and soil dewatering activities affected localized groundwater flow patterns. Groundwater samples also were collected during this time to maintain a continuous record of groundwater quality data, including Sr-90 activities, and to see if these were affected by temporary changes in groundwater flow. The third and longest testing period is post-construction. This period started once the clinoptilolite was placed and the sheet piles were removed, thereby allowing groundwater to flow through the PTW. Groundwater elevation data collected upgradient, downgradient and within the treatment wall were used to establish when water levels and flow patterns returned to baseline or pre-construction conditions and to confirm that groundwater was flowing through the treatment media within the PTW. Groundwater sampling for Sr-90 and other parameters began following sheet pile removal in order to observe short term effects on groundwater quality during the initial period of geochemical and hydraulic stabilization following construction. Continued data trending will support evaluation of wall performance over the longer term.

The monitoring network used to assess PTW operation is illustrated in Figure 3. Except for the dewatering wells used only to monitor pre-constructions conditions, the monitoring points are small diameter well points that were installed using direct-push technology. This reduced drilling time and costs compared to the installation of monitoring wells, and did not interfere with placement of the treatment media inside the cofferdam. Piezometers also were installed to provide more data points to define groundwater elevations and flow in and around the PTW.

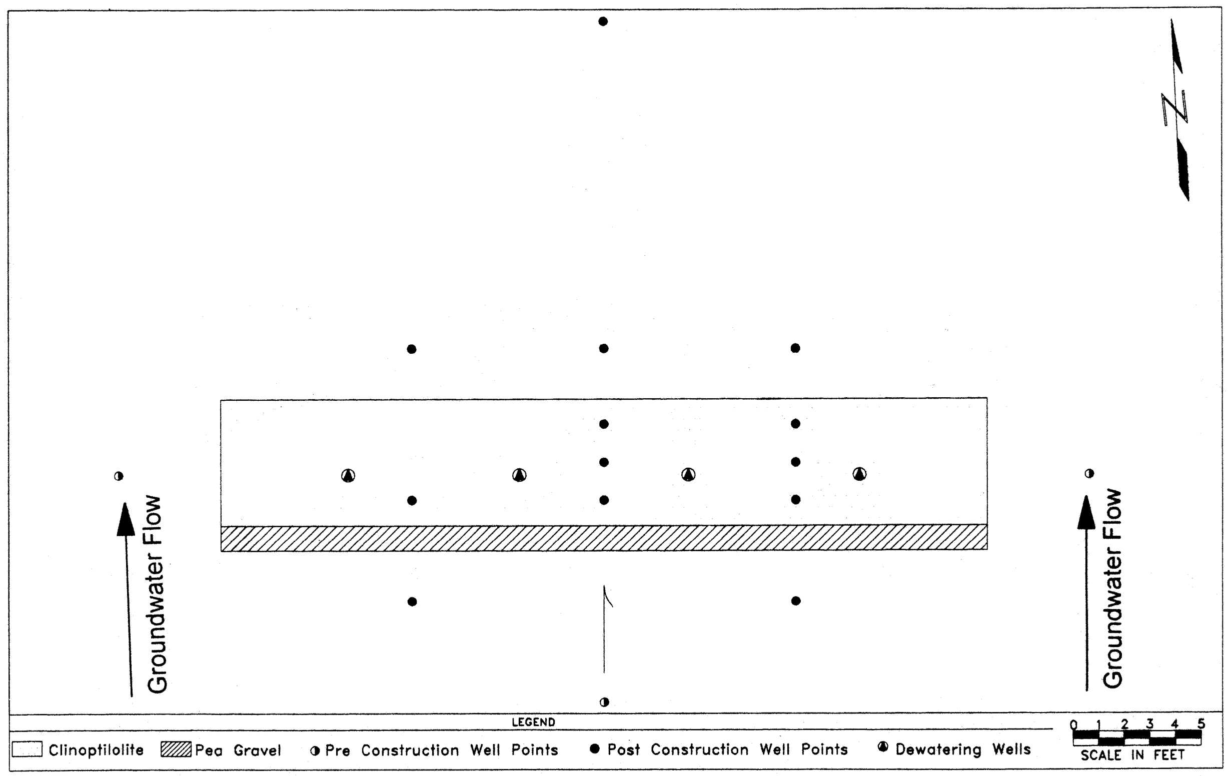


Figure 3 - PTW Monitoring Network

Final results from the pilot PTW project will be used to support the technical basis for deploying a full-scale PTW on the 1st lobe of the plume where the pump and treat system is located. Deployment of a full-scale wall at this location has the potential to eliminate the need to operate the current pump and treat system and improve overall leading edge controls.

SUMMARY

Initial mitigation of a groundwater plume at the WVDP included installation of a pump and treat system using ion exchange resins for ex-situ groundwater treatment. Alternative technology evaluations were undertaken to address the challenges posed by site hydrogeologic conditions, fluctuating water levels, and the resource intensive nature of operating the pump and treat system. Based on the growing number of successful treatment wall installations and recommendations by independent technical experts, the WVDP carried out a PTW pilot program to demonstrate this technology for mitigating Sr-90 contaminated groundwater at the WVDP site.

Information from various sources was used in developing the conceptual design, including data from previous media testing performed for the site, and available information from other sites. Additional bench testing also was performed using site groundwater and the selected media to confirm and refine previous testing results. These results were instrumental in supporting decision making and the design for the pilot installation. Based on the positive results and concurrence from consulted groundwater remediation experts, the WVDP determined that the next logical step was to demonstrate the technology in the field by installing a pilot scale treatment wall.

In the early stages, a multi-disciplinary project team was assembled to support and integrate all aspects of the project such as planning, design, customer and stakeholder interfacing, construction activities, etc. This and other important project management principles were key in leading to the safe and successful execution of the pilot project.

The design configuration was deliberately kept simple. A sheet pile cofferdam setup and conventional construction equipment and techniques were used that allowed workers to stay out of the cofferdam and away from radiologically contaminated soil.

An extensive monitoring program was carried out before, during, and following construction to closely monitor hydraulic conditions and assess operation of the treatment wall. Developed with input from technical experts, the program's focus is on confirming groundwater flow through the treatment media and the removal of Sr-90 as groundwater enters and flows through the wall.

Based on demonstration of successful installation and operation of the pilot scale PTW, plans are being developed for full scale field deployment at another location within the plume. These plans presently involve installation of a larger PTW downgradient of the existing pump and treat system to improve groundwater mitigation in the primary or western lobe of the plume.

REFERENCES

1. D.R. Lee, D. J. A. Smyth , S.G. Shikaze , R. Jowett , D. S. Hartwig and C. Milloy. "Wall-and-Curtain for Passive Collection/Treatment of Contaminant Plumes", Proceedings of the First International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Battelle Press, Columbus, OH (1998).

2. M. Furhmann, D. Aloysius, H. Zhou "Permeable subsurface sorbent barrier for Sr: laboratory studies of natural and synthetic materials," Waste Management '95, Tucson, AZ (1995).

3. K. Cantrell "A permeable reactive wall composed of clinoptilolite for containment of Sr-90 in Hanford groundwater", Proceedings of the International Topical Meeting on Nuclear and Hazardous Waste Management, 1358-1365, American Nuclear Society, Inc., La Grange Park, Il (1996).

4. A.J. Rabideau, J. E. Van Benschoten, C. Huang, A. Patel "Bench testing of zeolite materials," submitted to West Valley Nuclear Services Company, Department of Civil, Structural, and Environmental Engineering, University at Buffalo, Buffalo, NY (1999).