

MEMORANDUM

TO: Lenny Siegel
FROM: Peter Strauss
DATE: March 6, 2015
SUBJ: **Zero-Valent Iron (ZVI) Permeable Reactive Barrier (PRB) Treatability Study: History and Analysis**

The subject memo refers to the Zero-Valent Iron (ZVI) Permeable Reactive Barrier (PRB) Treatability Study by Geosyntec on behalf of Schlumberger Technology Corporation (STC), which became responsible for this site when it acquired Fairchild. This memo is organized to provide a brief history of the 401 National Ave Site, a description of the proposal, and an analysis of the Treatability Study proposal.

HISTORY OF THE SITE

This Site is referred to as 401 National Avenue, situated within the Former Fairchild Building 9 Slurry Wall. ¹ To contain high concentrations of chlorinated volatile organic compounds (cVOCs) in source areas, Fairchild installed subsurface slurry walls at three of its former facilities in 1986: Buildings 1-4 at 515/545 Whisman Road and 313 Fairchild Drive, Building 9 at 401 National Avenue, and Building 19 at 369 Whisman Road. Each slurry wall extends to the aquitard between the A and B1 aquifers.²

At 401 National, the slurry wall is approximately 40 feet deep. Within the slurry wall, there are four extraction wells. Groundwater is pumped to the surface where it is treated by a granular activated carbon (GAC) system. One requirement of the MEW Record of Decision (ROD) is to maintain an inward hydraulic gradient across the slurry walls and an upward gradient across the A/B1 aquitard within the slurry walls.

National Avenue Partners, LLC, purchased the property, and in May 2014 the City of Mountain View approved the redevelopment of 401 National in conjunction with three properties to the north. The approved redevelopment activities include the demolition of the former Building 9 and the construction of a two-story aboveground parking garage at

¹ Note that as part of a planned redevelopment, 401 National Avenue and the properties located to the immediate north have been consolidated into a single address: 600 National Avenue. For consistency with historical project documents, the project site for the ZVI PRB treatability study will be referred to as former Building 9, or 401 National Avenue throughout this report.

² Raytheon also installed a 100-foot-deep slurry wall around its former 350 Ellis Street facility to isolate the chemicals at the property. The wall extends through the "A" and "B1" aquifer to the upper half of the "B2" aquifer.

that site. Construction of the garage is scheduled to begin July 2015, although I have been told that the developer is still awaiting some permits.

Over the period 2009 through 2013, the maximum concentration of TCE detected in groundwater monitoring wells within the slurry wall was 13,000 micrograms per liter ($\mu\text{g/L}$). However, TCE concentrations in grab groundwater samples collected in September 2013 and November 2014, ranged from 100 to 560,000 $\mu\text{g/L}$. Total cVOC concentrations detected in September 2013 and November 2014 ranged from approximately 1,800 to 630,000 $\mu\text{g/L}$.

Draft Supplemental Sitewide Groundwater Feasibility Study

In 2012, EPA circulated a draft Supplemental Sitewide Groundwater Feasibility Study (SSFS), prepared in response to the 2009 Five-Year Review finding of non-protectiveness due to vapor intrusion. The Proposed Plan for the Vapor Intrusion Remedy³ stated:

The groundwater cleanup is expected to continue for many decades until concentrations of TCE and the other MEW Site contaminants of concern meet cleanup standards. It is important to note that groundwater is not currently used for drinking water or other household uses. Optimization efforts for the groundwater remedy are underway and alternative groundwater cleanup technologies to expedite cleanup are currently being evaluated and tested as part of a separate **Site-wide Groundwater Feasibility Study** [emphasis added].

A Remedial Action Objective in the Vapor Intrusion (VI) Remedy was “to accelerate the reduction of the source of VI (that is, site contaminants in the shallow groundwater and soil gas) to levels that are protective of current and future building occupants, such that the need for a VI remedy would be minimized or no longer necessary.”

This Remedial Action Objective was not addressed by the vapor intrusion remedy; instead, it was to be addressed by the current groundwater remedy, which was being re-evaluated by the SSFS.

The Draft SSFS was then sent to the National Remedy Review Board (NRRB). The NRRB posed a list of recommendations in 2013 that EPA Region IX believed could only be answered by continuation of its optimization efforts. Consequently, it put the SSFS on hold while additional optimization efforts continued.

In-Situ Bioremediation and PRB Pilot Study

In 2013, STC prepared a Work Plan for a Pilot Study for in-situ bioremediation (ISB) and a PRB at 401 National Avenue. The pilot study proposed to shut down the four existing groundwater extraction wells within the slurry wall and target ISB injections in the areas containing high VOC concentrations. It also proposed to breach the existing Building 9 slurry wall to promote groundwater flow in the A-zone across the Site. A permeable reactive barrier (PRB) filled with zero-valent iron (ZVI) was to be installed on the downgradient side of the breach in the slurry wall to passively treat groundwater as it migrates through.

³ Proposed Plan for the Vapor Intrusion Pathway, July 2009

The Mountain View Commercial Owners (MCO)⁴ and adjacent property owners objected to this pilot study, for several reasons. The first was that might mobilize certain metals. The second was that they objected to breaching the slurry walls. As they were downgradient from the proposed breaches, they were concerned that there would be an increase of high-concentrations of contaminated water flowing under their properties. Moreover, the adjacent property owners cited EPA's rejection of the PRBs in EPA's during the Draft Supplemental Sitewide Groundwater Feasibility Study (2012). It had concluded that breaching the slurry wall and emplacing a PRB was "unproven." CPEO disagreed with this rejection. The ISB and PRB Pilot Study were scrapped as a result of adjacent property owners' complaint.

In-situ Chemical Oxidation Treatability Study

The ISB portion of the Pilot Study was replaced by a Treatability Study using in-situ chemical oxidation (ISCO) inside the slurry wall. EPA had data from an earlier ISCO treatment along Evandale Ave. This study was approved in 2014, and the Site is now undergoing injections targeting high concentration areas inside the wall. This treatability study for ISCO is limited to three injections cycles because of the aforementioned construction schedule (July 2015 start date).

However, when EPA commented on the July 2014 ISCO pilot study work plan, it requested:

In addition, as part of the ongoing optimization efforts to accelerate groundwater cleanup and to evaluate the effectiveness of alternate groundwater technologies at facility-specific source areas at the MEW Site, EPA requests that Schlumberger reassess and evaluate implementation of a treatability study of a funnel-and-gate system in the downgradient (northern) slurry wall in conjunction with and consideration of the ISCO pilot study work and the redevelopment of the 401 National Avenue property.

Proposed PRB Treatability Project Scope

The scope of work for the ZVI PRB Treatability Study includes:

- Destruction of the four groundwater extraction wells located within the slurry wall footprint at 401 National Avenue.
- Installation of ZVI PRBs at two locations along the downgradient (north) side of the 401 National Avenue slurry wall. The soil-bentonite slurry wall in the A-zone to a depth of approximately 40 feet below ground surface (bgs) was installed in 1986. The slurry wall is approximately 34 inches thick. Note that the A-zone aquifer, roughly 14 ft. to 40 ft. below ground surface, is separated from the B-zone aquifer by an aquitard.
- Targeted injections of micro-scale ZVI immediately upgradient of the ZVI PRBs to geochemically reduce groundwater before it enters the ZVI PRBs.
- Performance monitoring following installation.

⁴ MCO members represent approximately 80% of commercial property square footage at the MEW Site

- A contingency plan for mitigating potential migration of cVOCs should the PRB meet expectations. Two inactive extraction wells would be installed downgradient from the proposed PRBs prior to construction of the PRBs. They would be activated if necessary, based on performance monitoring data from monitoring wells and samples within the PRB and immediately downgradient. These new extraction wells would provide additional capture of groundwater, as there is an extraction well at 405 National Avenue site covering the A, B-1, and B-2 aquifers.

The PRB Wall

Portions of the downgradient side of the existing slurry wall would be excavated and replaced with ZVI gates. Groundwater containing cVOCs would be treated as it flows off-site in the downgradient direction. ZVI systems rapidly degrade TCE to acetylene, ethane and ethane. In some cases, there are minor formations of the typical TCE-degradation products dichloroethylene and vinyl chloride.

Results of a modeling evaluation by Geosyntec indicate that without groundwater extraction, groundwater within the slurry wall boundary would flow through the PRBs. Further, nearly all groundwater flowing upward into the slurry wall boundary from the B1-zone would subsequently flow through the PRBs prior to discharging downgradient of the Site. Thus, the PRB would provide long-term mass removal following the conclusion of the ISCO treatability study.

The presence of calcium and alkalinity may result in the gradual decrease in effectiveness of the PRBs, so Geosyntec designed the wall with an engineering safety factor to extend the long-term reactivity of the barriers.

Neutralization Zones

The ISCO chemicals used in the treatability study (i.e., permanganate and persulfate) may cause deactivation of ZVI if these compounds enter the PRBs at sufficiently high concentrations. Though not expected, Geosyntec proposes to neutralize the ISCO chemicals by directly injecting micro-scale ZVI into the A-zone aquifer after the ISCO injections are complete, but prior to construction of the ZVI PRBs.

Performance Monitoring

The PRB performance monitoring network will include the following wells:

- One monitoring well installed within each of the ZVI PRBs to demonstrate cVOC degradation by the PRBs.
- One monitoring well installed directly upgradient of each of the PRBs to monitor influent cVOC concentrations and groundwater gradients across the PRB.
- One monitoring well installed directly downgradient from each of the PRBs. Since groundwater downgradient of the PRBs contains concentrations of cVOCs that exceed California Maximum Contaminant Levels (MCLs), the monitoring wells cannot be used to verify PRB performance. They will, however, monitor for potential increases in cVOC concentration downgradient of the PRBs.

Contingency

In the past, adjacent property owners expressed concerns that the installation of PRBs would cause groundwater with high cVOC concentrations to migrate onto their properties. This was an understandable concern. However, to prevent this from occurring, groundwater extraction wells would be installed immediately downgradient of the PRBs, and activated if monitoring wells reveal cVOC concentrations exceeding any of the California MCLs.

To minimize the potential for disruption following redevelopment, the contingency extraction wells and associated piping and treatment would be installed during PRB construction. Each new contingency extraction well would be located within approximately 1 foot of a PRB and screened from 21 to 26 feet bgs to capture the groundwater discharging from the PRBs. If necessary, the extracted groundwater would discharge through double-contained piping into the Fairchild System No. 1 piping network for treatment.

Property Owners Concerns

The MCO have submitted several letters, essentially repeated their objections to the earlier ISB/PRB Pilot Study. EPA has also met with the adjacent property owners. MCO summarized the groups concerns to include “contaminant migration, damage to fiber optic lines and other critical infrastructure, business disruption, security, lost productivity and economic impacts.”⁵ This letter also stated, “We are worried about EPA’s push to deploy untested groundwater remedies that could allow the migration of heavily contaminated groundwater, thereby significantly affecting neighboring properties.” The letter also stated that EPA should prepare a new Groundwater Feasibility Study to move forward with new technologies.

These are serious concerns that deserve a response. However, the MCO and their consultant (EKI) have failed to show that any of these concerns has a high probability of occurring. EKI points to some technical deficiencies in the draft, but we believe most of those can be addressed without a radical change in the proposal. However, conducting a true treatability study prior to implementation of the work plan would take at least a few years and prevent construction. If this alternative had been presented when STC first proposed the PRB in 2013, there would have been time for two years of evaluation.

EPA’s Counter-Offer

Because of the opposition from the MCO and possibly the new property owner and developer, EPA has offered to take the PRB off the table if STC is willing to continue injections of ISCO after construction begins, and to cover a wider area within the slurry wall. I have not yet seen this proposal,

ANALYSIS

I am inclined to support the implementation of the PRB technology because it has been proven effective in treating TCE. I think that the proposal is well thought out. Geosyntec has proposed a PRB that would have an engineering safety factor built into it (i.e.,

⁵ Letter from Karen Nardi, Arnold and Porter, to Enrique Manzanilla, EPA Region IX Director of Superfund Division, March 4, 2015.

thickness of the wall), considered factors that might influence the PRB effectiveness (e.g., the effect of ISCO chemicals on ZVI), developed a contingency plan, and incorporated a long-term performance evaluation.

What I think is lacking is a description of the probable benefits from this project, not only for the 401 National Site, but also for the entire MEW area. There are four slurry wall systems in the MEW area, enclosing a significant fraction of the MEW site.. These wall systems are first meant to contain high concentrations of contaminants and second to treat them. They require maintaining an inward and upward hydraulic gradient. *Thus, they appear to increase the need for vapor intrusion mitigation in overlying buildings.* For example, the two Google buildings on North Whisman with recent documented vapor intrusion lie above a slurry wall containment area.. In addition, these slurry walls are old. Some of them are leaking, and wall breakdown is possible, especially as a result of earth movements so common to this area.

Despite claims by MCO, PRBs using ZVI are an established technology to passively degrade VOCs. They have been studied for over 20 years and are used by the Department of Defense and the Department of Energy. One was installed at an industrial facility in Sunnyvale in 1994. Another was installed at Moffett Field. The ITRC and Battelle first prepared guidance documents of PRBs in 1997. EPA published a guidance document in 1998. What is perhaps new is breaching a slurry wall, and installing a PRB within the wall.

However, I do believe that STC and Geosyntec should address all of the technical concerns that were raised by EKI, which included model assumptions, keeping the existing extraction wells in operation (or alternatively, at least keeping them in reserve), assuring a more robust contingency plan, and assuring that neighboring properties will not have to have additional soil clean-up measures (the original Record of Decision required that soil within the slurry wall be cleaned to a more stringent standard than soils outside the slurry walls to be protective of groundwater).

We should keep the Vapor Intrusion Remedial Action Objective in mind: that is to accelerate groundwater cleanup to protect current and future building occupants. CPEO agrees with MCO that the groundwater Feasibility Study is necessary to select the wide range of remedies necessary to meet this objective, and it should be restarted as soon as possible. However, optimization studies using technologies such as ISCO and ISB are necessary to show how they can reduce the need for a VI remedy, whether they are conducted at 401 National or elsewhere on the MEW Site.

It is instructive to point out that the MCO, in their comments on the VI Proposed Plan, supported the Remedial Action Objective:⁶:

Expedite the Cleanup. MCO urges EPA to expedite completion of the groundwater cleanup. This would obviate the need for vapor controls. The underlying cause of the vapor problem is groundwater contamination that remains unremediated. Completing the cleanup should be a strong priority.

⁶ MCO comments on U.S. EPA's July 2009 "Proposed Plan for the Vapor Intrusion Pathway at the Middlefield-Ellis-Whisman (MEW) Superfund Study Area".

Although adjacent property owners have asked that no alteration be made to the existing slurry wall, they have not considered the problem that would occur if there were a gross failure of the slurry wall. The slurry walls are more or less subsurface dams, holding back the most contaminated water at the site. The slurry walls are over 30 years old, and they are showing signs of age. That is, they are not fully containing the plume within their walls. These leaks have so far not proven to be fatal flaws in the systems. However, they will degrade over time; a sudden event such as an earthquake would place more strain on these walls, possibly triggering failure and allowing the migration that MCO is trying to avoid.

If STC accepts EPA's counter proposal, we think that ZVI injection or a PRB with ZVI belong in the mix of technical solutions to be considered in other parts of the site. In 2014, Lawrence Livermore National Laboratory (LLNL) conducted the first phase of a Treatability Study that injects a thin ZVI barrier without trenching. This method could be used to demonstrate the effectiveness of ZVI and a PRB containing ZVI.