Assessing the Performance of Pump-and-Treat Systems – 16380

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ABSTRACT

Pump-and-treat (P&T) is a common groundwater remedy. However, a challenge with P&T remedies has been in evaluating their performance. A structured approach can be applied to gathering the information needed to support assessment of P&T remedies and decisions to close the remedy, continue P&T, optimize the P&T system, or transition to other remedy approaches. Supportive decision elements include analysis of contaminant concentrations and trends, quantifying contaminant mass discharge of plume and source zone, quantifying the attenuation capacity of the aquifer, using tools to predict future plume behavior and time to reach remedial action objectives, and information about the current P&T system design and operations. Several sites have successfully conducted a P&T performance assessment and supported decisions to change their remedy approach. These case studies are discussed in relation to a recent document, *Performance Assessment for Pump-and-Treat Closure or Transition*, that provides guidance for the assessment process and associate remedy decisions.

INTRODUCTION

Review of remedy performance and consideration of remedy closure or transition are consistent with the U.S. Environmental Protection Agency's (EPA's) Groundwater Road Map [1] and the EPA *Groundwater Remedy Completion Strategy* [2]. In addition, a recent National Research Council study examined groundwater remediation for complex contaminated sites and concluded that evaluating remedy performance and the potential need for transition to alternative approaches may be beneficial at these sites [3]. Existing guidance (see listing in [4]) provides information on design, operation, and optimization for pump-and-treat (P&T) systems. However, these documents do not provide specific technical guidance to support remedy decisions by site decision makers regarding P&T optimization, transition to a new remedy, or closure of the P&T remedy.

Recently, Truex et al. developed a document, *Performance Assessment for Pump-and-Treat Closure or Transition* [4], which provides guidance for the P&T performance assessment process in the context of supporting remedy decisions. Essentially, the approach in this document is organized to use a set of *decision elements* to help decision makers distinguish between several categories of *decision outcomes* associated with optimization, transition, or closure of P&T systems. Decision elements include analysis of contaminant concentrations and trends, quantifying contaminant mass discharge of plume and source zone, quantifying the attenuation capacity of the aquifer, using tools to predict future plume behavior and time to reach remedial action objectives, and information about the current P&T

system design and operations. The performance assessment approach includes revisiting the conceptual site model (CSM), where it is important to consider the current nature of the source and plume as well as the aspects controlling contaminant transport and remedy performance. However, to effectively support the P&T performance assessment and associated remedy decisions, the Truex et al. [4] document focuses efforts for updating the CSM on describing the site and current conditions in terms of the decision elements.

The decision elements from the updated CSM are applied in a decision logic framework to facilitate determining the outcome that is best supported by the performance assessment. Fig. 1 shows the primary elements of the decision logic, highlighting the process to distinguish between different categories of decision outcomes.

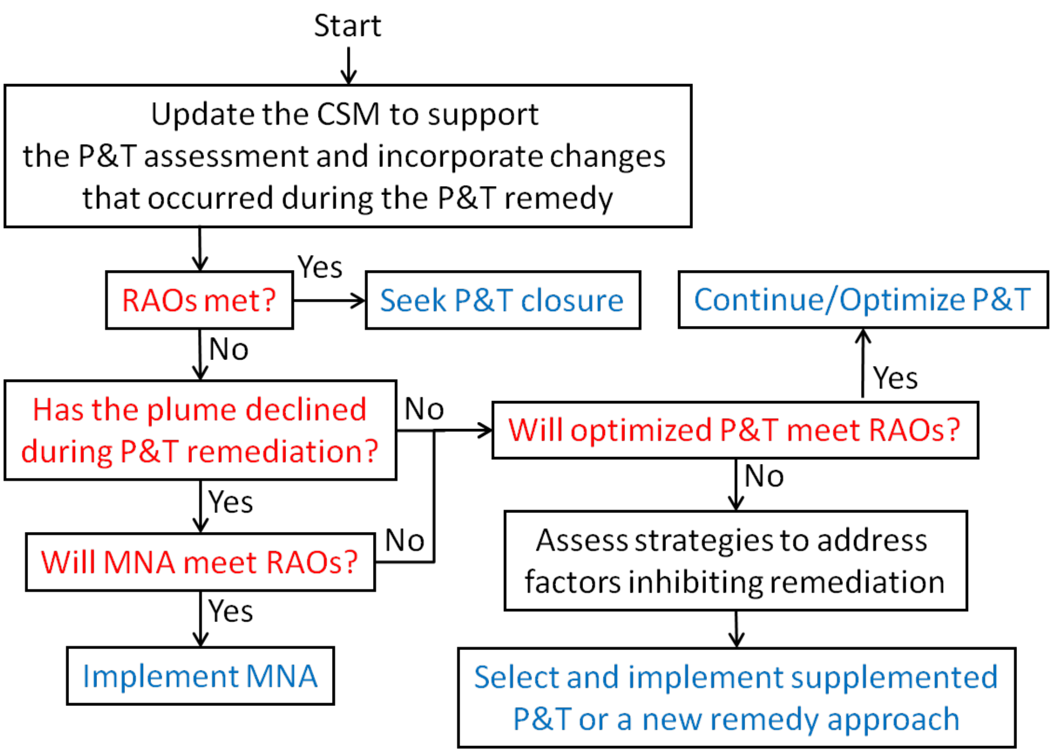

Fig. 1. Primary elements of the decision logic used for the P&T assessment (from [4]). The full decision logic includes additional elements of the decision process, which are omitted here for brevity. MNA = monitored natural attenuation; RAO = remedial action objectives.

Several sites have successfully conducted a P&T performance assessment and supported decisions to change their remedy approach. These case studies are discussed in relation to the approach presented in Truex et al. [4].

DESCRIPTION

Case studies of P&T performance assessment are presented herein. The case studies provide a synopsis of the contaminant issues and a description of how assessment, using the types of decision elements outlined by Truex et al. [4], was applied to support a remedy decision. These remedy decisions are then related to the corresponding decision outcomes that are included in the Truex et al. [4] document. Outcomes represented by these case studies include decisions to 1) optimize the P&T system, 2) transition to MNA, 3) apply a technical impracticability waiver with MNA as the long-term containment approach, and 4) transition from P&T to another remedy approach. These and additional case studies are included in the Truex et al. [4] document.

DISCUSSION

Several sites are described below that have successfully conducted a P&T performance assessment and supported decisions related to an existing P&T system.

DOE Fernald Preserve

The U.S. Department of Energy (DOE) Fernald Preserve overlies the Great Miami Aquifer, which the EPA has designated as a sole-source aquifer. A facility at the site operated from 1952 to 1989 to produce more than 226 million kg of uranium metal products. In the process of these production operations, the soil, surface water, sediment, and groundwater on and around the site were contaminated with uranium. A P&T groundwater remedy is underway for uranium in groundwater. Because of an observed decline in operational effectiveness, revised estimates of the cleanup timeframe were longer than initial predictions.

Sixteen different operational alternatives were modeled using the site groundwater model to assess the potential for P&T optimization to improve operational effectiveness and shorten cleanup timeframes [5]. The selected optimized configuration more efficiently addressed the remaining uranium plume in the aquifer over time. The model predicts that the optimized P&T design will accelerate cleanup in key portions of the aquifer and meet site RAOs within a reasonable time frame. Decision elements associated with selecting P&T optimization are summarized in Table 1.

Table 1. Fernald Site Case Study Decision Element Summary

Decision Elements	Site-Specific Assessment
Contaminant concentrations and trends	Plume declined, but at less than the expected rate, and new data identified an area with higher concentrations than initial estimates
Contaminant mass discharge from source areas or at selected plume locations	P&T performance trends compared to groundwater model predictions to assess P&T operational effectiveness
The attenuation capacity of the aquifer	Not used
Estimated future plume behavior and time to reach RAOs for the site	Groundwater model used to estimate plume behavior for P&T configuration alternatives
P&T system design, operational, and cost information	Applied optimization evaluation and selected an improved configuration that is predicted to accelerate cleanup in key portions of the aquifer and meet RAOs in a reasonable time, with reduced cost

DOE Idaho National Laboratory Test Area North

The Test Area North (TAN) site at the DOE Idaho National Laboratory was used for historical nuclear fuel operations and heavy metal manufacturing. From 1953 to 1972, liquid wastes and sludge from experimental facilities were disposed to the aquifer via an injection well at the site. A chlorinated solvent groundwater plume downgradient of this source area is nearly 3 km long and 0.8 km wide. The site consists of three separate contamination zones, with different remediation approaches for each zone. The contamination zones include 1) the source (hot spot) around the waste injection well, with initial trichloroethene (TCE) concentrations greater than 20,000 µg/L, 2) a medial zone of groundwater contamination with TCE concentrations between 20,000 to 1,000 µg/L extending downgradient from the source zone, and 3) a distal portion of the TCE plume with concentrations less than 1,000 µg/L. Remediation approaches selected for these zones and incorporated in a 2001 ROD amendment included 1) in situ bioremediation for the source zone, 2) groundwater P&T for the medial zone, and 3) MNA for the distal zone.

A tracer-corrected method was applied to estimate an attenuation half-life for the contaminants. Biological attenuation mechanisms were evaluated using a novel suite of assays, including DNA, enrichment cultures, and enzyme activity probes, to reveal that indigenous microorganisms were significantly contributing to natural attenuation. Transition to MNA was initiated using rebound data from the medial P&T area and the attenuation rate data to demonstrate that the plume would not increase beyond an acceptable size after cessation of medial zone P&T operations. The data showed that the plume had been diminished to the point where P&T operations could be terminated and that MNA would meet the site RAOs. Continued monitoring, as part of the MNA remedy, has been used to verify remedy performance. Decision elements associated with transition to MNA are summarized in Table 2.

Table 2. TAN Site Case Study Decision Element Summary

Decision Elements	Site-Specific Assessment
Contaminant concentrations and trends	Plume declined with P&T
Contaminant mass discharge from source areas or at selected plume locations	Conducted a rebound test to assess plume stability
The attenuation capacity of the aquifer	Conducted a rebound test to assess plume stability. A tracer-corrected contaminant concentration study was used to develop attenuation rates. Additional studies verified attenuation processes.
Estimated future plume behavior and time to reach RAOs for the site	Evaluation showed that plume would not increase beyond an acceptable size with P&T terminated.
P&T system design, operational, and cost information	P&T optimized over time during the remedy

County Pesticide Site

A county-owned property near Crescent City, CA, was operated as a collection point for pesticides for Del Norte County from 1970 to 1981. Contamination of groundwater by 1,2-dichloropropane (1,2-DCP) and 2,4-dichlorophenoxyacetic acid (2,4-D) was likely caused by rinsing pesticide containers onsite and then disposing of the residues and rinsates in a bermed, unlined sump area. P&T system was installed with the goal of both containing the downgradient edge of the plume and restoring the aquifer.

The P&T system was operated for 7 years. Concentrations of contaminants other than 1,2-DCP were reduced to levels below their respective standards. A 2000 ROD amendment was issued that changed the remedy to MNA. A technical impracticability (TI) waiver was issued, waiving the need to attain the 1,2-DCP drinking water standard (maximum contaminant level [MCL]) of 5 µg/L everywhere at the site. Hence, the 2000 ROD amendment also called for the implementation of institutional controls to prevent the use of groundwater at the site, with MNA containing and slowly diminishing the plume. The site was delisted from the National Priorities List in 2002, but monitoring is ongoing because 1,2-DCP concentrations remain above the MCL. Decision elements associated with transition to MNA and use of a TI waiver are summarized in Table 3.

Table 3. County Pesticide Site Case Study Decision Element Summary

Decision Elements	Site-Specific Assessment
Contaminant concentrations and trends	Plume declined with P&T, but expect it will be difficult to reach the MCL for 1,2-DCP
Contaminant mass discharge from source areas or at selected plume locations	Not used
The attenuation capacity of the aquifer	Not used
Estimated future plume behavior and time to reach RAOs for the site	MNA is predicted to control the plume, but with 1,2- DCP above the MCL – Used a combination of TI waiver, institutional controls, and MNA
P&T system design, operational, and cost information	Not used

Nebraska Superfund Site

The Nebraska site has a tetrachloroethene groundwater plume that was identified in 1986 as affecting a municipal water supply well for a medium-sized city in Nebraska. The initial remedy included application of soil vapor extraction (SVE) for the soils above the water table and P&T for the groundwater remediation. Over time, the plume did not decline as much as anticipated.

The P&T system was operated until 2009 and the SVE system was operated until 2012. A ROD amendment issued in 2012 changed the remedy to include in situ thermal remediation for the source area and in situ chemical oxidation or enhanced bioremediation for the dissolved-phase plume. In situ chemical oxidation has been implemented. Design of in situ thermal remediation for high groundwater concentrations under and immediately downgradient of the dry cleaners is underway. The transition to an alternate set of technologies was spurred by various optimization analyses and the recognition that the P&T system was not diminishing the plume at the expected rate. Decision elements associated with transition to other remedies are summarized in Table 4.

Table 4. Nebraska Superfund Site Case Study Decision Element Summary

Decision Elements	Site-Specific Assessment
Contaminant concentrations and trends	Plume did not decline significantly
Contaminant mass discharge from source areas or at selected plume locations	Not used
The attenuation capacity of the aquifer	Not used
Estimated future plume behavior and time to reach RAOs for the site	Estimated P&T would not meet goals in a reasonable time
P&T system design, operational, and cost information	Evaluated optimization and determined other treatment processes would be more effective.

CONCLUSIONS

The case studies presented herein provide examples of successful evaluation of P&T remedy performance. To provide a structured approach that can facilitate this assessment process at other sites, a *Performance Assessment for Pump-and-Treat Closure or Transition* document [4] has been developed and can be applied to guide the assessment process. The document includes information about compiling appropriate information for decision elements that can be used to help decision makers distinguish between several categories of decision outcomes associated with transition, optimization, or closure of P&T systems.

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