Wyckoff/Eagle Harbor Superfund Site
Soil and Groundwater Operable Units

Thermal Remediation Pilot Study Summary Report

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Prepared by
US Army Corps of Engineers – Seattle District

for
US Environmental Protection Agency - Region 10

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ACRONYMS LIST

AC	Alternating current
acfm	Actual cubic feet per minute
ADAS	Automated data acquisition system
atm	Atmospheres
bgs	Below ground surface
BTU	British thermal units
BTU/gal	British thermal units per gallon
°C	Degrees Celsius
CD	Conceptual Design
cfm	Cubic feet per minute
CLP	Contract Laboratory Program for USEPA
DA	Design Analysis
DAA	Design Analysis Amendment
DAF	Dissolved air flotation, or diffuse air flotation
dBA	Decibels
DNAPL	Dense Non-Aqueous Phase Liquid
DTS	Distributed temperature sensor
EPDM	Ethylene propylene diene monomer
°F	Degrees Fahrenheit
FASP	EPA Region 10 Field Analytical Support Program
FPA	Former Process Area
FS	Feasibility Study
ft	Feet
GAC	Granulated activated carbon
gal	Gallon
GFI	Ground fault interrupter
GMS	Groundwater Modeling System
gpd	Gallons per day
gpm	Gallons per minute
GWTP	Groundwater treatment plant
HDPE	High density polyethylene
hp	Horsepower
HX	Heat exchanger
ID	Inside diameter
in	Inches
ISTD	In-Situ Thermal Desorption

ITTAP	In-situ Thermal Technologies Advisory Panel
kg	Kilograms
kg/d	Kilograms per day
kg/s	Kilograms per second
kPa	Kilopascal
lb	Pounds
lb/hr	Pounds per hour
l.e.	Liquid equivalent
LNAPL	Light Non-Aqueous Phase Liquid
LRVP	Liquid Ring Vacuum Pump
m	Meters
mA	Milliamps
MarVac	Marine Vacuum, Inc.
MBTU	Million British Thermal Units
mg/kg	Milligram per kilogram
mg/L	Milligram per liter
MLLW	Mean lower low water
mm	Millimeters
MTCA	Washington State Model Toxics Control Act
µg/L	Micrograms per liter
ng/kg	nanograms per kilogram
NAPL	Non-aqueous phase liquids
NPDES	National Discharge Elimination System (permit)
NPL	National Priority List
NTU	Nephelometric Turbidity Units
OCDD	Octachlorodibenzodioxin
OD	Outside diameter
O&M	Operation and Maintenance
OU	Operable Unit
PAH	Polynuclear aromatic hydrocarbons
PCP	Pentachlorophenol
PETG	Polyethylene terephthalate glycol
PLFA	Phospholipid fatty acid
ppm	Parts per million
psi	Pounds per square inch
psig	Pounds per square inch (gauge)
PVC	Polyvinylchloride
RAMP	Remedial Action Management Plan
ROD	Record of Decision

RTU	Remote Telemetry Unit
scfm	cubic feet per minute at Standard Temperature and Pressure (298.15 K and 101.33 kPa, unless otherwise noted)
SEE	Steam-Enhanced Extraction
sf	Square foot
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WAC	Washington Administrative Code
yd^3	Cubic yards
2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin (or simply dioxin)
3D	Three dimensional

Note regarding units: No attempt was made to provide consistent units throughout the report. Instruments in different parts of the system may have provided data in inconsistent units (for example, Fahrenheit for liquid temperature vs. Celsius for subsurface temperature). Data are reported in the units provided by the instruments. In other instances of inconsistent units, units may have been determined by the discipline that was responsible for that section of the report, and those units may not have been consistent with units used by other disciplines.

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) is providing remedial design and remedial action services to the U.S. Environmental Protection Agency (USEPA) Region 10 for the Wyckoff/Eagle Harbor Superfund Site (the Site), located on Bainbridge Island, Washington. The USACE designed a pilot study that was intended to determine the effectiveness of innovative thermal remediation to enhance the recovery of non-aqueous phase liquids (NAPL) from the site. This was the first time this thermal technology was attempted in this type of environmental setting: the Pacific Northwest with 50°F water on three sides of the property. This work was performed to meet the requirements of the Record of Decision (ROD) for the Soil and Groundwater Operable Units (OU) (USEPA 2000). The pilot study was designed to meet objectives divided into two broad categories:

- To assess the likelihood that full-scale thermal remediation will achieve the cleanup goals for the Site
- To provide information for implementation of the potential full-scale thermal remediation

Initially, the project team was assisted by the In-Situ Thermal Technologies Advisory Panel (ITTAP) to USEPA. As the project moved forward to construction and operations, cost-cutting measures resulted in downsizing of the project team and a gradual loss of input from industry experts.

Bids for a combined construction and operations contract were considerably higher than the government estimate, due to risk factors added by bidders and to cost omissions from the estimate. The pilot study was then revised with less-robust extraction and treatment components, and the existing wastewater treatment plant was incorporated into the test with very few modifications. Due to cost downsizing, some upgradient injection and extraction wells were eliminated, reducing the thermal treatment zone to about half of the originally identified pilot-test area and leaving NAPL-contaminated soil upgradient of the revised pilot test area.

The funding schedule required the project to be split into three phases: Infrastructure Construction (earthwork, vapor cap, boiler building and wells), Mechanical/Process Construction (boiler, pumps, piping, and treatment), and Pilot Operations, each with a separate contract.

The original pilot test area was proposed to cover one acre, with a total volume of 35,300 cubic yards, containing an estimated 40,000 gallons of creosote NAPL. The actual thermal treatment zone consisted of 16,400 cubic yards. The pilot test area is separated from the remainder of the site by an open-ended sheet-pile wall.

The pilot study proceeded for six and a half months, from October 2002 to April 2003. Operations were restricted by equipment problems, and the pilot study was terminated. The average steam injection rate for the operating period was 12 percent of the design rate, and the average pumping rate was 24 percent of the design rate. The total time of operation of the vapor-extraction system was about 1 month, operating continuously no more than 3 days. Because roughly one pore volume (liquid equivalent) of steam was injected, compared to design and laboratory bench-scale test recommendations of 2-5 pore volumes, the pilot study should not be viewed as a definitive application of thermal remediation technology, however, there are some conclusions that can be made based on the data collected.

Very little steam penetration was achieved due to the low injection and extraction rates. Steam flow was primarily vertical to the groundwater surface and into the vadose zone. In March 2003, the average temperature of the vadose zone (excluding the vapor cap) reached a maximum of 98º C while the saturated zone reached a maximum average of 72º C.

Repeated technical issues with the pilot study were diverse: issues with the extraction systems (liquid and vapor), conveyance systems (liquid and vapor), and treatment plant occurred. The most serious problems were: aspiration of liquid by the vapor-vacuum pumps, overloading of the biological water-treatment system, deterioration of gaskets due to materials incompatible with site contaminants, and clogging of pipes and treatment facilities by precipitating polycyclic aromatic hydrocarbons (PAH) (especially naphthalene).

There were equipment constraints that limited operations of the system. Constraints included capacity of the treatment plant, inability to treat the vapor stream due to equipment failure, installation of only two liquid-ring vacuum pumps instead of three, the installation of a plate-and-frame heat exchanger for the vapor line instead of a shell-and-tube heat exchanger, and not enough capacity in the vapor condensate receivers. These system constraints caused operators to limit steam injection and liquid extraction rates. The vapor system was offline for months while a different heat exchanger was designed, manufactured and installed. During this period, operations consisted of limited injection and extraction that promoted clogging of the liquid extraction system pipelines and equipment with crystallized PAHs. As a consequence, the system was shut down.

The equivalent of approximately 2,940 gallons of NAPL was recovered during the pilot study: 340 gallons as NAPL and 9,800 kg (equivalent to 2,600 gallons) in the dissolved phase. During the same time period, the equivalent of 1,455 gallons of NAPL was extracted by the pump-and-treat system in the remaining seven acres of the Former Process Area (FPA): 1,295 gallons as NAPL and 606 kg (equivalent to 160 gallons) in the dissolved phase. Prior to the pilot, the average amount of NAPL extracted per month was approximately 320 gallons with an average of approximately 24 gallons per month in the dissolved phase. Though the amount of NAPL removed did not show a marked increase during the pilot study, the amount of contaminants removed in the dissolved phase increased dramatically.

Available data suggest that significant contamination was removed in the vapor phase, however some of the planned monitoring instruments were not installed when the vapor system was in operation, and accurate vapor-flow measurements could not be made. Additionally, due to the early termination of the study, it was not possible to assess in-situ degradation via biologic and abiotic processes. The mass removal that occurred during the pilot study was minor compared with what could have been achieved with a fully functional steam-enhanced extraction (SEE) and treatment system.

Lessons learned that would apply to any technically complex project include: the need to inform senior management of issues associated with funding constraints that impact system capacities, the need to assess risks associated with design features inconsistent with industry practice, and to have contingency plans in order to manage these risks effectively.

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SECTION 1.0 INTRODUCTION AND PROJECT OBJECTIVES

The U.S. Army Corps of Engineers is providing remedial design and remedial action services to the U.S. Environmental Protection Agency Region 10 for the Wyckoff/Eagle Harbor Superfund Site, located on Bainbridge Island, Washington (Figure 1.0-1). The USACE designed a pilot study that was intended to determine the effectiveness of innovative thermal remediation to enhance the recovery of NAPL from the site. This work was performed to meet the requirements of the Record of Decision for the Soil and Groundwater Operable Units (OU) (USEPA 2000).

In 1998, USEPA was asked to evaluate in-situ thermal technologies, including steam injection, as potential remedies for clean up of soil and groundwater contamination at the Site. In order to do this, a panel of experts on thermal remediation was assembled by USEPA to provide technical assistance on the evaluation of the application of in-situ thermal technologies for this site specifically, and to provide input on the design and operation of the system at sites where USEPA makes a decision to proceed with in-situ thermal technologies. This panel became known as the In-Situ Thermal Technology Technical Assistance Panel (ITTAP), and was comprised of the principal engineers and researchers from both academia and industry who had pioneered the use of thermal remediation in the United States. USEPA met with the panel several times during 1999 and 2000. Based on the success that had been achieved using thermal remediation at other sites, the ITTAP panel supported the use of thermal remediation at Wyckoff.

The USEPA identified in-situ thermal technology (steam injection) as a potential remedy for clean up of soil and groundwater contamination at the Site. The purpose of the pilot study falls into two broad categories:

1. To assess the likelihood that full-scale thermal remediation will achieve the cleanup goals for the Site;

2. To provide information for implementation of the potential full-scale thermal remediation.

The pilot study design was based on meeting these objectives. In the interim, a sheet pile barrier was constructed to prevent movement of contaminants beyond the Site boundaries. If the pilot study is not successful in demonstrating the effectiveness of thermal treatment and/or the full scale system is not implemented for any number of reasons, a "containment" remedy is now partially in place. The final containment remedy would include a fully enclosed sheet pile wall (incorporating the existing outer sheet pile wall) that surrounds contaminated soil and groundwater in the Former Process Area (FPA), a replacement groundwater pump-and-treat system to maintain the water level within the sheet pile wall, a soil cap to isolate surface soils in the FPA, and shoreline improvements.

The purpose of this report is to document the design, construction, and operation activities for the pilot study performed by the USACE from 2000 through 2003, with particular attention to shortcomings of the project that contributed to its early termination. In this regard, the document may provide a roadmap for future projects that will allow them to avoid pitfalls associated with constraints imposed by complex technologies, budget, and schedule.

The pilot study began operations in October 2002. Due to complications with several systems caused by high concentrations of contaminants in the waste stream, serious limitations to the existing waste-water treatment plant, and multiple equipment failures, steam injection was stopped in April 2003. The USEPA and USACE are currently evaluating various options before potentially continuing with the pilot study.

The report is divided into the following sections:

1.0 Introduction
2.0 Site History and Previous Treatment Operations
3.0 Pilot Test Area Baseline Conditions
4.0 Design and Construction Summary
5.0 Operations Description
6.0 Summary of Results
7.0 Cost Summary
8.0 Conclusions
9.0 Lessons Learned

1.1 STEAM-ENHANCED EXTRACTION TECHNOLOGY DESCRIPTION

Steam-enhanced extraction has its roots in the petroleum industry, where steam injection is used to enhance oil recovery from reservoirs. Beginning in the late 1980’s, steam injection has been adapted for the recovery of volatile and semivolatile contaminants from unconsolidated media (Hunt et. al, 1988; Udell and Stewart, 1989; Itamura and Udell, 1993). This research has shown that there are three main mechanisms in steam injection that contribute to contaminant recovery, as summarized by Udell (1996) and Davis (1997):

- Physical displacement of NAPL as the steam migrates from injection to extraction wells, assisted by the reduction in NAPL viscosity during heating, leading to greater mobility.

- Increased vaporization and extraction in the vapor phase.

- Increased solubilization of contaminants with subsequent removal in the dissolved state by the groundwater extraction system.

In addition, in-situ destruction due to either chemical or biological mechanisms may contribute to the remediation process during steam injection (Lief et al. 1998).

Initially, as steam is injected, the steam condenses, transferring the latent heat of condensation from the steam to the well bore, groundwater, and formation matrix immediately surrounding the injection zone of the well. As steam injection continues, the hot water (condensate) moves into the formation, pushing the cold (ambient temperature) formation water in advance of this front. When the soil at the steam injection point has absorbed sufficient heat, steam will begin to enter the formation, pushing the cold formation water and hot condensate water ahead of it. The first fluid to come in contact with the compounds of concern is the cold water bank, which flushes mobile compounds in displaced groundwater. The hot water that follows reduces the viscosity of the NAPL, displacing it by hydrodynamic forces, potentially reducing residual saturation, and enhancing biodegradation. When the steam front reaches the contaminated zone, additional contaminant removal occurs through volatilization, evaporation, and steam distillation of volatile and semi-volatile compounds.

In some cases where the NAPL saturation is high, a bank of NAPL or highly-concentrated contaminants can be formed in front of the steam zone. A NAPL bank forms when oil-phase fluids are displaced and driven ahead of the steam zone, or when compounds volatilized from the steam zone are condensed at the steam front. When the pollutants represent a mixture of volatile and semi-volatile compounds, as in creosote, the compounds with lower boiling points will vaporize first, followed by the higher-boiling point compounds. As a result, there will be a corresponding differentiation of the constituents in the bank of condensed compounds moving through the formation in advance of the steam front.

A physical characteristic of steam injection processes is steam override due to gravitational forces. Steam override is caused by the density difference between steam and water, and will tend to make the displacement process less effective during steam injection remediation. The degree of steam override increases as: 1) the difference in density between the liquid and vapor phases increases, 2) the permeability of the formation decreases, 3) the viscosity of the liquid phase increases, and 4) the injection rate decreases. Steam override cannot be eliminated, but by increasing the steam injection rate, the difference between the vapor and liquid viscous forces is reduced and thus the amount of override can be decreased (Davis, 1998).

The pressure of the injected steam increases formation pore pressures, which may also serve to inhibit volatilization. Manipulation of subsurface pressures by reducing or halting steam injection while continuing aggressive vapor and groundwater extraction after steam breakthrough to the extraction wells, called “pressure cycling”, can enhance the recovery of volatile compounds by creating a thermodynamically unstable condition, in which vaporization is enhanced by the boiling of pore fluids. For sites contaminated with semi-volatile and non-volatile mixtures of chemicals such as creosote, pressure cycling is used both to enhance vaporization of the lighter fractions of contaminants, and to induce mixing of injected steam and air with the contaminated groundwater. This may stimulate degradation reactions that take place under aerobic conditions at elevated temperatures. These reactions may be thermodynamically driven (sometimes called hydrous pyrolosis/oxidation) or biologically mediated.

1.2 PROJECT OBJECTIVES

Nine primary objectives were developed to meet remedial action objectives in the 2000 ROD for the Soil and Groundwater Operable Units. These nine objectives can be divided into three broad categories: performance assessment, potential impacts of full-scale thermal treatment on the environment and surrounding community, and process monitoring. The specific project objectives are presented below:

Performance Assessment Objectives

- Demonstrate that thermal remediation technologies will remove substantially all mobile NAPL from the pilot test treatment area.
- Demonstrate that the post-thermal treatment concentrations of NAPL constituents dissolved in groundwater that move from the site to Eagle Harbor and Puget Sound will not exceed marine water quality criteria, surface water quality, and sediment standards at the mud line.
- Demonstrate that surface soil (0 to 15 ft) concentrations within the pilot test area attain Washington State Model Toxics Control Act (MTCA) Method B cleanup levels.

Cleanup levels for the site are included as Appendix A.

Community and Environmental Impacts of Full-Scale Thermal Remediation Objectives

- Determine the potential impacts (noise, air emissions, lower aquifer and odors) of full-scale thermal treatment to the surrounding community.
- Evaluate the possible adverse effects that full scale thermal treatment may have to Eagle Harbor and Puget Sound near shore marine habitats.

Process Objectives

- Evaluate operational approaches to thermal remediation that may impact the removal of NAPL, such as steam movement and recovery of NAPL from the aquitard.
- Evaluate treatment plant performance during the pilot test to allow optimization of operations and monitoring mass balance of contaminant removal.
- Evaluate microbial populations before and after thermal treatment to assist in determining long-term contaminant destruction.
- Evaluate contaminant oxidation rates during thermal treatment to assist in mass balance calculations.

Additionally, an objective to evaluate the effectiveness of biological treatment and break down of primary contaminants in extracted liquids produced during a thermal remediation system was added to the original list of objectives established in the ROD. The extent to which each of these objectives was met during this pilot test is discussed in Section 8.0.

1.3 PILOT STUDY PLANNING DOCUMENTS

Several documents were prepared in support of the pilot test. These documents contain much of the detail on the technical planning process, design, and operations.

- Interim Record of Decision (Interim ROD). Groundwater Operable Unit. USEPA. September 30, 1994. Documents the selection of containment of NAPL and contaminated groundwater as the remedy for the site.

- Feasibility Study (FS). Soil and Groundwater Operable Units. CH2M Hill. October 17, 1997. Includes a comparison of 23 alternatives for the Soil OU. Concludes that regardless of the alternative selected for the Soil

OU, there would be significant remaining contamination associated with the Groundwater OU.

- Focused Feasibility Study for Thermal Remediation Technologies (FFS). Soil and Groundwater Operable Units. CH2M Hill. June 1998. Includes a comparison of numerous thermal remediation alternatives to containment. Concludes that thermal technologies may be preferred over the containment option.

- Conceptual Design (CD). Soil and Groundwater Operable Units. USACE. September 9, 1999. Describes the full-scale thermal remediation conceptual design for the soil and groundwater operable units as well as many of the design considerations made in developing the conceptual design.

- Record of Decision (ROD). Soil and Groundwater Operable Units. USEPA. February 2000. Documents the selection of thermal remediation as the remedy for the site to be implemented in two phases: Phase 1 - pilot test; Phase 2 – full scale. As stated in the ROD, implementation of full scale thermal remediation was dependent on the pilot study reasonably attaining the performance expectations. Hydraulic containment was selected as the contingency remedy.

- Thermal Remediation Pilot Test Area Selection Memorandum. Groundwater and Soil Operable Units. USACE. April 21, 2000. Proposes three areas for consideration for the pilot test and recommends Area C.

- Comprehensive Report. Wyckoff NAPL Field Exploration. Soil and Groundwater Operable Units. Wyckoff/Eagle Harbor Superfund Site. USACE. May 2000. Presents results of the soil sampling and analysis conducted in the upland area of the site.

- Thermal Remediation Shoreline Model Report. Groundwater and Soil Operable Units. USACE. May 22, 2000. Using numerical modeling, evaluates effects of thermal remediation on temperatures in intertidal sediments and explores engineering controls.

- Final Conceptual (10%) Design (Pilot Study CD). Thermal Remediation Pilot Study. USACE. August 9, 2000. Documents the initial pilot test design effort, including consideration of design alternatives.

- Final Design Analysis (DA). Thermal Remediation Pilot Study. USACE. August 31, 2001. Documents the pilot study design effort, including consideration of design alternatives, provides justification for design decisions, and presents information on the project schedule.

- Steam Injection Treatability Study. Final Report. USEPA. July 11, 2002. Presents results of the steam treatability study conducted at the Robert S. Kerr Environmental Research Center in Ada, OK.

- Final Design Analysis Amendment (DAA). Thermal Remediation Pilot Study. USACE. August 6, 2002. Documents changes to the Final Design Analysis for the Thermal Remediation Pilot Study, dated August 31, 2001.

- Preliminary Review Draft Baseline Characterization Report. Thermal Remediation Pilot Study. USACE. November 1, 2002. Describes the results from the baseline characterization work performed during installation of the extraction, injection, and instrument string wells for the Thermal Remediation Pilot Study.

- Draft Remedial Action Management Plan (RAMP). Thermal Remediation Pilot Study. USACE. November 22, 2002. Management plan for integrated site operations of the Thermal Remediation Pilot Study and the groundwater treatment plant and extraction system.

1.4 INITIAL CONSTRUCTION

Following the signing of the ROD in February 2000, a contract was awarded to Bay West, Inc. (Bay West) in August 2000 for installation of two sheet pile walls. A 1,870-foot-long perimeter vertical barrier wall was installed as part of the thermal remediation remedy to separate contaminants in the FPA from the marine environment. Additionally, a 536-foot-long vertical barrier wall was installed in the southern portion of the upland to isolate the 1-acre pilot test area from the rest of the upland portion of the site. Sheet pile installations were completed by February 2001.

The final design of the Thermal Remediation Pilot Study was completed in August 2001 (USACE Design Analysis report). Phase I of this work was performed under the Site Infrastructure Contract between Marine Vacuum, Inc. (MarVac) and USACE which was awarded in July 2001. The Phase I work was completed between August 2001 and March 2002 and primarily consisted of construction of the boiler building and the subsurface (belowground) portion of the pilot study's elements, including the installation of the vapor cap, the water supply well, and the steam injection and extraction wells. Additional contract specifications for the pilot study were developed by the USACE in the spring of 2001 that included pre-thermal operation of the existing groundwater treatment plant (GWTP) and extraction system, minor modifications to the existing GWTP, installation of the thermal components of the existing boiler building and pilot test area, and a start-up phase for all new equipment. This work was to be followed by an operation and maintenance (O&M) phase for steam injection and liquid/vapor extraction and an operational post-thermal period for ongoing O&M of the existing groundwater treatment plant and extraction system.

The solicitation to contractors was issued in the summer of 2001, however, an award was not made and the solicitation was cancelled because the proposals received greatly exceeded the government cost estimate.

1.5 PILOT STUDY DOWNSIZING

Due to the disparity between contractor proposals and the government cost estimate, USEPA requested the design team redesign the pilot study contract by downsizing and down scoping the project to meet the project budget while maintaining the overall goals and objectives of the project and with the government assuming the majority of the risk. The procurement strategy was also re-evaluated due to schedule and budget constraints, and it was determined that three contracts, rather than one, would best serve the needs of the project and help to limit the government's assumption of risk. Procurement #1 was for interim operations and maintenance of the existing treatment plant and extraction system and was awarded to SCS Engineers, Inc. (SCS) on January 1, 2002. Procurement #2 was for the construction of the Steam Injection Pilot System and was awarded to Pease Construction (Pease) on January 23, 2002. Procurement #3 was for O&M of the steam injection pilot study system, the existing well-field outside of the pilot test area, and the GWTP and was awarded to SCS on September 20, 2002. The scope of these changes was presented in the Design Analysis Amendment. Changes to the design, starting from the Conceptual Design, Design Analysis, Design Analysis Amendment, and through construction, are discussed in Section 4.0. It should be noted that because the sheet pile wall and several injection and extraction wells within the pilot test area had already been installed prior to the request to downsize the overall pilot study, the technical team's ability to select appropriate design elements to adjust was limited. However, a more aggressive approach to the downsizing may have allowed a better fit to the reduced budget.

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SECTION 2.0 SITE HISTORY AND PREVIOUS TREATMENT OPERATIONS

The Wyckoff Soil and Groundwater OUs occupy a relatively flat lowland and intertidal area bounded by a densely vegetated bluff on the south. The lowland area has an average elevation of approximately 16 feet MLLW while the hillside area rises to elevations above 200 feet. The north and west portions of the site are bounded by Eagle Harbor, and Puget Sound abuts the eastern margin of the site (Figure 2.0-1). The entire Wyckoff property occupies approximately 57 acres (about 18 of which encompass the Soil OU), including a spit that is approximately 8 acres in size with about 0.8 miles of shoreline, which extends northward into Eagle Harbor. The spit was extended and filled at least twice prior to the 1950s, and was the location of the FPA where wood treatment activities that caused the current soil and groundwater contamination were carried out.

The focus of the pilot study was the pilot test area located in the FPA within the Soil and Groundwater OUs. The pilot test area comprises approximately 12% of the surface area of the FPA.

2.1 SITE HISTORY

Prior to 1904, the Wyckoff property was owned by a sand mining operation and a brickyard. From 1904 through 1988, the site was used for the treatment of wood products (e.g., railroad ties and trestles, telephone poles, pilings, docks and piers) by a succession of owners and companies. Chemicals used at the site include creosote, pentachlorophenol, solvents, gasoline, antifreeze, fuel, waste oil and lubricants. These chemicals were stored in above-ground storage tanks, conveyed through above- and below-ground piping, disposed in sumps, spilled and buried on site.

USEPA began an investigation of the property in 1971, and the site was subsequently placed on the National Priority List (NPL) in 1987. In 1988, the Wyckoff Company ceased all operations on the property. In 1989 a groundwater pump and treat system was installed to treat contaminants in the FPA. In 1993, USEPA assumed management of the Soil and Groundwater OUs, and in 1994 the assets of the former Wyckoff Company (now Pacific Sound Resources) were placed into an environmental trust.

2.2 SITE GEOLOGY AND HYDROGEOLOGY

The Wyckoff site straddles the boundary between (1) a glacial drift plain deposited 13,000 to 15,000 years ago as part of the Vashon Stade of the Fraser Glaciation and (2) marine and fluvial deposits of the Seattle Basin. The subsurface can be divided into the following general hydrogeologic units:

- Vadose zone
- Unconfined upper aquifer
- Low-permeability aquitard
- Semi-confined lower aquifer

Figure 2.2-1 displays a southwest-northeast profile through the site, which shows typical relationships between soil types and occurrence of NAPL.

The vadose zone is approximately 10 ft thick and consists of fill and native materials composed of discontinuous silt and fine sand layers. NAPL has been observed in the vadose zone, but it is not pervasive.

The upper aquifer consists of approximately 5-10 ft of fill, silt, and fine sand (similar to vadose zone soils), overlying a sequence of marine sand and minor interbedded gravel, silt, and clay. The marine sands range in thickness from 5-70 ft, with thickness increasing to the northeast. The upper aquifer in many parts of the site is grossly contaminated with NAPL and dissolved-phase constituents. Prior to installation of the outer sheet-pile wall, the upper aquifer was in direct communication with Eagle Harbor and Puget Sound. Tidal effects, transmitted from the lower aquifer through the aquitard, are still evidenced in some wells. The natural groundwater gradient is from the south and radially towards Eagle Harbor and Puget Sound.

Separating the upper aquifer from the lower semi-confined aquifer is a relatively impermeable layer comprised of marine silt and glacial till. The top of the aquitard extends from near ground surface in the southern part of the site to approximately 75 ft bgs in the north. At the time of design, the aquitard was thought to be continuous throughout the site, with thickness varying from as little as 5 ft to 40 ft. More recent interpretations indicate that the aquitard is absent in the southeast corner of the site and may be laced with interconnected sand lenses elsewhere. NAPL has been observed in several borings that penetrate the aquitard, primarily associated with sand and gravel interbeds. More recent interpretations indicate that the aquitard is absent in the southeast corner of the site and may be laced with interconnected sand lenses elsewhere.

The lower aquifer consists primarily of sand, with lesser amounts of silt, clay and gravel. The base of this aquifer has not been determined with certainty, although the few boring logs that penetrate deep enough suggest that the aquifer extends to approximately 200 ft bgs. Tidal effects are ubiquitous in the lower aquifer, presumably due to tidal loading on the aquitard. Horizontal groundwater gradients are towards Eagle Harbor and Puget Sound. Vertical gradients are generally upward (from lower to upper aquifer), but short-term reversals may occur at low tide. Low levels of PAH contamination are present in some monitoring wells and NAPL was observed in CW-15 during the baseline groundwater characterization sampling in November 2002.

2.3 GROUNDWATER TREATMENT SUMMARY

In 1988 the Wyckoff Company was ordered by USEPA to install groundwater extraction wells and a GWTP to extract and treat contaminated groundwater, minimize further releases of contaminants to the surrounding surface water, and to recover as much NAPL as possible. The system includes both biological and physical/chemical unit processes, including activated carbon. The GWTP remained in operation under Pacific Sound Resources until November 1993 when the USEPA took over the site under Superfund.

The GWTP accommodates a maximum practical flow rate of 80 gpm. On average, the treatment plant treats approximately 2.5 million gallons of groundwater per month, for a total from November 1993 to September 2002 of approximately 250 million gallons of groundwater. Separated from the extracted groundwater was approximately 59,000 gallons of NAPL that was shipped off-site for destruction.

Until the pilot study was conducted, the treatment system remained relatively static as far as processes and upgrades. However, during the conceptual design phase, the GWTP was recognized to be near the end of its useful life. Therefore, prior to the start of the pilot study, minor upgrades to replace the already failing depurator and for new piping to sustain the higher temperature waste stream anticipated from the pilot test area were designed in order to handle the anticipated increase in contaminant loading during steam injection operations. Details on the design changes and implementation are included in Section 4.

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SECTION 3.0 PILOT TEST AREA BASELINE CONDITIONS

The pilot test area was selected in April 2000 (Appendix B) because information gathered during previous investigations indicated that this area contained all of the geologic units present at the site with the exception of the marine silt unit, and that relative volumes of the geologic units are representative of the overall project area. The down-sized project area includes approximately 16,400 cubic yards of soil in the vadose zone and the contaminated aquifer. Also, it was believed that there were at least five feet of LNAPL in the upper portion of the aquifer, as well as several feet of DNAPL directly overlying the aquitard in this area, and that significant NAPL contamination was present in the non-marine clay and glacial unit. NAPL was believed to occur as deep as 11 feet into the aquitard. As a result of observations during drilling conducted for baseline characterization, estimates of the amount of LNAPL and DNAPL in the area were approximately 10,000 and 30,000 gallons, respectively.

During design of the original pilot test area injection and extraction well arrays, it was known that residual NAPL existed up-gradient of the area, but it was believed that this contamination could easily be removed by excavation to prevent interference with the pilot study. Downsizing of the pilot test area wellfield resulted in exclusion of some areas with mobile NAPL upgradient of the treatment zone, in addition to the areas with residual NAPL. Neither the mobile nor the residual NAPL was excavated prior to the start of pilot study operations.

During the installation of the injection and extraction wells and instrument strings, baseline characterization of the pilot test area was carried out. The purpose of the baseline characterization was to determine the location of NAPL in the pilot test area and to measure the concentrations of the contaminants of concern in soils within the pilot test area for comparison with post thermal treatment conditions. Site-specific hydraulic conductivity data were determined through pumping tests conducted at extraction well E-4 (Appendix C). These data assisted in selecting the optimum steam injection well screen length, and to confirm the original design assumptions used for estimating flow rates. In addition, soil samples were collected from the pilot test area to evaluate microbial populations in the vadose and saturated zones. Three soil samples were collected and analyzed for physical characteristics and thermodynamic properties.

3.1 FIELD INVESTIGATION METHODS

Field work was performed by the USACE beginning in May 2001 and completed in March 2002. Soil borings for sampling and analysis were completed using either a truck-mounted or a track-mounted geoprobe, depending on the requirements for diameter of the sampling device. Samples were collected from locations pre-identified for installation of injection wells, extraction wells, or instrument strings. Cores were collected in either a 2.2 inch or 3 inch outside diameter by four foot long steel sample barrel fitted with a clear polyethylene terephthalate glycol (PETG) or polyvinyl chloride (PVC) sample sleeve. The larger diameter borings, accomplished with the track-mounted geoprobe, were necessary to accommodate the downhole instruments used in the holes completed as instrument strings. Continuous cores were collected until the aquitard was encountered. Each core retrieved was logged for stratigraphy and evaluated for the presence of NAPL by a USACE geologist. The following conservative assumptions were used to translate observed NAPL occurrence into potential *in situ* cumulative thickness:

1. If mobile NAPL was noted, the entire soil interval in which the NAPL was found was assumed to contain NAPL;

2. If mobile NAPL stringers were noted, and soil grains were coated throughout the soil interval, then the entire soil interval was assumed to contain NAPL;

3. If mobile NAPL stringers were noted, and a heavy sheen was present, then half of the soil interval was assumed to contain NAPL;

4. If NAPL stringers were noted, then each stringer was assumed to represent 0.1 feet of NAPL; and

5. If soil grains were coated or a sheen was present, no NAPL thickness was assumed.

Two samples for chemical analysis were collected from each four foot long core, one representing the top two feet and a second representing the bottom two feet. Samples from 0 to 6 foot depth were considered vadose zone samples, and were analyzed for semi-volatile organic compounds by an EPA Contract Laboratory Program (CLP) laboratory using EPA SW-846 Method 8270B. The samples that had low PAH concentrations were reanalyzed using Selected Ion Monitoring to allow for reporting limits that were less than the MTCA Method B soil cleanup levels. Each sample from the saturated zone was analyzed for PAH, diesel and oil range petroleum hydrocarbons, and pentachlorophenol (PCP) by the EPA Region 10 Field Analytical Support Program's

(FASP) mobile laboratory. The on-site FASP laboratory used gas chromatography/flame ionization detector methods to identify PAH, C12 to C24 (diesel range) and C24 to C35 (motor-oil range) concentrations. PCP concentrations were measured using electron capture detector methods. Approximately 50 samples from the saturated zone were also analyzed by the CLP method to obtain a broader target analyte list than was possible with the FASP analytical protocols. Seventeen vadose zone samples were shipped to an off-site laboratory for dioxin-furan analysis. The results of this investigation are presented in the Preliminary Review Draft Baseline Characterization Report.

3.2 PILOT TEST AREA GEOLOGY AND HYDROGEOLOGY

The depth to the top of the aquitard in the pilot test area ranges from approximately 25 feet at the southern part of the treatment area to 35 feet at the northern portion. Four of the geologic units present in the FPA were found in the pilot test area: fill; marine sand and gravel; non-marine clay; and glacial clay, silt and sand. A marine silt that approaches thicknesses of 37 feet in other parts of the site is absent in the pilot test area, as is a fluvial sand that occurs in relatively restricted areas. Figure 3.2-1 shows a location map for three profiles through the pilot test area. The profiles are displayed in Figures 3.2-2, 3.2-3, and 3.2-4.

Approximately the top five to seven feet of the pilot test area appears to be sand or silt fill, although in places the fill is up to 18 feet deep. The fill material was imported from nearby sources, and consists of silt and fine-grained sand similar in physical characteristics to the underlying marine sand and gravel unit, making it difficult to differentiate between the two units. Locally the fill consists of fine brown sand and contains anthropogenic material such as bricks, broken glass, and metal fragments.

The central and southwestern portion of the pilot test area is covered by a relatively thin (less than five feet thick) layer of non-marine clay. This clay is believed to have been excavated from the upland bluff to the south of the site. It consists of fine to medium brown sand, overlain by very soft to medium gray clay with occasional plant fibers, wood fragments, and roots.

The marine sand and gravel unit comprises the majority of the treatment zone, with a thickness ranging from a few feet at the southern end of the pilot test area to approximately 25 feet at the northern end. It is a nearshore marine/beach deposit, which is present over nearly all of the Wyckoff facility. The unit is generally continuous to the top of the glacial deposits. It consists of loose to dense, poorly graded, gray to dark gray, fine to medium sand with shell fragments throughout. Gravel lies in contact with the aquitard in the central part of the pilot test area, extending from the northern point to the southern extent of the treatment area.

The glacial clay, silt, and sand lies stratigraphically beneath the marine sand and gravel unit, and forms an aquitard separating the upper aquifer from the lower aquifer in the FPA. The aquitard has a northeastward slope that averages 7 degrees from horizontal. The elevation of the aquitard was well predicted over most of the pilot test area, with the exception of the northeast corner where a distinct depression exists. The glacial deposits consist mainly of gray to brown, stiff to hard clay and silt, with some sand and gravel, and no visible organic matter. Sand intervals within the glacial aquitard have been observed in the central portion of the FPA, close to the pilot test area. The glacial deposit was not sampled during the baseline characterization.

The water table in the pilot test area is generally six to ten feet below ground surface. Aquifer testing conducted after installation of the pilot test area extraction wells indicated that horizontal conductivity within the pilot test area is in the range of 15 to 30 feet/day (average 26 feet/day), with an average vertical anisotropy of 4.7. Thus the actual hydraulic conductivity is less than half the value of 54 feet/day that was used in the thermal remediation model, and the vertical anisotropy is approximately ¼ of the value of 20 used originally. The piezometric level in the lower aquifer is one to two feet higher than the static water level in the upper aquifer, indicating that vertical flow is upward through the aquitard under average conditions. Evidence for tidally-influenced fluctuations in pilot test area extraction wells E-5 and E-6 during aquifer testing implies that there is fairly good communication between the upper and lower aquifers in part of the pilot test area. Hydraulic communication may be enhanced by interconnected sand layers within the aquitard.

Samples taken from three instrument string locations (T-1, T-22, and T-30) were analyzed for physical characteristics and thermodynamic properties. The samples were chosen to represent the range of soil types observed in the pilot test area. Results of the analysis are presented in Table 3.2-1.

3.3 CONTAMINANT DISTRIBUTION IN SOIL

Both LNAPL and DNAPL were found during the baseline characterization, with significant accumulations in both the northern and western portions of the pilot test area. In the western portion, there is considerable LNAPL in the non-marine clay and marine sand and gravel unit, generally at depths of 12 to 16 feet bgs. In this LNAPL zone the highest concentrations of PAH and total petroleum hydrocarbons (TPH) were detected.

Generally the total PAH concentrations are in the range of 5,000 to 10,000 mg/kg at this depth, but concentrations as high as 105,000 mg/kg were measured. TPH concentrations are generally about three times the concentration of the PAH, but the ratio is lower when the concentrations of PAH are greater. Total TPH concentrations as high as 125,000 mg/kg were measured, and the highest concentrations of TPH are co-located with the highest PAH concentrations. Naphthalene makes up 90 percent and more of the PAH found in the LNAPL in the western portion of the pilot area. Thus, the LNAPL in the pilot test area appears to be primarily composed of naphthalene and petroleum hydrocarbons. Naphthalene, with a melting point of 80 ˚C, is normally a solid at ambient temperatures. It is likely that the petroleum hydrocarbons in this area act as solvents to maintain the naphthalene in a dissolved state. Crystalline PAHs also occur within this area, usually at or near the base of the non-marine clay.

In DNAPL zones along the western portion of the pilot area, soil samples show total PAH concentrations in the range of 1,000 to 3,000 mg/kg. Naphthalene was also the most common PAH found in the DNAPL, but in some individual samples, phenanthrene was more abundant than naphthalene.

In the southeastern portion of the pilot area, particularly around extraction well E-5, contaminant concentrations in many of the soil samples were less than detection limits. Only a few soil samples have been collected from the northeastern portion of the pilot test area, and the data do not allow conclusions to be drawn about the level of contamination in that area. At the east and central area next to the sheet pile wall are two instrument string borings (T-52 and T-53) that again show very high naphthalene and TPH concentrations in the 8 to 10 foot depth interval, similar to that found in the western portion of the site.

The samples submitted to the CLP laboratory in order to obtain a broader target analyte list showed that PAHs were the most abundant constituents detected by this method. Other constituents detected less frequently and at generally smaller concentrations include 1-methylnaphthalene, 2-methynaphthalene, 1,1’-biphenyl, 4-methylphenol, 2,4-dimethylphenol, and acetophenone.

PCP was typically detected in soil samples collected from the pilot test area only at low concentrations (usually less than 1 mg/kg). Most of the detections were in the vadose zone soil samples. However, a few locations along the northeastern part of the sheet pile wall, such as T-49, E-2, and E-6A, had higher concentrations over significant depths. PCP concentrations in the range of 1 to 20 mg/kg were detected in the 8 to 18 foot depth range of these boreholes.

A total of 17 soil samples were analyzed for dioxins and furans. These samples were from either the 0 to 4 inch or 4 to 4.33 ft depth interval. Octachlorodibenzodioxin (OCDD) was detected in the highest concentration of all the congeners with concentrations generally in the range of 10,000 to 40,000 ng/kg. The highly-toxic 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD or simply dioxin) was detected only at low concentrations, the highest detection being 0.9 ng/kg. The surface soil samples had toxicity equivalent concentrations in the range of 10 to 130 ng/kg. The concentrations in the deeper samples were generally lower, ranging from 0.05 to 38 ng/kg.

3.4 MICROBIAL POPULATION EVALUATION

In order to evaluate microbial populations before steam injection, soil samples were obtained during the installation of the pilot system to determine PAH degradation and microbial community structure. Microcosms were constructed using vadose and saturated zone samples from various areas of the pilot test area, then incubated for 8 or 9 weeks, before sacrificing to determine PAH concentrations. Control microcosms were also constructed using sodium azide to eliminate microbial activity, however, control microcosms exhibited a loss of PAHs that could have been due to microbial activity or to vaporization of contaminants during the incubation period. Vadose zone soil microcosms showed relatively little change in PAH concentrations during the incubation period. Most of the saturated zone microcosms exhibited a loss of PAHs, however, without good data from the control microcosms and without demonstrating oxidation activity by oxygen uptake or byproduct formation, microbial degradation cannot be documented.

In order to determine microbial community structure, which can be defined as the relative abundance and diversity of microorganisms present, vadose and saturated zone samples were submitted to Microbial Insights, Inc, for phospholipid fatty acid (PLFA) analysis. Results from this analysis show that the total biomass values suggest similar cell populations in all samples, with estimates ranging from 1.27 to 8.7 x 10^6 cells/gram dry weight. In general, the viable biomass and microbial type distributions were similar for a given sample before and after the degradation study. All samples were dominated (>45%) by Gram-negative bacteria. Two indicators of metabolic activity and stress suggested that the saturated zone is a less hospitable environment for bacteria than the vadose zone. Results of this study are included in Appendix D.

Because the pilot study was not completed, confirmation soil samples needed to complete the microcosm study were not collected and the study has not been completed.

3.5 GROUNDWATER RESULTS

Groundwater samples were obtained from seven extraction wells (E-1 through E-7), five lower aquifer monitoring wells (99CD-MW02, 99CD-MW04, CW-05, CW-09, and CW-15), and three upper aquifer monitoring wells (MW-17, MW-18, and MW-19) in early November 2002. Well locations are shown in Figure 3.5-1. Data summary tables are included in Tables 3.5-1 through 3.5-3 and in Appendix I. At this time, some amount of steam had been injected into the pilot test area, and temperatures in the upper half of the upper aquifer around the injection wells had already reached temperatures as high as approximately 50–60 ˚C. Temperatures around the extraction wells remained close to ambient temperatures. Thus, these are not truly background samples, but they provide the best information available on groundwater conditions at the start of the pilot study.

3.5.1 Pilot Test Area Extraction Wells

Pilot test area well monitoring was implemented to test remedy effectiveness. Specifically, trends in dissolved-phase constituents would be tracked to assist in post-treatment predictions of attainment of performance objectives. Two extraction wells were sampled with the upper and lower aquifer samples on November 5, 2002 (E-4 and E-6). All seven extraction wells in the pilot test area were sampled on November 7, 2002. Extraction wells E-1, E-2, E-3, E-6 and E-7 have similar high concentrations of PAH. Extraction well E-4 had PAH concentrations that were an order of magnitude lower, which might be expected since soils immediately to the east of this well were relatively clean. Extraction well E-5 was surrounded by mostly clean soils, thus it contained only very low concentrations of PAH early in the pilot study. It appears that the sample from extraction well E-1 was over diluted by the laboratory, as the reporting limits are high, and even the constituent with the highest concentration (naphthalene) is qualified as estimated (J qualified). This was a consistent issue with the high concentration extraction well water samples sent to the USEPA CLP laboratory. Additionally, the two samples collected from E-6 showed high variability in results, most likely due to the use of the sampling port for sample collection. Low-flow sampling methods were not used to collect samples from the extraction wells.

Among PAHs, naphthalene is present at the highest concentration, as would be expected due to its abundance in the soil and relatively high solubility. The high molecular weight PAHs were generally not detected in this first round of groundwater samples. PCP was only detected in extraction well E-6 effluent in this initial round of sampling, and the concentration was relatively low (22 μg/L) compared to maximum concentrations in other parts of the site. Other constituents that were detected include 1,1'-biphenyl, 2,4-dimethylphenol, 2-methylnaphthalene, 2-methylphenol, and 4-methylphenol, the same constituents that were found in the soil samples.

3.5.2 Upper Aquifer Monitoring Wells

Upper aquifer monitoring was initiated to document conditions (for completeness) in the upper aquifer outside of the pilot test area. Three monitoring wells in the upper aquifer, MW-17 which is to the west of the pilot test area, MW-18 which is just outside of the pilot test area to the northeast, and MW-19 which is to the southwest, were also sampled in November 2002. MW-17 and MW-18 are in highly contaminated areas, and thus, show PAH contamination in excess of the cleanup levels (see Appendix A for specific cleanup levels). MW-19 is in a cleaner area of the site, and contains less contamination. However, the concentrations of benzo(a)pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene in this well exceed the cleanup levels.

3.5.3 Lower Aquifer Monitoring Wells

Sampling of lower aquifer monitoring wells was intended to document any adverse effects of thermal remediation in the pilot test area on groundwater quality in the lower aquifer. Five lower aquifer wells were sampled in November 2002: CW-05, CW-09, CW-15, 99CD-MW02, and 99CD-MW04. The lower aquifer monitoring wells closest to the pilot test area, 99CD-MW02 and 99CD-MW04, both showed low levels of PAH contamination at this time. PAH detected in these samples included acenaphthene, anthracene, phenanthrene, fluoranthene, and pyrene. None of these concentrations were greater than the cleanup levels. The other lower aquifer monitoring wells that were sampled are all closer to the shoreline than the pilot test area, and all have historically shown contamination. During the November 2002 sampling round, all three wells contained PAH concentrations that slightly exceeded the cleanup levels. A small amount of NAPL was purged from CW-15 during this sampling round. Compounds that exceed the cleanup levels included benzo(a)anthracene, chrysene, benzo(a)pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, and pentachlorophenol.

3.5.4 Summary of November 2002 Groundwater Results

Groundwater samples were collected from upper aquifer extraction and monitoring wells, as well as from lower aquifer monitoring wells in November 2002 just after the start of steam injection. Extraction wells E-1, E-2, E-3, E-6 and E-7 have similar high concentrations of PAH. Extraction well E-4 had PAH concentrations that were an order of magnitude lower, which might be expected since soils immediately to the east of this well were relatively clean. Extraction well E-5 was surrounded by mostly clean soils, thus it contained only very low concentrations of PAH early in the pilot study. Upper aquifer monitoring wells MW-17 and MW-18 are in highly contaminated areas, and thus showed PAH contamination in excess of the cleanup levels. Upper aquifer monitoring well MW-19 is in a cleaner area of the site, and contains less contamination. The lower aquifer monitoring wells closest to the pilot test area, 99CD-MW02 and 99CD-MW04, both showed low levels of PAH contamination at this time. Lower aquifer monitoring wells CW-05, CW-09, and CW-15 are all closer to the shoreline than the pilot test area, and all have historically shown contamination.

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SECTION 4.0 DESIGN AND CONSTRUCTION SUMMARY

This section describes the design and construction of the pilot study systems. The treatment duration, treatment area, above-ground conveyance systems, and fluid-cooling and treatment systems were progressively downsized throughout the redesign and construction process. Since the downsizing had significant impacts on the project outcome, the evolution of each major system, including revisions based on revised calculations and modeling and changes made in the field, are described in this section.

Detailed original design criteria and assumptions are documented in the pilot study planning documents described in Section 1, specifically the Pilot Study Conceptual Design and the Design Analysis. Elements of the system that were redesigned are described in the Design Analysis Amendment. Additional changes were made during construction and pilot study operations. Construction at the site began in November 2000 and continued through the operational phase of the pilot study. A timeline showing when each system was installed is included in Figure 4.0-1. The layout of the systems at the Site during the operational phase of the pilot study is shown in Figure 2.0-1.

Three construction contractors were responsible for installation of the major systems at the Site: Bay West, Inc., Marine Vacuum, Inc. and Pease Construction, Inc. USACE-Seattle District personnel designed, procured, and installed all subsurface instruments and the automated data acquisition system (ADAS). Construction oversight was provided by USACE personnel.

4.1 DESIGN PROCESS

The design process was initiated through a series of four meetings between USEPA, USACE, and the ITTAP, from April 1999 through October 1999. During this time, several planning documents were prepared, with review by ITTAP and other technical reviewers within USEPA and USACE:

- Conceptual Design. Soil and Groundwater Operable Units. 1999.

- Thermal Remediation Shoreline Model Report. Groundwater and Soil Operable Units. 2000.
- Thermal Remediation Pilot Test Area Selection Memorandum and Amendment. Groundwater and Soil Operable Units. USACE. 2000.

After the ITTAP meetings were concluded, some of the panel members were retained to review the pilot study design documents, including:

- Thermal Modeling Protocol. 2000.
- Thermal Modeling Proposal. 2000.
- Comprehensive Report. Wyckoff NAPL Field Exploration. Soil and Groundwater Operable Units. 2000.
- Final Conceptual (10%) Design. Thermal Remediation Pilot Study. 2000.
- Final Design Analysis. Thermal Remediation Pilot Study. 2001.

The last of the design documents, listed below, received internal (USEPA and USACE) project team review only:

- Final Design Analysis Amendment (DAA). Thermal Remediation Pilot Study. 2002.

A three dimensional (3D) thermal model was used to provide design criteria such as optimum well spacing and screen lengths, steam injection rates, vapor and liquid extraction rates, heating and steam-breakthrough times, and surface temperatures. Modeling code requirements and a comparison of available codes were presented in the Thermal Modeling Proposal and the Thermal Modeling Protocol. The 3D numerical, thermal, multiphase, multicomponent flow and transport code M2NOTS (Adenekan, 1992) was selected because of its previous use for solving problems involving steam injection into NAPL-contaminated soils, and also because of the long service record of the underlying flow code TOUGH (Pruess, 1987). Code support was provided by the University of California at Berkeley. During preparation of the DAA, the design model was converted to NUFT (Nitao, 1998), a similar code that was more user-friendly and could be used with the Department of Defense Groundwater Modeling System (GMS) graphical-user interface.

During the redesign as described in the DAA, calculations for non-condensable gas flow and numerical modeling (NUFT) of the estimated liquid flow rate, vapor flow rate, heating time, steam injection break-though, and pressure cycling parameters were re-run. These new values were to be used by the operations team during and after active steaming operations to evaluate the performance of the system.

Fluid conveyance and treatment system designs incorporated design criteria developed by field testing, the above subsurface and process-design modeling, and consultation with ITTAP members. The site groundwater model was completed while system design was in progress, providing calibrated hydraulic parameters that were used to update the thermal model and well field design.

Criteria generated during the course of the original design process, as well as the revised criteria developed during the redesign, are summarized in Table 4.1-1.

4.2 SYSTEM DESCRIPTIONS

The design and construction of each of the major systems of the pilot study are described in this section. The original design for each system is presented and then compared to the revised design as well as the system that was actually constructed at the site. Changes were made to the design, both prior to and during construction, as well as during operation of the pilot study, in order to meet project schedule and budget constraints. In general, the changes in the project design required changes to be made to the operational strategies for the individual systems. The original design and subsequent changes made to the major systems are summarized in Tables 4.2-1 through 4.2-3.

4.2.1 Sheet Pile Wall

From November 2000 to February 2001 a 536-foot long sheet pile wall surrounding the steam injection pilot test area was constructed by Bay West. The pilot test area sheet pile wall was designed to mimic the shape of the entire FPA to evaluate NAPL removal collected against the wall and the impacts of heating on the sheet pile wall. The driving depths of the sheet pile varied from 15 to 45 feet. The toe of the wall was keyed a minimum of 4 feet into the upper surface of the underlying glacial till. The original design and location of the sheet pile wall was not changed during the course of the project.

4.2.2 Well Field

This section describes the design and construction of the injection and extraction wells located in the pilot test area. The original design and subsequent changes made to these systems are summarized in Table 4.2-1.

Instrumentation strings for subsurface water level and heat monitoring were also installed in the well field. Subsurface instrumentation included vibrating wire pressure transducers, thermocouples, and a fiber optic distributed temperature sensor (DTS) system. Details on instruments and the ADAS are included in Appendix E.

Well locations and screen lengths shown in the original design (DA) were based on model simulations of a 7-spot well array, using the M2NOTS code. Model runs were performed with variable vertical and horizontal hydraulic conductivities to provide a well field design that could accommodate a range of field conditions. Wells were designed to be located in the field according to the following criteria:

- The maximum well-spacing (distance between injection and extraction wells) is 1.6 times the aquifer depth, based on model results.
- Arrays would be 7-spot if possible (6 injection wells surrounding a central extraction well).
- Arrays should cover the NAPL-contaminated portion of the pilot test area, with the southern-most injection wells outside the NAPL-contaminated area.
- Injection and extraction wells should alternate along the sheet pile wall.

These design criteria were derived from site data, heat- and fluid-flow calculations and models, assumptions based on standard industry practice, and input from ITTAP.

The resulting well field design consisted of two 7-spot arrays, one 6-spot array, and 4 partial arrays bisected by the sheet pile wall, incorporating 25 injection wells and 14 extraction wells. However, due to the need to reduce project costs, only 16 injection wells and seven extraction wells were included in the redesign (DAA) and installed at the site. At the time the decision was made to reduce the number of injection and extraction wells, several wells had already been installed. Locations of the injection and extraction wells are shown in Figure 4.2-1. Well construction details are shown in Figure 4.2-2. Specifications for the extraction well pumps are shown in Table 4.2-1.

The southern-most arrays shown in the original design were eliminated during the redesign, and it was understood at the time that the relatively small volume of NAPL in those arrays would not be treated. It was further believed that contaminants could potentially be displaced in the upgradient direction by the expanding steam zone, with some potential for recontamination of the treated area once steam injection was halted. However, the project team felt that hydraulic control, established by the southern extraction wells (E-3, E-5, and E-7), would limit recontamination to the southernmost portion of the pilot test area. It should be noted that it was intended that this area would be re-treated during full scale operations.

The original design required injection wells to be 4-inch and 6-inch inside diameter (ID) with a service port on the side of the riser. The larger wells could be used for extraction if necessary. Each injection well head would include a pressure-relief valve and an air-injection port. Of the 16 injection wells installed at the site, ten are 6-inch diameter wells and six are 4-inch diameter wells. An air-injection port was installed at each injection wellhead. The pressure-relief valves were not installed at each well-head because the pressure relief system was installed at the boiler itself.

The original design required extraction wells to be 6-inch and 10-inch ID. The wells were to contain pneumatic piston pumps (Blackhawk® or QED Hammerhead®) to remove groundwater and NAPL. The larger extraction wells (up to five) would be fitted with dual pumps at two different elevations to allow combined removal of dissolved phase and NAPL.

Of the seven extraction wells installed at the site, six are 10-inch diameter wells and one is a 6-inch diameter well. Before bids were received for the construction contract, Blackhawk® pumps were deleted and replaced with QED pumps due to field problems observed at a different SEE site. The QED pumps were believed to be more compatible with elevated temperatures and chemically reactive environments, and also were not likely to generate liquid emulsions when pumping water and NAPL together. During negotiations for the construction contract, the upper pumps were eliminated to save costs. QED pumps were supposed to be installed in all extraction wells one foot above the bottom of the screen. During thermal operations it was discovered that some of the pumps were placed several feet higher than intended because of miscommunication between the contractor and USACE oversight personnel regarding reference points. The pumps that were positioned incorrectly were repositioned during operations.

Model simulations performed for the original design utilized 10-foot injection screens located at the base of the aquifer, with extraction wells screened from the base of the aquifer to 8 feet below ground surface. Aquifer testing during well installations indicated average horizontal and vertical hydraulic conductivities of 25 and 5 ft/day, respectively. Since these values were near the high end of the range used in model trials, injection screen lengths were reduced to 5 feet. Extraction well screens were extended to 4 feet below ground surface to improve near-surface contaminant removal.

The original design required all injection and extraction wells to be constructed entirely of type 304 stainless steel, with 0.02-inch-slot wire-wound screens set at the base of the aquifer, and 5-foot sumps placed into the aquitard. A filter pack of #10-20 sand was selected, retaining at least 70% of the formation. The design required the wells to be grouted with 40% silica-cement grout. Wells were installed according to these design parameters.

The injection and extraction well installations penetrated the geomembrane in the vapor cap (Section 4.2.4). The original design required high-density polyethylene (HDPE) boots to be installed where wells penetrated the vapor cap. HDPE boots were installed at the extraction wells to seal penetrations in the geomembrane, however, boots were not installed for the injection wells or the instrument string penetrations because it was thought at the time that the boots would be melted by the high temperature of the injected steam. Instead, these penetrations were grouted through the cap to the surface. Integrity of the geomembrane was necessary to optimize performance of the vapor collectors and limit fugitive emissions.

4.2.3 Steam Generation and Conveyance

This section describes the design and construction of the steam generation and conveyance system. The steam generation and conveyance system consists of a feed water supply and treatment system, a deaerator, a boiler, a blow down tank, and piping from the boiler to the injection wells. The original design and subsequent changes made to these systems are summarized in Table 4.2-2.

The original design called for a boiler feed-water supply rate of 50 gpm. Feed water was to be supplied from an on-site well. The feed-water requirement was decreased to 40 gpm during the redesign due to treatment plant capacity constraints. Water was to be pumped from the well, using a submersible pump, to a 1,500-gallon water storage tank located near the boiler building via an underground 4-inch diameter cast iron pipe. Three feed water pumps were to be used to convey the stored water to a water softening system consisting of two water softeners that are regenerated with a brine solution from a brine storage tank. Treated feed water was then to be fed to the boiler through four plate and frame heat exchangers (HX-1, HX-2, HX-3, and HX-4) designed to preheat the boiler feed water (upstream of a deaerator) and recover heat from the extracted liquid and vapors. The feed-water heater was expected to increase the overall thermal efficiency of the process.

The required on-site well was installed in January 2002. The pump size was reduced during construction from the designed 400 gpm to 225 gpm. The formation in which this well was drilled is capable of producing greater than 200 gpm. Well construction information is found in the On-Site Water Supply Well Report (USACE, 2002). The subsurface feed water piping, pump, water storage tank, deaerator, and water softening system were installed from June through September 2002. Changes made to these systems are detailed in Table 4.2-2.

An 800-horsepower fire-tube boiler, capable of delivering 25,000 lb/hr (3.47 kg/s), with an efficiency of 86.8%, was called for in the original design. The costs of leasing and purchasing were evaluated during design, and purchasing was judged to be cost-effective. The boiler was installed in a pre-engineered metal building with a concrete foundation. The layout of the boiler plant is shown in Figures 4.2-3 and 4.2-4.

The boiler installed at the site followed the design requirements, except the boiler capacity was increased to 27,600 lb/hr because it was from a different manufacturer than the one originally specified. A blow down tank, needed to eliminate the build up of mineral scale from the boiler, was also called for in the design. The redesign required the boiler blow down to be discharged to the product tank located in the boiler building where it was to be combined with the extracted liquids on the way to the treatment plant. Since the boiler size was increased, the boiler supplier recommended increasing the designed capacity of the system for handling blow down. The tank size necessary to handle blow down was increased and a tank was installed outside the boiler building under a contract modification. This tank is allowed to discharge liquid into the swale on the north side of the boiler building that discharges onto the contaminated soil in the FPA instead of going to the treatment plant for processing. Boiler blow down water is not considered contaminated.

Maximum fuel consumption of the boiler was expected to be 5,400 gpd of low-sulfur #2 fuel oil. The original design required two storage tanks: a 6,000-gallon “day tank”, and a 20,000-gallon reserve tank. The fuel oil storage and supply system was sized to match the expected boiler operations. Total fuel usage was expected to be 250,000 to 300,000 gallons, the amount required to heat the pilot test area and deliver 2 pore volumes l.e. of steam to the subsurface. These two fuel storage tanks were installed as designed.

Modeling for the original design predicted an average maximum steam injection rate of 2 gpm l.e. per well (1,000 lb/hr). The predicted total steam requirement was 44 gpm (22,000 lb/hr), assuming that flow rates for injection wells adjacent to the sheet pile wall would be reduced by 50%. The predicted steam flow rate for each individual injection well was unchanged after aquifer testing and the redesign effort, due to the compensating effects of higher hydraulic conductivity, lower extraction vacuum, and reduced injection screen length. The reduction in the number of injection wells decreased the total steam requirement, however, to 32 gpm l.e. (16,000 lb/hr instead of 22,000 lb/hr).

The original design required steam to be delivered to wells by insulated piping, with a 6-inch ID main distribution pipe. The steam lines were to be sloped continuously downward toward an anchor point, then lifted up 2 feet, and then sloped back downward toward another anchor point. Steam flow to the subsurface was to be controlled at each well with a manually-operated pressure-regulating valve and flow rate was to be monitoring using flow meters.

Installation of the steam injection piping to the well field was completed in July 2002. Steam is distributed to the injection wells through ASTM Grade A-53 Schedule 40 black steel piping. The pipes were insulated to prevent unnecessary heat loss. An aboveground 6-inch diameter main distribution pipe, in a U-shaped layout, provides steam to the injection wells with branches from the main. Piping was installed on above ground pipe supports. The slope of the steam line was continuously downward toward the boiler plant rather than sloping the line toward an anchor point as called for in the design as a contractor-designed request. Drip legs were installed near four concrete anchor points. Condensation is piped back to the nearest injection well. Pressure regulating valves and flow meters were installed as designed. Flow was determined by pressure differential across a calibrated flow control valve. The steam generation, vapor and liquid process flow diagram is shown in Figure 4.2-5. The aboveground piping layout for steam, vapor and liquid conveyance is shown in Figure 4.2-6.

4.2.4 Contaminated Vapor/Liquid Conveyance and Treatment

This section describes the design and construction of the contaminated vapor/liquid conveyance and treatment system. The vapor system consists of seven vapor collectors in the subsurface of the well field, piping from the well field, a heat exchanger, condensate pumps and tanks, liquid ring vacuum pumps, a sour gas vapor line to the boiler, and a thermal oxidizer. The liquid system consists of piping from the extraction wells in the well field, heat exchangers, a product tank, and the groundwater treatment plant. The original design and subsequent changes made to these systems are summarized in Tables 4.2-1 and 4.2-3.

4.2.4.1 Product Composition

Concepts regarding the composition of recovered product were based on site NAPL-testing results as reported by USEPA in the Steam Injection Treatability Study, known thermodynamic relationships, and average chemical properties (Table 4.2-4).

Although NAPL component concentrations were known to vary over the project site, it was understood that the most abundant compounds in extracted groundwater would be LPAH. The liquid solvent fraction in the creosote mixture was believed to consist of diesel-range aliphatic compounds, which were known to have low solubility. Due to their high vapor pressures, diesel-range aliphatic compounds would be transported primarily in the vapor phase rather than the aqueous phase, and their presence in the recovered product would strongly affect its characteristics. The pilot study was expected to employ aggressive vapor extraction, which would draw the aliphatic fraction toward the extraction wells and the surrounding formation; thus the compounds comprising the liquid solvent portion of the creosote mixture were expected to be present in both extracted liquid and vapor, and the recovered product was expected to be primarily in liquid form.

4.2.4.2 Vapor Conveyance and Treatment System

The vapor collector system in the well field was designed to be installed on the original ground surface of the pilot test area, and was to consist of an 8-inch thick gravel layer containing 4-inch diameter collector laterals. The laterals were 30 to 80-foot-long slotted steel pipes; one collector pipe was to be located above each well array. The original design assumed a vacuum of 1 psi (6900 Pa), however this was reduced to 0.2 psi (1500 Pa) during the redesign, and the design of the lateral pipe diameter was reduced to 3 inches. A six-inch soil layer was to be laid over the gravel to help protect the vapor cap geomembrane. The cap was to consist of a 60-mil HDPE membrane, overlain by a 12-inch protective soil layer, and a 6-inch gravel layer to allow for vehicle traffic. Four 10-foot-square panels of different polypropylene geotextiles were to be installed below the geomembrane to test their ability to withstand thermal and chemical conditions during steam injection. Soil partition cells were to be installed throughout the cap to allow for experimentation with vapor extraction rates.

The vapor cap and collector system installation was completed by MarVac in September 2002. The installed vapor collection system and vapor cap followed the original design. Vapor cap soil partitions were not installed due to budget constraints. The collector laterals used were 4-inch diameter in lieu of the 3-inch diameter in the redesign in order to accommodate the required number and length of slotted openings in the pipe. The vapor cap collection piping and branch detail are shown in Figure 4.2-7. The laterals are 37.5 to 88.5 feet long slotted steel pipes with one collector pipe. The laterals were connected to vapor-extraction piping from extraction wells and conveyed to the heat exchanger and treatment system. The vapor cap was graded with a crown at the center of cap and sloped at a minimum of 1% toward the sheet pile wall and the swale at the southern end of the pilot test area. Weep holes were installed in the sheet pile walls at the elevation of the top of the gravel surface.

Two 10-foot x 10-foot test cells of geotextile fabric (one a polyester fabric, one a polypropylene fabric) were installed beneath the vapor cap in the pilot test area. The test cell locations are shown on Figure 4.2-1. The vapor cap system was installed prior to the installation of any wells, the subsurface monitoring instrumentation system, and conveyance piping.

The original design showed vapors being extracted from the wells and the surface vapor collectors through insulated 8-inch maximum diameter black steel pipe. Three liquid-ring vacuum pumps would be used to pull the vapor through the pipe, each rated at 450 cfm at 40 deg C and 33.6 kPa absolute pressure. Vacuum at the well heads was intended to be 0.5 atm. For the redesign, the vapor extraction piping was downsized from 8-inch maximum to 6-inch, and the insulation was deleted. Additionally, the number of vacuum pumps was reduced to two (one operating and one standby), each with a total maximum flow rate of 450 acfm, or 140 scfm, (56% of the original design criterion) to achieve a vacuum pressure at the well heads of 0.25 atm.

According to the original design, extracted vapor was to be cooled in the boiler plant by two heat exchangers (HX-3 and HX-4), allowing water vapor and other condensable gases extracted from the vapor cap and extraction wells to be condensed. Any condensate that formed was to be collected in a condensate tank associated with HX-3 and then added to the liquid treatment stream. Cooled non-condensable vapor was to be used to supplement the boiler combustion air during boiler operation. The second heat exchanger (HX-4) was deleted in the redesign. The original design included the use of a steam-regenerated carbon-adsorption system when the boiler was not in operation. For the redesign, this unit was replaced with a thermal oxidizer.

Non-insulated, six-inch diameter pipe of standard weight (Schedule 40) black steel was installed at the site to convey extracted vapor to the boiler plant, as per the redesign. The original design showed the vapor line sloping towards a low point at the four anchor points to collect condensate, where a pump would convey condensate to the nearest extraction well. The installed vapor line was sloped toward the boiler plant and an extraction main drip leg, consisting of an 8-inch diameter pipe section, was installed outside the boiler plant to collect condensate. The condensate was then pumped via a condensate pump (PDP-1) to the liquid product tank in the boiler plant. The pump was housed in a vinyl storage shed in the pilot test area.

Vapor from the well field and surface vapor collectors was cooled in one plate and frame heat exchanger (HX-3). Condensables were collected in a condensate receiver and pipeline drip leg (8 inch diameter by 24 inches long) installed downstream of HX-3 and upstream of the vacuum pumps to prevent liquids from damaging the pumps. The vacuum pumps had filters that prevented particulate matter from entering the pump. A bypass line for the non-condensable vapor was installed to allow for commissioning of the liquid ring vacuum pumps (LRVP). Shortly after steam injection was started, however, a slug of liquid inundated the collection system and entered one of the vacuum pumps. Gasket and seal materials of LVRP-1 failed. At the same time, the contaminant-containing liquid in HX-3 caused the rubber seals between the plates to swell, come out of their frames, and leak water onto the boiler building floor. The vapor system was shut down and it was never operated again.

The cooled non-condensable vapor was then conveyed through one of the two installed liquid ring vacuum pumps (LRVP-1 and LRVP-2). During operations, the non-condensable vapor was thermally treated in the boiler via the combustion air line. A thermal oxidizer fueled by propane was installed for thermal treatment of the non-condensable sour gas when the boiler was shut down. During commissioning of the thermal oxidizer, however, it was found that the burner was too small for the vapor system and a larger burner (and fan motor) was installed after operations were terminated in April 2003. However, the vapor recovery system was never restarted after the vacuum pump and heat exchanger failed and the thermal oxidizer was never used.

4.2.4.3 Liquid Conveyance and Treatment System

Thermal modeling predicted an average liquid extraction rate of 5 gpm per extraction well, for a total of 45 gpm from the pilot test area. According to the model, a maximum total extraction rate of 50 gpm would be required to keep water levels from rising during the initial expansion of the steam zone. The average individual well pumping rates did not change substantially for the redesign, however, the total average pumping rate was decreased to 25 gpm due to the reduced number of extraction wells. Extraction from the pilot test area was partially constrained by the 80 gpm maximum capacity of the treatment plant. The treatment plant needed to be able to handle both extracted liquid from the pilot test area as well as groundwater pumped from the FPA necessary to maintain hydraulic control of the entire site. According to the site groundwater model, the year-round average pumping requirement outside the pilot test area would be 20 to 40 gpm after the outer sheet pile wall was installed.

Liquid from the pilot test area extraction wells was to be conveyed from the well field to the boiler plant through a 3-inch pipe and collected in a product tank prior to being cooled in the heat exchangers. The total organic carbon (TOC) content of the liquid was to be measured using an in-line TOC analyzer. As per the design, the extracted liquid was conveyed from the well field to the boiler plant through a 3-inch diameter pipe of standard weight (Schedule 40) black steel. Extracted liquid then flowed into the product tank. Influent of the product tank was analyzed for TOC using an automated, in-line TOC analyzer with data collected through the ADAS.

Extracted fluids from the well field, including condensable gases, were to be cooled in two heat exchangers. The heat exchangers included in the original design required up to 150 gpm of cooling water at 15 ºC. During steam production, the boiler feed water would be used to cool extracted liquids in two liquid-to-liquid heat exchangers (HX-1 and HX-2) and vapors in two vapor-to-liquid heat exchangers (HX-3 and HX-4) (see discussion above on vapor conveyance and treatment). Since the boiler requirement was to be 57 gpm, the excess 93 gpm was to be routed through a cooling tower, and the addition of the recycled water to the cooling stream would reduce the well-water requirement to 70 gpm. It was understood in the original design that the available cooling capacity might occasionally be insufficient during peak vapor extraction periods, and vapor extraction rates might have to be reduced.

Design changes assumed a reduced cooling water demand of 40 gpm, and eliminated the cooling tower. The cooling capacity of the boiler-feed water was given as 2.1 Mbtu/hr, roughly equivalent to 10% of the anticipated enthalpy of the injected steam. As in the original design, it was understood that the cooling capacity could be insufficient for predicted peak vapor extraction rates (at peak rates, the extracted vapor was expected to be mostly steam). The cooling capacity of the system was further constrained by the capacity of the groundwater treatment plant to discharge untreated non-contact cooling water. The non-contact cooling water discharge pipe was connected to the main treatment plant effluent pipe after tank 303. The size and configuration of the discharge outfall into Puget Sound limited the amount of treated water that could be discharged, which was reduced by the amount of non-contact cooling water.

Two plate and frame heat exchangers (HX-1 and HX-2) were installed in the boiler plant to cool extracted liquids. New 2-inch HDPE piping was installed to convey cooled liquids from the heat exchangers to the existing treatment plant. Extracted liquid from the pilot test area was combined with extracted liquids from the former process area at the treatment plant header. A new 2-inch pipeline was installed to convey non-contact cooling water from the heat exchangers to the treatment plant sumps. This inadvertently limited the amount of cooling water the treatment system could handle and therefore limited the amount of steam that could be injected into the pilot test area.

Liquid treatment design was intended to employ the existing treatment plant as much as possible, however, the Conceptual Design Report stated that the existing plant had reached the end of its useful life. It was understood that the bioreactor could become inoperative due to changes in temperature and contaminant concentrations resulting from thermal treatment (ITTAP, 1999). The Conceptual Design Report recommended additional granular activated carbon (GAC) polishing capacity to provide backup for potential loss of the bioreactor due to microbial upset or structural failure. A new treatment plant had been designed at this time at EPA, however, it was not built to support the pilot study due to the need to reduce overall project costs.

Liquids would exit the heat exchangers in the boiler plant at 40 ºC, and be conveyed to an existing 58,160 gal equalization tank (T-401) at the treatment plant. An emulsion-breaking chemical would be added upstream of the equalization tank, and the tank would be fitted with a skimmer to remove floating product. Coagulant and polymer would be added, and more product would be separated by a dissolved air flotation tank (DAFT). Skimmed product would go to an existing froth tank (SEP-108) and then would be routed to a product storage tank (T-105). Remaining water would be recycled back through the DAFT, mixed with a neutralizing chemical, routed to another equalization tank (T-402), and then to the existing aeration basin (T-203). Vapors from all tanks prior to the aeration basin would be extracted and conveyed to the vapor treatment system.

Corroded air spargers and piping in the existing aeration basin would be replaced, and additional spargers would be installed in the existing clarifier to augment the capacity of the aeration basin, basically creating a second aeration basin. Effluent from the two aeration basins would be routed to an additional DAFT, and separated solids from the DAFT would be recycled back to the aeration basins. Clarified effluent would be routed to two existing multimedia filters and a third new one, then through the existing GAC system, to a new 25,000 gal effluent storage tank. The existing effluent tank would be replaced due to damage from the earthquake that occurred on February 28, 2001.

Recovered NAPL would be pumped from the froth tank to existing 10,150 gal and 7,100 gal product storage tanks, removed by tanker truck, and disposed off-site. Spent GAC, multimedia filter material, and sludge from the bioreactor would also be disposed off-site. Treated effluent would continue to be discharged to Puget Sound via the existing effluent pipe and diffuser structure, in compliance with regulatory requirements. During the redesign, the skimmer at tank T-401 and vapor recovery from all tanks were eliminated. Additionally, the second DAFT, the third multimedia filter, and the conversion of the clarifier to an aeration basin were eliminated from the design. The effluent tank that was severely corroded and damaged by the earthquake was to be repaired instead of being replaced. This repair was completed by Marine Vacuum, Inc. when the build-up of tank bottom sludges was removed prior to the start-up of the pilot study.

The liquid treatment plant layout and process flow diagram are shown in Figures 4.2-8 and 4.2-9, respectively. The liquid treatment used the existing treatment plant and disposal practices, with the following exceptions:

- A chemical tank containing caustic for emulsion breaking was installed that included a chemical feed pump. A static mixer installed within the feed line to T-401 enabled mixing of the caustic into the liquid stream which was originally designed as an automated system. During the re-design, it was converted to a manually operated system due to cost constraints. However, this chemical feed system was not used during the pilot study.

- Coagulant and polymer were introduced to the liquid stream via a static mixer upstream of the DAFT. A small polymer tank was installed at the DAFT effluent as a wet well for the DAFT pumps. Coagulant and polymer addition was not implemented until March 2003.

- The froth tank, T-108, was elevated and piping modified in order to gravity feed the recycled liquid back to the DAFT.

- A chemical tank containing acid was installed to neutralize the liquid stream from the DAFT. A static mixer and chemical feed pump were installed to introduce the acid into the liquid stream, which was originally designed as an automated system. During the re-design, it was converted to a manually operated system due to cost constraints. However, the acid feed system was not used during the pilot study.

4.3 MONITORING SYSTEM

The monitoring system was continuously revised from conceptual design to construction. Extensive data collection was performed throughout the duration of the pilot study in order to evaluate the system's effectiveness in meeting the nine project objectives presented in Section 1.1. Data were to be collected from the following site areas or systems:

- Pilot test area. Temperature and pressure were to be monitored in the subsurface to track the movement of heat and fluids throughout the treatment area. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-1. See Appendix E for more detail concerning pilot test area monitoring.

- Steam generation system. Flow, temperature, and pressure of steam production from the boiler into the wells were to be monitored to support heat flux calculations. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-2. Due to cost constraints, some originally planned instruments were not installed or were installed after active steam injection started. Additionally, some instruments may not have performed as intended and data were lost or unreliable.

- Liquid and vapor extraction systems. Flow, temperature and chemical characteristics of extracted liquids, as well as flow and temperature of extracted vapors, were to be monitored to support operational decisions and determine remedy effectiveness. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-2. Due to cost constraints, some originally planned instruments were not installed or were installed after active steam injection started. Additionally, some instruments may not have performed as intended and data were lost or unreliable.

- Groundwater treatment plant. Water samples were collected from selected sampling points within the GWTP to monitor performance and optimize operations. Effluent discharge samples were collected from the GWTP to demonstrate compliance with substantive requirements of the NPDES permit and 1988 Consent Decree. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-3.

- Upper and lower aquifer groundwater. Groundwater samples were to be collected from groundwater wells and extraction wells to evaluate the effectiveness of the thermal treatment system and to evaluate potential for off-site migration of NAPL or contaminants of concern. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-3.

- Site perimeter. Noise, air quality, intertidal conditions, boiler air emissions and sheet pile wall integrity were to be monitored to evaluate the potential impacts of full-scale thermal treatment to the surrounding community and the near shore marine habitats. Specific media, locations, parameters measured, testing frequency (proposed and/or actual), and whether the monitoring was implemented are summarized in Table 4.3-4.

  Initial noise monitoring (baseline) was eliminated during negotiations with the O&M contractor. It was agreed during negotiations that a previously conducted noise survey would suffice as the baseline survey. Air quality and boiler air emissions for the community were to be provided by a separate contractor (URS) at the request of USACE. Air quality PM-10 monitors were set-up and calibrated but never used. The boiler stack emissions were to be monitored by URS when the boiler operations had stabilized and the sour gas to be burned in the boiler had reached the standard operating conditions. Since this condition was never reached before the vapor extraction system failed, stack emissions were not monitored. Sheet pile wall leakage monitoring was performed approximately 3 months after the sheet pile walls were installed. The next round of sampling that was contracted out to URS was to be performed after the pilot scale operations were completed. This sampling event was never initiated.

SECTION 5.0 OPERATIONS DESCRIPTION

This section discusses the proposed operations strategy and details of actual operations. Additionally, the nature of the project team, communication methods, decision-making process, and tools used to aid in communications and decision-making are described. Operations log sheets that were posted daily to the project web page are included as Appendix F.

5.1 OPERATIONS STRATEGY

As conceived, the operations strategy represented the consensus of experts from industry, academia, and USACE. The fundamental principles and procedures were developed from knowledge of other sites and from engineering analyses that included fluid and heat flow calculations and numerical modeling. However, due to the innovative nature of thermal treatment technology and the heterogeneous subsurface conditions at the project site, procedures were to be continuously re-evaluated during the pilot study. Revisions to the intended treatment strategy were necessary because of conditions encountered during system construction, commissioning, equipment limitations, monitoring results during operations, system performance during operations, and cost constraints.

5.1.1 Intended Operations Phases

The thermal treatment process was to be performed in three phases, as detailed in the RAMP and summarized below. A fourth phase related to site-wide management of groundwater was part of the operations plan, but it is not specifically a pilot study concern and is not discussed here.

5.1.1.1 Initial Heating

Objective: Heat subsurface to steam temperature, thereby enhancing mobility of NAPL; continue until recovery of liquid NAPL has peaked and begins to diminish.

Implementation: Initiate steam injection while maintaining hydraulic control through liquid extraction at the extraction wells and pneumatic control through vapor extraction at the extraction wells and in the vapor collector layer. Target injection rates were 400-800 lbs/hr per well or an overall rate of between 6,500 to 13,000 lbs/hr of steam. Liquid extraction rates were targeted at 30-50 gpm for the entire pilot test area, which translates to an average of 4-7 gpm per well. Vapor extraction was to be accomplished through establishing a vacuum (up to 0.25 atm).

Duration: Breakthrough of steam to the extraction wells (and nearly complete site heat-up) was anticipated to take 2-4 weeks. Period to reach diminishing liquid NAPL recovery was uncertain.

5.1.1.2 Pressure Cycling

Objective: Optimize vapor and liquid-phase recovery at low NAPL saturations by maintaining an economical mixture of groundwater and steam in the aquifer. Pressure cycling is believed to enhance vaporization of lighter fractions of contaminants and increase dissolution rates of NAPL. Pressure gradients established during pressure cycling may promote flow of NAPL.

Implementation: Steam flow to the injection wells is reduced, while liquid and vapor extractions continue. When contaminant recovery decreases, steam injection is re-initiated. On breakthrough of steam to extraction wells, steam flow is reduced, and a new cycle commences.

Duration: A few days to a few weeks per cycle. This phase was to continue until contaminant recovery diminished. Total duration of the pressure cycling phase was uncertain, but contract limitations restricted duration of the initial heating and pressure cycling phases to six months, with options for an additional two months.

5.1.1.3 Fluid Extraction and Monitoring

Objective: Confirm continued reduction of contaminants.

Implementation: Continue extracting liquids and vapors, while monitoring contaminant concentrations. Vapor extraction would diminish and eventually cease during this phase.

Duration: Six months after cessation of steam injection, with an additional two months optional.

5.1.2 Actual Operations Phases

Of the three intended operational phases, the pilot study never went beyond the initial heating phase. Failure of the vapor extraction system and the treatment plant aeration basin led to cessation of operations on December 15, 2002, and prevented achievement of target temperatures in the subsurface. When operations resumed on January 13, 2003, the vapor extraction system was inoperable, so the guiding principle became to maintain subsurface temperatures (using low steam injection rates), while minimizing steam breakthrough to the extraction wells and the surface. It was anticipated that aggressive operations (injection and extraction at design rates) would commence once system problems had been resolved. A detailed timeline is presented in Figure 5.1-1.

The actual implementation phases were as follows:

Phase I—Commissioning and Startup. This phase started October 1, 2002 and continued until October 29, 2002. It should be noted, though, that not all systems (or components of systems) were completely installed or commissioned by October 29. During this phase, sporadic steam injection started (during daylight hours only), and liquid extraction commenced.

Phase II—Continuous Steam Injection. This phase started on October 30, with more aggressive steam injection during daytime, while boiler operators became familiar with equipment. Twenty-four hour operations started on November 7. Phase II continued until the vapor system and aeration basin failed on December 15. The following points highlight operating conditions:

- Out of 39 potential days of continuous operation, the pilot system was successfully operated for 20 days, with six days completely shut down and 13 days of partial operations.
- The longest period of continuous operation was November 18-23.
- Multiple problems were encountered throughout Phase II. The most serious were caused by material incompatibility with the effluent, resulting in failure of seals and gaskets in the liquid and vapor conveyance lines. Additionally, waxy and crystalline deposits of PAH clogged lines from the wellfield to the treatment plant. Analysis of one sample of crystalline deposit revealed that it consisted of 75% naphthalene and 25% other PAHs. An evaluation of the extracted liquid composition and the physical/chemical processes that may have occurred to create this situation is included in Appendix G.

- For days when the boiler was operating, steam injection averaged 5,180 lbs/hr (32% of maximum design rate), with a peak rate of 11,263 lbs/hr on November 9. Injection rates were, in part, limited by uncertainty about whether the effluent discharge line into Puget Sound would be able to handle the increased non-contact cooling water flow. Final connections for non-contact cooling water were completed by December 12, after an engineering analysis determined the effluent line could handle the flow into the treatment plant.

- Liquid extraction averaged 16 gpm (32% of maximum design rate). Most extraction was from extraction wells E-2, E-3, E-4, E-5, and E-6. Performance of extraction wells E-1 and E-7 decreased, partly due to crystalline PAH formation in the pump exhaust ports. Precipitation in exhaust lines was exacerbated by well head plumbing, which routed the narrow diameter lines outside the wellhead and allowed rapid cooling on contact with ambient air. In the case of extraction well E-1, significant precipitation of crystalline PAH was also occurring inside the well. Lower permeability soils in the western part of the pilot test area (E-1 and E-7 arrays) may have contributed to problems encountered in those wells. Low permeability affected both the ability to extract liquids and to inject steam. Limited steam injection in turn made it difficult to raise temperatures to the point where precipitation of PAH would be avoided.

- Based on discussions with field personnel (during Phase III engineering evaluations), it is believed that the vapor extraction system was not being operated as intended. During Phase I, the vapor collectors and extraction wells were tested with valves in the open position, and there is no evidence from field data sheets that valve positions were ever altered. Modeling during design suggests that subsurface vacuum would be insignificant when vapor collector valves were operated in this manner due to high permeability in the vapor cap. Optimal valve positioning was to be determined by observation of the vapor system performance during the pilot study. Since the vapor system was in operation for a very short time period, these observations were not accomplished.

- Failure of the aeration basin coincided with a dramatic drop in dissolved oxygen in the basin, which suggests that the bacteria had utilized all of the available oxygen during consumption of high concentrations of contaminants. Air diffusers in the basin were unable to provide rapid enough replenishment of oxygen, causing bacteria to die or go dormant. See Section 6.6.3 for a more detailed account of the aeration basin failure.

- The condensing vapor-to-liquid heat exchanger (HX-3) failed on December 15 after the very narrow passages between the plates plugged with solid naphthalene crystals and the seals between the plates disintegrated due to chemical non-compatibility with the waste stream.

- The vapor collection system failed on December 15 when one of the liquid ring vacuum pumps was inundated with liquid. The source of this liquid has not been confirmed; however, liquid in the vapor line may have come from non-contact cooling water from the failed heat exchanger, vapor condensate, or rain water from the vapor collector lines in the well field.

- Based on water level collapse observed from December 14 to December 16 (from an average of 6.1 to 2.1 ft MLLW), the volume of water displaced by steam was equivalent to 25% of the saturated volume on December 14. Although the volume calculation was based on simplifying assumptions regarding aquifer dimensions, temperature sensor data corroborate the conclusion of the analysis. A value of 24.6% was obtained for the proportion of temperature sensors registering greater than 100 ^{o}C below 6.1 ft MLLW. The calculated displacement equates to a cylinder (half cylinder for wells along sheet-pile wall) with a radius of 11 ft around each injection well. Based on interpolated temperature profiles (see Section 6.2.2), the actual steam distribution around each well probably approximated an inverted cone, rather than a cylinder.

- Average site temperature increased from 19 ^{o}C to 71 ^{o}C.

Phase III—Engineering Evaluations. This phase consisted of preliminary evaluations of the condition of the pilot system and development of potential engineering solutions to the problems encountered. It lasted from December 16, 2002 to January 12, 2003. Steam injection was not conducted during this period. To regain hydraulic control, liquid extraction from the pilot test area started again on January 4, 2003. Average site temperature decreased to 56 ^{o}C. Engineering evaluations and system repairs continued during Phase IV.

Phase IV—Low-Level Steam Injection. This phase was initiated to maintain subsurface temperatures in anticipation of resolution of engineering problems and resumption of aggressive thermal operations. Phase IV lasted from January 13 to March 22 and consisted of continuous steam injection at relatively low rates, with liquid extraction to maintain hydraulic control. Vapor was not extracted during this phase. Phase IV ended when problems developed with the boiler. Highlights of operations are as follows:

- Out of 69 potential days of continuous operation, the system was successfully operated for 65 days, with only 4 days of partial operations (including the first day of this phase).

- The primary problems encountered during this phase were a continuation of the clogging problems in liquid lines and the treatment plant caused by wax and crystal buildup.

- For days when the boiler was operating, steam injection averaged 2,283 lbs/hr (14% of design rate), with a peak rate of 3,072 lbs/hr on January 13.

- Liquid extraction averaged 20 gpm (40% of design rate). Most extraction was from extraction wells E-2, E-4, E-5, and E-6. Extraction well E-1 was not put back on-line, because the inside of the well was fouled with crystallized PAH. Exhaust ports for extraction wells E-3 and E-7 repeatedly fouled with crystalline PAH, limiting pump performance. When functioning, even low extraction rates at extraction well E-7 resulted in significant drawdown, indicating limited recharge to the well.

- Average site temperature increased to a maximum of 78 ^{o}C on March 5 and then decreased slightly to 76 ^{o}C at the end of the phase.

Phase V— Sporadic Low-Level Steam Injection. This phase lasted from March 23 to April 15, at which time it was decided to discontinue all pilot operations. Problems with the boiler burner and with maintaining a proper air-fuel mixture in the boiler prevented continuous operations. Panting in the boiler, believed to be due to improper air-fuel mixtures, eventually caused welds to crack. Operationally, key points are as follows:

- Out of 24 potential days of operation, the boiler was partially operational on seven days, although steam injection was recorded for just two of those days.

- For days when the boiler was operating and steam was being injected, injection rates averaged 1,834 lbs/hr.

- Liquid extraction averaged 14 gpm out of extraction wells E-2, E-3, E-4, E-5, and E-6. Extraction wells E-1 and E-7 were not turned on. Extraction well E-3 continued to experience exhaust port crystallization problems.

- Average site temperature decreased to 68 ^{o}C at the end of the phase.

Phase VI—Liquid Extraction. This phase started April 16 and continues to the present. Pilot test area wells are operated to the minimal extent necessary to maintain hydraulic control.

5.2 TEAM COMMUNICATION AND DECISION MAKING

An accelerated approach to sampling, analysis and operational-decision making was required for this project. Automated data reporting systems as well as fast turnaround sample analysis and reporting were used to minimize the operations team's response time needed to adjust system operating parameters. A description of the project teams roles and responsibilities, as well as the communication tools used, are included in this section.

5.2.1 Project Team

The project team consisted of representatives from USEPA Region 10, the USACE Seattle District Office, the USACE Hazardous, Toxic, and Radioactive Waste Center of Expertise in Omaha, Nebraska, and numerous contractors (Table 5.2-1). The project team provided the overall framework for the construction, operations, maintenance and data collection and management activities. Within the project team was a core technical team (Operations Team) made up of individuals who had developed site-specific expertise in geologic, hydrologic, chemical analytical methods and operations. This team was to provide a continual, integrated, and multidisciplinary presence throughout the project, and was the primary team responsible for the daily decision-making, optimization of field activities and interactions with USEPA.

The Operations Team was led by a team Coordinator who facilitated the team's decision-making process. The Operations Team consisted of the following roles:

- USEPA Remedial Project Manager
- USACE Project Manager
- USACE Site Manager – Operations Team Coordinator and Health and Safety Officer
- USACE Hydrogeologist
- USACE Monitoring Coordinator and QA/QC Officer
- O&M Contractor Representative
- SteamTech Thermal Expert and other Expert Consultants (on an as-needed basis)

The Operations Team members reviewed project data and convened mid-morning each workday to review monitoring and process data. The SteamTech expert and other consultants were asked to participate on a less frequent basis but were expected to keep current with data on the website. The Team Coordinator provided a summary of the data and reported system status at the beginning of each daily Operations Team meeting. The Operations Team then decided on operational objectives for the next 24-hour period. Once the operational goals for the project were decided, the Operations Team Coordinator directed the O&M Contractor (SCS Engineers) to implement the decisions. The decisions and directions provided to the Contractor were documented in a daily Operations Team Meeting Summary posted to the project website.

Additional support was provided to the Operations Team by project team technical staff within the USACE-Seattle District and the USACE HTRW Center of Expertise when needed to resolve reoccurring or consistent issues. For example, when treatment plant breakdowns impacted operations, a Process Engineer was added to the Operations Team to help resolve technical problems, provide advice, and assist in making operational decisions. Technical Support Team members were expected to review project data on the website on a regular basis and stay current regarding on-site developments and progress.

Several communication methods and tools were used to ensure that all team members were aware of current site activities and could participate effectively. Methods and tools included daily conference calls, meetings, email, and a webpage for posting data, meeting minutes, and notes from technical discussions. Contents of the project web page are listed in Table 5.2-2.

SECTION 6.0 SUMMARY OF RESULTS

This section presents the pilot study technical data from the pilot study operations. In section 6.1, the operational results are presented from a water and energy balance standpoint. Section 6.2 presents the subsurface temperature monitoring results. In Section 6.3, the heating observed is compared to heating estimates derived from the energy balance, including estimates for heat losses. The results of the chemical monitoring program and the performance of the vapor and water treatment systems are presented in Sections 6.4 through 6.6. The available estimates for chemical mass removed from the subsurface are listed in Section 6.7. Calculation methods used during the data interpretation and graphing process are included as Appendix H. Data collected during the Pilot Study are included as Appendix I.

6.1 OPERATIONAL RESULTS

Water and energy balance results are presented in this section.

6.1.1 Steam Injection Rates and Totals

Three different lines of data were used to document the actual steam injection rates from early October 2002 to May 20, 2003:

1. Steam injection rates were measured at each of the 16 injection wells.
2. The diesel usage was converted to an equivalent steam production rate.
3. The water used by the boiler was converted to equivalent steam injection rates.

The estimates are shown on Figure 6.1-1. Generally, the numbers from the steam rate measurements and the diesel usage agree well. Comparatively, the water usage seems to underestimate the steam production rate for times where good and frequent data exists from the well field. The feed water orifice plate was apparently never calibrated properly, so water usage data have been deemed unreliable. Consequently, where the data was available, the diesel usage data was used to fill in steam production data for times where well-field data was missing.

The resulting, probable steam injection rates over the duration of the project are shown in Figure 6.1-2. Steam injection rates typically varied between 2,000 and 8,000 lbs/hr during operations. The highest rates of around 12,000 lbs/hr were achieved in early November, during the stage where rapid heating was targeted. After restarting steam injection in January of 2003, injection rates were between 2,000 and 3,000 lbs/hr, or approximately half of the rates achieved during heat-up in November-December, 2002.

Figures 6.1-3 and 6.1-4 show the injection rates for the injection periods of 2002 and 2003, respectively. Please note that the scales are different, since the steam injection rates were higher in 2002 than in 2003. Typical injection rates were in the 100 to 500 lbs/hr range per well during November and December of 2002, until injection was ceased on December 15, 2002. Injection rates were limited by the ability of the formation to accept steam. The data show large differences in the injection rates among the wells, with some wells injecting less than 100 lbs/hr, and others consistently injecting more than 300 lbs/hr.

During 2003, typical injection rates were in the 50 to 300 lbs/hr range per well, until injection was ceased on April 12, 2003. As for Figure 6.1-3, the data show large differences in the injection rates among the wells.

Table 6.1-1 lists the typical injection rates for each well during the two major injection periods. As discussed later, there is a clear trend showing higher injection rates in the wells located in the eastern half of the pilot test area.

Figure 6.1-5 shows the cumulative amount of steam injected for each of the 16 injection wells, based on the well head steam flow measurements. It should be noted that there is substantial variation in the injection rates among the wells. Generally, the eastern wells (I-2, I-7, I-8, I-9, I-10, I-14, and I-15) injected more steam than the western wells (I-1, I-3, I-4, I-5, I-11, I-12, I-13, and I-16).

6.1.2 Pore Volumes Injected

A total of 993,000 gallons of water was injected in the form of steam. The pilot test area volume was estimated at approximately 16,400 cubic yards. Using an average porosity of 28%, this yields a pore volume of 927,000 gallons. The resulting number of steam pore volumes is:

$$pv_{steam} = V_{steam} / pv_{pilot\ test} = 993{,}000 / 927{,}000 = 1.1$$

This is a very modest number of pore volumes, and not a sufficient amount of steam to heat the entire pilot volume to steam temperature, given the energy removal taking place by the extraction system, and the heat losses. Goals for other, primarily non-creosote, sites have targeted between two and five pore volumes of steam. In conclusion, early termination of this pilot test meant that the volume of steam injected was approximately half of the amount that would be a typical minimum for this site volume.

6.1.3 Extraction Rates and Totals

The liquid extraction rates based on pump stroke counters are shown in Figure 6.1-6 for each of the seven extraction wells. Because an ideal discharge volume was assumed for each stroke for all pumps (actual values were different for each well and less than the ideal), the extraction rates are considered approximate. Extraction wells E-1 and E-7 had low pumping rates most of the time, and neither pumped liquid after February 4, 2003.

The cumulative liquid extraction for all the seven extraction wells combined is shown in Figure 6.1-7. This figure reveals the low volumes extracted from extraction wells E-1, E-3, and E-7, the western-most extraction wells. In addition, extraction wells E-1 and E-7 are located adjacent to the sheet-pile wall.

The total extraction rate from the seven pilot test extraction wells combined is shown on Figure 6.1-8. Before the site was heated, extraction rates typically ranged between 3 and 5 gpm. Then, during the aggressive heating period in November-December, the extraction rate varied between 10 and 20 gpm, with a typical average rate of 14 gpm. The pumping rate was maintained in this range, with a few excursions, during the remainder of operations. In the first half of April 2003, the rate was lowered to between 5 and 9 gpm.

6.1.4 Observed Water Levels During Operation

The measured water levels in the operational extraction wells are shown in Figure 6.1-9. Figure 6.1-10 shows the water levels measured in instrument string monitoring locations.

Initial water levels in the pilot test area were around 8 ft MLLW. During the first aggressive heating period, the water level was generally lowered by between three and 15 ft in the extraction wells (Figure 6.1-9). At the instrument string monitoring locations, water level drops of between two and eight ft were observed (Figure 6.1-10).

During the cessation of operations between December 15, 2002 and January 3, 2003, a substantial water level rebound was observed in both the extraction wells (where pumping was ceased) and the monitoring locations between the wells. Rises to above 10 ft MLLW (two ft above the starting water level) were observed in both the extraction wells and the monitoring locations. The average pilot test area water level rose 6.8 ft during this period, which corresponds to an average recharge rate of approximately 12 gpm. Sources contributing to recharge of the aquifer are groundwater flow from upgradient, through the sheet-pile wall, through the aquitard from the lower aquifer, and infiltrating precipitation through the cap.

A large increase in the water levels occurred in the first half of November 2002. This water level rise corresponds to a period where the injection rate (in the form of steam) exceeded the liquid extraction rate. At extraction well E-2, in particular, the water level rose to 12.9 ft MLLW, which is 0.7 ft above the top of the screen. This rise in water level coincided with a slug of liquid that hit the vacuum pumps on November 10, 2002. Although a vacuum of 0.25 atm is insufficient to draw water to the level of the aboveground conveyance lines, water may have been entrained along with air being removed by the vapor extraction system (in a slurping effect).

During 2003, water levels were lowered again, but to different levels than in 2002. Less draw-down was observed.

Three extraction wells, E-3, E-4, and E-5, stand out by having much more draw-down than the other wells and the monitoring locations. These three wells are the only extraction wells completely surrounded by injection wells, and the only extraction wells not placed adjacent to the sheet-pile wall. Drawdown is a function of well efficiency, formation permeability, and injection and extraction rates in each array. Because the pressure transducers are located in the filter pack, a change in well efficiency is not believed to be the cause of unusual drawdown. Formation relative permeability with respect to water may have been affected by development of an oil-phase condensation bank, thereby impeding flow of groundwater to the extraction wells. Exceeding the supply of water, by over-extraction, could also have resulted in excessive drawdown. Although there were clearly times when extraction exceeded injection, it is not certain whether that was the only factor responsible for drawdown observed in extraction wells E-3, E-4, and E-5. E-3, in particular, displayed significant drawdown even at very low extraction rates. [Extraction well E-7 also showed considerable drawdown, but this was primarily due to lower permeability along the western side of the pilot test area.]

6.1.5 Water Mass Balance

Water fluxes in and out of the pilot test area are shown in Figure 6.1-11. Prior to the injection of steam, a net extraction rate of between 0 and 5 gpm was maintained. Then, during the first two weeks of steam injection (between October 29, 2002 and November 10, 2002), more water was injected as steam than was extracted as water. Toward the end of this two-week period, water levels were observed to increase dramatically at nearly all monitoring locations (Figure 6.1-9 and 6.1-10).

Apart from a single day on December 12, 2002, the water balance was maintained during the rest of the pilot test such that net injection did not occur. Figure 6.1-11 shows that a typical net extraction rate of between five and 15 gpm was maintained.

The cumulative volume of water injected and extracted is shown in Figure 6.1-12. Note that the rate and volume of condensate produced (represented by the yellow lines in Figures 6.1-11 and 6.1-12) were estimated due to the lack of data. Equipment to measure the flow of condensate was not installed and therefore condensate flow data are not available.

The net liquid extraction (black line) shows a steady increase during operations, except during the period from late October to mid November discussed above. A net total of 2.6 million gallons of water was extracted from the pilot test area (3.6 million gallons total extracted, 1.0 million gallons injected as steam).

The estimated amount of water that entered the pilot test volume from the outside was calculated based on the net water extraction and the observed water level changes in the pilot test area (based on average water levels as presented in Figures 6.1-9 and 6.1-10).

During the aggressive heating period from October 22, 2002, to November 28, 2002, the water balance indicates that water was leaving the pilot test area. However, the balance reversed in late November, and during the rest of the pilot test water was entering at substantial rates from outside the pilot test area.

6.1.6 Energy Balance

Enthalpy fluxes for injection, extracted fluids (steam and heated vapor and water), estimated heat losses through the surface, bottom, and sheet-piles, and net enthalpy exchange for the site are shown in Figure 6.1-13.

Injection rates were in the 2 to 8 million BTU/hr range during November-December 2002, and decreased to between 2 and 3.5 million BTU/hr in 2003. The enthalpy balance clearly shows that energy is added, and the site is heated, any time steam was injected. During steam generator shut-down periods, such as the two periods in late November, the continued extraction leads to the pilot test volume cooling, as the net enthalpy flux becomes negative.

It is noteworthy that the estimated heat loss through thermal conduction through the surface, bottom, and sides of the pilot test area are in the 0.6 to 0.9 million BTU/hr range after the site heated substantially. This is a relatively high enthalpy flux, equal to an enthalpy flux of between 600 and 900 lbs/hr of steam. After cessation of steam injection in mid-April, the enthalpy flux became negative, and the pilot test area cooled accordingly with a net energy loss of about 0.5 to 0.6 million BTU/hr.

Cumulative energy amounts for the same streams are shown in Figure 6.1-14. This figure also contains an estimated stored energy amount calculated based on the average temperature measured in the many temperature sensors and an estimate for the pilot test volume and heat capacity. A total of 9,400 million BTU of steam energy was injected, with about half of this (4,800 million BTU) injected in 2002. By early-mid November, increased temperatures were observed in subsurface temperature sensors (as well as in extracted liquids), and energy removal started becoming significant.

During the period without steam injection from December 15, 2002 to January 13, 2003, a total of 800 million BTU was removed from the pilot test volume. This was reflected in a similar decrease in the average subsurface temperatures (represented by the blue line in Figure 6.1-14).

The heat losses through the vapor cap, through the bottom of the site, and through the sheet-pile wall were estimated based on the observed temperatures near those boundaries. Figure 6.1-15 shows the estimated cumulative energy losses, broken down in the three categories. The energy loss through the surface cap is significant, since relatively high temperature gradients (in the range of 20 ºC per meter) were observed in the soils right under the cap. The energy loss through the bottom was lower, as indicated by a lower temperature gradient between the two deepest temperature sensors (generally below 8 °C per meter). For the sheet-pile wall, the average temperatures of sensors adjacent to the wall, but inside, was used. The estimate is uncertain, since a temperature drop-off distance of five ft (1.5 m) was assumed. The data available from instrument strings outside the sheet-pile wall are not of proper resolution to measure the expected temperature increases, as the closest instrument strings were roughly 10 ft from the wall.

Overall, an estimated 3,400 million BTU was lost to the surrounding areas by thermal conduction. This is approximately 36 % of the injected steam energy. In a following section, a comparison of the heating calculated based on the energy balance to that observed by the temperature monitoring sensors will be made.

6.2 SUBSURFACE TEMPERATURES ACHIEVED

Subsurface temperature monitoring results are presented in this section.

6.2.1 Extracted Water Temperatures

The temperature of the extracted liquids from each of the seven extraction wells is shown on Figure 6.2-1. Increased extracted liquid temperatures were apparent around 11/10/02, less than one week after the onset of continuous steam injection. The heating occurred fastest in extraction wells E-1, E-2, and E-6, until the water recovery rate from extraction well E-1 diminished a week later.

Generally, the wells that had consistent water flow through December of 2002 heated to temperatures between 90 and 160 ^{o}F (E-2 and E-3). The average weighted temperature of the extracted water rose from the background temperature (57 ^{o}F) to 130 ^{o}F, before steam injection was halted on December 15, 2002.

When extraction and injection was resumed in early January of 2003, the temperatures quickly rose again, and generally kept rising until the end of steam injection on April 12, 2003. The average temperature of the extracted water had then increased to 160 ^{o}F.

After cessation of steam injection, gradual temperature decreases in the extracted water were observed, and the average temperature fell to around 125 ^{o}F in a period of five weeks, as extraction continued. Extraction well E-6 experienced the sharpest drop in temperature (>40 ^{o}F from late March to late April, 2003). This preferential cooling in the vicinity of E-6 is consistent with aquifer testing results that indicate potential for upwelling from the lower aquifer in this area. See Section 6.2.2.1 for additional discussions about temperature fluctuations at extraction well E-6.

6.2.2 Subsurface Temperature Sensor Data

Subsurface temperature data were collected using thermocouples and the DTS system. Generally, data were processed once per day. The data were presented as temperature profiles at individual instrument strings and as vertical sections and pseudo-horizontal slices through the pilot test area. The slices and sections were obtained from 3-D interpolation of temperature data using the kriging method in the GMS software. The lower four slices roughly paralleled the northeasterly dip of the aquitard and were evenly spread (vertically) throughout the aquifer. From bottom to top (from aquitard through the aquifer), the slices were labeled A through D. A fifth, horizontal slice (Slice E) was created for the collector layer. Nine vertical sections were taken at various orientations through the pilot test area (Figure 6.2-2).

To enable direct comparison of data from DTS and thermocouples, an instrument string containing both systems was installed at T-7. Although the temperature readings were taken at slightly different vertical spacings—1 m (3.28 ft) for DTS, 5 ft (1.52 m) for thermocouples—there is excellent overall agreement between profiles (Figure 6.2-3). However, DTS readings were consistently 3 ^{o}C higher than those from thermocouples. Manual measurements at E-5 verified that the DTS readings were high by 3 ^{o}C. The difference is readily apparent on October 2, 2002, and it persists through the highest temperatures reached in this instrument string on December 14. No attempt was made to correct for the difference between the two systems for data calculations or graphical presentation.

The effect of sporadic operations during the month of October—while equipment was being commissioned (Phase I)—can be seen as pockets of higher temperature in the pilot test area (Figure 6.2-4). Because steam injection was limited to relatively low rates during daylight hours only, most heating was restricted to the area slightly above and adjacent to the well screens, from mid-aquifer (Slice C) down to the aquitard (Slice A). With the start of continuous, 24-hr operations in early November 2002, the isolated heat blooms centered on injection wells started to coalesce. At this point it is apparent that steam over-ride was causing greater transfer of energy to the vadose zone (Slices C and D) than lower levels in the aquifer. This observation is borne out by Sections C and F (Figure 6.2-5), as well as by temperature profiles through individual instrument strings. During early December, hot spots were developing in the vapor collector layer (Slice E), and steam was noted coming out of a sheet-pile wall interlock near injection well I-1.

During Phase II, the average pilot test area temperature reached a peak of approximately 71 ^{o}C on December 15th, although the base of the aquifer averaged only 52 ^{o}C. These average temperatures are not strictly comparable to those shown on Figure 6.3-1, because the figure uses all subsurface temperature data (including data from instrument strings outside the sheet-pile wall and from upgradient), whereas this section limits the discussion to areas within the sheet-pile wall where steam injection was occurring.

Phase III was marked by slow cooling, as well as by some redistribution of heat throughout lower parts of the aquifer (Figure 6.2-4). During this period average site temperature decreased to 56 ^{o}C.

Upon resumption of low-level steam injection operations in Phase IV, hot spots developed within a week or two (Figure 6.2-4). As was observed during Phase II, the hot spots were concentrated around injection wells, and most of the heat was being transferred to the upper part of the aquifer and the vadose zone (Slices C and D).

Although sporadic operations continued into April (Phase V), very little steam was injected. Some cooling can be seen in all five slices for the period of March 24 to April 7, 2003.

6.2.2.1 Evidence for Aquitard Leakage in the Vicinity of E-6

An evaluation of pumping test data (Appendix C) suggested that there was communication between the upper and lower aquifers in the vicinity of extraction well E-6. Temperature data provide support for this hypothesis. On three occasions after abrupt cessation of steam injection, dramatic cooling was observed in the lower half of extraction well E-6 (Figure 6.2-6). It is believed that cold water upwelling from the lower aquifer caused temperatures to drop as much as 50 ^{o}C within 24-48 hours. The change in temperature was not accompanied by a significant change in water level. The temperature response at extraction well E-6 contrasts with that of extraction well E-4, which saw little immediate change when steam injection stopped.

6.2.2.2 Vapor Collector Layer Temperatures

Contoured temperature data for the collector layer during the week of December 8, 2002 point to uneven temperature distribution that is possibly related to uneven distribution of vacuum across the pilot test area. On the west side of the pilot test area, a cold temperature trough corresponds with the position and alignment of one of the subsurface horizontal vapor collectors (Figure 6.2-7). In contrast, hot spots along the eastern and northern side of the site appear to be associated with other horizontal collectors. Permeability variations across the site may have influenced migration of vapor into the collector layer. In particular, subsurface soils are recognized as being more permeable in the east and north than in the west. However, it is unlikely that permeability is the sole factor responsible for temperature patterns observed, because the subsurface beneath the cold trough is not different from other areas on the western side of the site in terms of permeability. There are at least two possible explanations for the observed patterns.

Scenario One

- Vacuum was drawing preferentially from the western side in the collector where the cold trough is located. Preferential application of vacuum may have been caused by fouling of horizontal collectors (PAH precipitation) or incorrect collector valve settings;
- Cool air was drawn into the collector on the west, either through holes in the impermeable membrane or along the join between the membrane and the sheet-pile wall;
- The collectors in the north and east were under little or no vacuum;
- The hot spots in the east and north are due to steam override promoted by low injection rates; and
- Association of the hot spots with collectors in the north and east is coincidental.

Scenario Two

- Vacuum was drawing preferentially from the eastern and northern side;
- Vacuum enhanced vertical movement into and then across the relatively high permeability materials in the collector layer; and
- Little or no vacuum in the west resulted in a stagnant, cool zone in the collector layer.

When steam injection stopped on December 10, 2002, the effect on temperatures in the collector layer was pronounced (Figure 6.2-7). The hot spots in the north and east cooled dramatically, with ten sensors in the collector layer along the eastern side of the pilot test area registering decreases of 25-73 ^{o}C (average 51 ^{o}C). Although steam injection resumed on December 11, 2002, effects were not readily apparent in the collector layer the following day (when the maximum temperature differential was registered). The most likely explanation for the drop in temperature is that precipitation ponded along the eastern side of the pilot test area and then drained into the collector layer, either through holes in the impermeable membrane or along the join between the membrane and the sheet-pile wall.

After the final cessation of steam injection on December 15, 2002, marking the end of Phase II of operations, collector layer temperatures in the east and north again declined sharply (Figure 6.2-4). Figure 6.2-8 shows the response of one collector layer thermocouple (T-52) along with precipitation recorded at SeaTac airport. The preceding six days had experienced measurable precipitation, and heavy rains occurred on December 14, 2002. With multiple variables potentially influencing collector layer temperatures (namely, steam injection, vacuum in the vapor collector, and precipitation), it is difficult to establish cause-and-effect for December observations. However, support for the second scenario is seen in temperature and precipitation data from March 2003. The month of March was selected because significant rainfall events occurred, steam injection rates were fairly constant, and the vapor system was not running. On March 12, 2003, the top sensor in instrument string T-52 experienced a 26 ^{o}C drop (Figure 6.2-8). The temperature drop coincided with significant rainfall on the sixth consecutive day of rain. Similarly, on March 21 the same sensor registered a further 15 ^{o}C drop, also corresponding to a period of significant rainfall. Given consistency of operations during these two periods, it appears that temperature variations in some areas of the cap were affected by infiltration of water. The degree of temperature drop seems most consistent with contact with cool water and not with conduction of cooler temperatures through the cap.

Generally speaking, the drop in temperature during December is a phenomenon restricted to the eastern and northern side of the pilot test area (Figure 6.2-9). In March 2003, however, the collector layer sensors exhibiting the greatest (>20 ^{o}C) temperature change were scattered across the pilot test area. The discrepancy in sensor response between December 2002 and March 2003 may indicate different causal relationships or may indicate that the cap became progressively more permeable. It is worth noting that steam emissions through the cap were not reported, which suggests that they were successfully drawn off by the vacuum system (when functioning) or that leaks were small enough that the steam condensed immediately after breaking through the membrane.

6.2.2.3 Heat Distribution Along the Inside of the Sheet-Pile Wall

Although it is impossible to predict how thorough NAPL removal would have been along the inside of the sheet-pile wall, temperature data show that that area was heated as effectively as the central part of the pilot test area (Figures 6.2-10 to -13). In general, temperature profiles are similar for instrument strings along the sheet pile wall and for the extraction well E-4 array in the center of the site.

6.2.2.4 Heat Transfer through the Sheet-Pile Wall

Conductive transfer of heat through the sheet-pile wall becomes noticeable by the end of the first week of December, and maximum temperatures of slightly greater than 25 °C (average 21 °C) are achieved by the end of March or early April at T-74, -76, and -81. These instrument strings are located approximately 10 ft outside the sheet-pile wall. Prior to commencement of operations, the average temperature at T-74, -76, and -81 was 14 °C.

6.2.2.5 Subsurface Heterogeneities

Heterogeneities in subsurface soil types are a feature of the Wyckoff site. The pilot test area was selected in part to establish the ability of thermal remediation to clean up all soil types affected by creosote contamination. There are some indications that heterogeneity influenced heat propagation. At instrument string T-27, hot water and steam were able to move above and below a silt and silty sand layer from 8-12.5 ft MLLW (Figure 6.2-12). A temperature differential of 40 °C between the low permeability layer and the zones immediately above and below persisted through May 2003 (Figure 6.2-13).

A clay layer from approximately 1-5 ft MLLW at instrument string T-56 clearly influenced temperature distribution (Figure 6.2-10). Unlike T-27, though, temperature was evenly distributed through that layer by February 2003, and the entire interval achieved a temperature of 100 °C in March 2003 (Figure 6.2-11). Evidence from T-56 suggests that it is possible to thoroughly heat even low permeability zones.

Instrument string T-29 appears to show similar geologic control (at –2.5 ft MLLW) on temperature distribution to that of T-27 (Figures 6.2-12 and -13). However, the boring log indicates that the entire interval in question consists of poorly sorted sand with gravel. Evidence for a low permeability layer does not exist, although less-than-complete recovery during drilling may have obscured real soil heterogeneities.

The different responses over time at T-27 and -56 may reflect overall permeability differences in the western and central parts of the site. Conductive heat transfer may have been more important in the lower permeability western area, which allowed slower, more even heating with time. In contrast, higher permeability areas in other parts of the pilot test area experienced fairly rapid temperature changes, with lower permeability interbeds lagging significantly behind.

6.2.2.6 Effectiveness of Low-Rate Steam Injection

During the period from January to March 2003, which was characterized by low-level steam injection, there was only minor improvement in the ability to bring hot temperatures down to the aquitard surface. As a consequence of the low injection and extraction rates, most of the injected steam condensed rapidly, and the majority of the affected zones were swept by hot water (not steam). The low injection and extraction rates employed were not effective at improving temperature distribution through the aquifer. This point is illustrated by a comparison of temperature profiles in Sections C and F for December 10 and March 17 (Figure 6.2-5). These two dates represent the times closest to maximum heating during Phase II (continuous steam injection) and Phase IV (low-level steam injection). While there is noticeably better distribution of temperature at the base of the aquifer on March 17 than December 10 (Figure 6.2-4), some of that evening out of temperatures is the result of conductive heat transfer throughout the aquifer during Phase III. It is clear that low-level steam injection exacerbated the problem of steam over-ride, as exhibited in Slice D. By contrast, injection at design rates would more likely have created greater pressure differentials, thereby resulting in better penetration of steam into pore spaces and, presumably, better sweep across the aquitard.

6.3 COMPARISON OF PROCESS DATA TO SUBSURFACE HEATING OBSERVATIONS

In this section, the heating observed in the subsurface is compared to heating estimates derived from the energy balance, including estimates for heat losses.

6.3.1 Average Temperatures Used for Energy Balance and Heat Loss Calculations

Based on subsurface sensors, the average temperatures were calculated for the following selections:

- All pilot test area sensors.
- The shallowest sensors in each monitoring location, excluding the sensors in injection wells (these are relatively deep and do not represent the temperature near the vapor cap).

- The deepest sensors located near or in the top of the aquitard (monitoring locations, extraction wells, and injection wells).
- The sensors located next to the sheet-pile wall (17 instrument strings total: injection wells I-1, I-2, I-3, I-6, I-16, extraction wells E-1, E-2, E-6, and E-7, and temperature monitoring locations T1, T4, T7, T10, T49, T52, T53, and T56).

The average temperatures were calculated for each day of operation (Figure 6.3-1). The measured temperature averages were consistently less than 75 ^{o}C, which shows that the operational target of boiling temperatures (100 ^{o}C at the water table and higher below) was never reached. The data also clearly shows that the bottom sensors stayed cooler than average, with the average temperature peaking around 52 ^{o}C in March of 2003.

The temperatures next to the sheet-pile wall were generally above the average temperatures, indicating that heating along the sheet-pile was not hindered compared to the overall average heating. However, this data is partially skewed towards higher temperatures, since five out of the 17 temperature monitoring locations along the wall were injection wells. This is a larger fraction of injection wells than the average (16 injection wells, 97 total inside monitoring locations). Since each injection well has only three sensors, this effect is minor, and it can be concluded that the sheet-pile wall did not hinder steam flow or heating next to, and inside the wall.

6.3.2 Comparison of Observed Heating to Energy Balance Calculations

Based on the energy balance, average obtained temperatures for the pilot test volume were calculated and compared to the measured temperatures (Figure 6.3-2).

The measured and calculated temperatures match relatively well. However, it should be kept in mind that the energy removal from steam being extracted, and the energy losses by thermal conduction, were estimated based on relatively sparse data, and based on several assumptions. Therefore, the good match of the data could be somewhat coincidental. However, overall it may be concluded that the energy balance calculations and the observed subsurface temperature changes are in agreement, and that no apparent contradictions exist in the data set.

It is interesting to note that the injection and extraction rates varied systematically across the site, with much higher flow rates in the eastern half of the site. The cumulative amounts of water extracted for each well is shown in Figure 6.3-3. Figure 6.3-4 shows the average steam injection rate from October 30, 2002, to December 14, 2002, the period where steam was injected at rates as high as practical. Both figures are consistent with soil borings indicating that the formation was tighter in the western section of the pilot test area.

6.4 CHEMICAL MONITORING RESULTS

Chemical monitoring results for extracted liquid, non-condensable gases, and groundwater monitoring wells are discussed in this section.

6.4.1 Extracted Liquid Composition

Extraction well PAH data are summarized in Figures 6.4-1 and 6.4-2. The work plan called for up to twice daily sampling of the extraction wells. Samples were collected daily during steam injection from all extraction wells that were operational. Naphthalene is by far the most abundant PAH in the effluent samples.

Considerable difficulties were encountered with naphthalene crystals plugging the pump exhausts, thus requiring frequent maintenance. This appears to be particularly true for extraction wells E-1 and E-7 (Figure 3.5-1), both of which are located in the western portion of the pilot test area and within the area where extremely high naphthalene concentrations were found. These wells had low pumping rates most of the time. Extraction well E-1 did not pump after November 21, 2002, and extraction well E-7 was not used after February 4, 2003. Later in the pilot operations, it appears that naphthalene crystallization problems were also encountered in extraction well E-3. This extraction well is right in the center of the area with high naphthalene content. Thus, some of the lack of effluent concentration data is because the pumps were undergoing maintenance and were out of service. At other times, a well was operating and a sample was obtained but was not submitted for analysis due to the presence of a visible NAPL layer in the sample. However, it appears that samples containing NAPL were analyzed on several occasions (see data for E-1 on 11/15/02, E-3 on 2/4/03 and 2/17/03, and E-7 on 1/16/03).

Although soil sampling in the immediate vicinity of extraction well E-5 had shown that the area around this well contained small amounts of contamination, significant amounts of NAPL were present within the E-5 array to the east and northeast. Initial effluent samples from this well showed little or no PAHs for the first month of operations. After that time, contaminant extraction rates from that well were significant, and they remained similar to the other extraction wells for the rest of the pilot study.

Presumably, contaminants along the eastern part of the array were mobilized and driven inward (away from the injection wells) and extracted at E-5.

At about the time that the steam zones appear to extend from the injection wells to the extraction wells over some depth intervals in the northern portion of the site, which occurred around December 10, the concentrations in the effluent samples increased. For E-2, the increase in concentration was approximately an order of magnitude, while for wells E-3, E-4, and E-6, the increase in concentrations was closer to two orders of magnitude. E-3 appears to have consistently the highest PAH concentrations in the effluent, however, the extraction rate from this well was always low. E-5 exhibited an even greater relative increase in concentrations because its initial concentration was so low. These increases in concentration are expected, as the solubility of PAHs generally increases exponentially with temperature (Bamford et. al, 1998).

PCP concentrations in the effluent are shown in Figures 6.4-3 and 6.4-4. These figures show that most of the PCP extracted came from well E-2, where concentrations went as high as 1,900 μg/L. E-2 is at the northern-most portion of the pilot test area, where there were not much soils data available from the baseline sampling. Extraction well E-6 on the eastern portion of the pilot test area also showed significant PCP concentrations during the period of low-level steam injection (Phase IV).

6.4.2 Extracted Liquid Total Organic Carbon Results

The TOC content of the liquid effluent stream from the pilot test area was measured automatically with a frequency of every 20 minutes for most of the period of operations. Frequency changed to every hour in March 2003. Figure 6.4-5 displays the average daily TOC reading and cumulative TOC removed for the period from November 7, 2002 to April 10, 2003. The TOC analyzer was not operational until November 9, 2002, so data are not available for the period of limited injection and extraction during Phase I and the beginning of Phase II.

With the start of 24-hour injection and extraction on November 7 (Phase II), the TOC concentration of the effluent started gradually increasing. Within 3 to 4 weeks, TOC had doubled to approximately 500 mg/L. By December 15, the average daily TOC concentration was approximately 1,900 mg/L. Spikes of greater than 1,000 mg/L became common on November 10, followed by spikes of greater than 3,000 mg/L on December 3. The highest spike recorded was 10,000 mg/L (out of range) on December 14. During Phase II, the cumulative amount of carbon removed was estimated as 2,600 kg, which equates to an average of 67 kg/d. Assuming a simple 1:1 relationship between mass of carbon and mass of creosote, with no corrections for density or other elements that contribute to contaminant mass, the creosote equivalents of 2,600 kg and 67 kg/d are 680 gal and 18 gpd, respectively. Given the simplifying assumptions, these figures probably underestimate the amount of creosote removed in the dissolved phase.

Phase III saw very little extraction, during which TOC was estimated based on values for December 16 and January 20. Total extracted during Phase III was estimated as 170 kg (44 gal creosote).

Phase IV was characterized by less fluctuation in TOC than was observed during Phase II. Average daily TOC values ranged between approximately 500 and 1,400 mg/L, with spikes over 2,000 mg/L occurring relatively infrequently (roughly 1% of all TOC readings during this phase). Greater consistency in TOC concentrations is presumably a reflection of fairly constant subsurface temperatures. The total carbon removed during this phase was estimated as 6,300 kg (1,700 gal creosote equivalent) or approximately 91 kg/d (24 gpd creosote). Although contaminants were apparently being removed at higher average rates than during Phase II, it is worth noting that peak removal during Phase II was equivalent to roughly 250 kg/d (66 gpd creosote).

During Phase V, when steam injection was sporadic and limited, TOC concentrations averaged approximately 570 mg/L (45 kg/d or 12 gpd creosote). Spikes over 1,000 mg/L were rare, and none were recorded over 2,000 mg/L. Total removed during this phase was estimated as 850 kg (220 gal creosote).

For the period from November 7, 2002 to April 10, 2003, approximately 9,300 kg of carbon were removed from the pilot test area in the dissolved phase. This mass removed is roughly equivalent to 2,600 gal of creosote.

6.4.3 Extracted Vapor Composition

Non-condensable gas monitoring was planned as part of the pilot study. Vapor sampling equipment was not installed between the heat exchanger and the vapor treatment system as planned for in the design; therefore, chemical data for the vapor phase are not available for analysis.

6.4.4 Monitoring Well Sampling Results

Groundwater monitoring was conducted of both upper and lower aquifer monitoring wells to evaluate potential impacts from the pilot study. Samples were collected from both aquifers in November 2002. Additional samples were collected from the lower aquifer in December 2002 and January 2003. Locations of the monitoring wells are shown in Figure 3.5-1.

6.4.4.1 Upper Aquifer Monitoring Results

During November 2002, groundwater samples were obtained from the upper aquifer wells MW-17, MW-18, and MW-19, and two extraction wells within the pilot test area, E-04, and E-06. PAH were detected in all of these wells. Concentrations of PAH were greatest in MW-17 and MW-18 located outside the pilot test area. Concentrations of several compounds, including naphthalene, exceeded groundwater cleanup levels. Concentrations of PAH in MW-19, which is located southwest (upgradient) of the pilot test area, were significantly less; however, the concentrations of carcinogenic PAH exceeded groundwater cleanup levels.

6.4.4.2 Lower Aquifer Monitoring Results

During December 2002 and January 2003, groundwater samples were obtained from the lower aquifer monitoring wells 99CD-MW02, 99CD-MW04, CW-05, CW-09, and CW-15 (Figure 3.5-1). The December 2002 sampling round showed very few detections of PAHs in any of these monitoring wells. Only well CW-15 had contaminant concentrations that were greater than the cleanup levels. In the January sampling round, the concentrations in all the wells except for CW-09 returned to approximately the level they had been in the November 2002 sampling round, and some constituents went to higher concentrations. CW-09, 99CD-MW02, and 99CD-MW-04 still were less than cleanup levels for all constituents, however, CW-15 and CW-5 had concentrations that were greater than cleanup levels.

In January 2003, monitoring well 02CD-MW01 was also sampled. This well was installed for the purposes of monitoring the lower aquifer just outside the pilot test area to the northeast, in an area where there was concern about the integrity of the aquitard (Appendix J). This was the only time that this well was sampled. It contained small amounts of various PAHs, including chrysene and benzo(b)fluoranthene that were greater than the cleanup levels.

Data from these monitoring wells during the first three months of the pilot would suggest that groundwater quality in the lower aquifer was not adversely affected by the pilot operation.

6.4.5 Chemical Data Quality

A review of laboratory data for extracted liquid or groundwater samples included a review of laboratory performance criteria and sample-specific criteria as specified in the RAMP. Results were evaluated to determine if the measurement quality objectives for the project were met. The data were determined to be acceptable for project uses as qualified. No data were rejected.

Field measurements were not subject to a formal data quality review. However, dissolved oxygen and carbon dioxide results from the daily sampling of the extraction wells were rejected due to the following issues:

- The sampling ports used to collect samples from the extraction wells did not allow for low flow sampling methods to be used, resulting in non-representative samples.
- The pumps installed in the extraction wells (Hammerhead) allowed air from the compressor to mix with the extracted liquid prior to and during sampling, resulting in non-representative samples.
- The sampling ports allowed mixing of ambient air with groundwater samples, potentially resulting in non-representative samples.
- The light to dark brown color of the extracted liquid interfered with the color interpretation of the CHEMetrics colorimetric field test kit.

6.5 VAPOR TREATMENT SYSTEM DATA SUMMARY

Non-condensable gases were treated by running them through the burners of the gas-fired boiler. For regulatory compliance, boiler emissions monitoring was planned. The pilot monitoring plan contained provisions for emissions stack testing when boiler operations had stabilized and the sour gas to be burned in the boiler had reached the standard operating conditions, but the contract and equipment were not in place prior to start of operations. In addition, the steady-state operational conditions that were to be reached prior to stack sampling never occurred. Therefore, chemical data for stack emissions are not available for analysis. Boiler emissions testing to determine maximum potential emissions was predicated on operation of the boiler full time at capacity. Because the boiler never achieved full time operations at capacity, testing would not have been relevant to address regulatory compliance.

6.6 WATER TREATMENT SYSTEM DATA SUMMARY

The water treatment system consists of a series of processes designed to remove contaminants from the combined liquid waste streams from the former process area and pilot area (Figure 4.2-9). The main components include the DAFT, the aeration basin, and three activated carbon vessels. Treated water is discharged to Puget Sound. The effectiveness of each system in removing contaminants from the waste stream is discussed in this section. Treatment plant data are summarized in Table 6.6-1.

6.6.1 Extracted Liquid Waste Stream

The flow of combined extracted liquid from the former process area and the pilot area stayed fairly constant during the pilot study at around 40 to 50 gpm (approximately 30 to 35 gpm from the FPA and 10 to 15 gpm from the pilot test area). Prior to the start of the pilot study (January through September 2002), the average total PAH and PCP concentrations in water from the FPA that went into the treatment plant were 15,500 and 860 µg/L, respectively. Total PAH and PCP concentrations in treatment plant influent from January through December 2002 are shown in Figure 6.6-1. Concentrations of contaminants going into the treatment plant increased dramatically beginning in November 2002 and stayed relatively high through April 2003 when the pilot study operations ceased. Concentrations of total PAH, naphthalene, and PCP in treatment plant influent (sampling location SP-0) are shown in Figures 6.6-2 through 6.6-4. Influent concentrations peaked during the weeks between December 2 and December 15, 2002, overloading the capacity of the treatment system and contributing to the decision to stop aggressive steam injection operations.

6.6.2 Dissolved Air Floatation Tank

The DAFT is designed to remove contaminants in the non-aqueous or oil phase by floating the separate phase to the surface with air bubbles and removing it to a separate holding tank (tank 108). Only a small volume of separate phase NAPL was removed by the DAFT during the pilot study. Crystals of naphthalene began clogging the DAFT in January 2003 and additions of a combination of chemical flocculent and polymer were used to reduce this problem beginning routinely in March 2003. A sample of this material was analyzed for PAH by the Region 10 laboratory. The sample was 75 percent naphthalene, with the remaining 25 percent identified as various other PAH. The effectiveness of the DAFT in removing total PAH, naphthalene, and PCP are shown in Figures 6.6-2 through 6.6-4.

Samples of the DAFT influent and effluent were collected once a week during pilot operations and results are at times inconsistent and highly variable. Total PAH and PCP concentrations in DAFT effluent are at times greater than concentrations of the DAFT influent. Concentrations also fluctuate from week to week. This may be due to the heterogeneous nature of the samples (SP-0 is collected from a pipeline and SP-4 is collected from the well-mixed tank effluent line), allowing either NAPL sheen or droplets, or naphthalene crystals, to impact the samples.

The amount of NAPL collected from the site from December 1998 through June of 2003 is shown in Figure 6.6-5. The bulk of the NAPL removed from the site has been from accumulations in sumps in extraction wells in the former process area. Much less has traditionally been separated from the liquid waste stream running through the treatment plant and separated by the DAFT (formerly by the depurator). This trend continued during the pilot study. A detailed analysis of the mass of contaminants removed during the pilot study is included in Section 6.7.

6.6.3 Aeration Basin

The aeration basin is the primary treatment method for the liquid waste stream. In the aeration basin, site-specific microorganisms biodegrade site contaminants. Concentrations of total PAH, naphthalene, and PCP going into and out of the aeration basin are shown in Figures 6.6-6 through 6.6-9. Concentrations are typically reduced by up to 99 percent within the aeration basin. During the weeks from December 2 through December 15, 2002, the concentrations of contaminants coming into the aeration basin peaked and overloaded the capacity of the biological system. The dissolved oxygen and total PAH concentrations in the aeration basin are shown in Figure 6.6-10.

During the week of December 2, the aeration basin showed effects of higher concentrations of PAHs and the clarifier visibility decreased. On December 8, a polymer ball formed in the static mixing chamber between the aeration basin and the clarifier. The ball plugged the mixing chamber and caused the aeration basin to overflow with liquid. The liquid flowed into the aerobic digester, causing solids to mix into the liquid. The liquid then flowed back into the aeration basin, loading the basin with digester solids. Basin monitoring revealed very high concentrations of PAHs and low dissolved oxygen values.

After the mixer plugging problem occurred, examination of the aeration basin microorganism life revealed very little activity. The aeration basin was taken off line (from December 8 to December 11), put in a closed loop operational mode, and inoculated with backwash tank solids to rehabilitate it. Solids from the mixing chamber plug problem also migrated to the multimedia filters and carbon vessels. The filters and vessels were backwashed several times to remove the solids. Effluent was not allowed to discharge to Puget Sound until all systems had been backwashed and were operational.

On December 15, a nearly complete die-off of aeration basin microorganisms occurred due to high concentrations of PAH in influent from the pilot test area. Dissolved oxygen concentrations dropped to approximately 1 mg/L and the treatment plant was put into recycle mode with no discharge to Puget Sound. The basin was again re-inoculated with backwash tank solids to rehabilitate it before it was put back on line on December 18.

Following this series of events, dissolved oxygen concentrations were maintained above 2 mg/L by switching on the additional air blower to restore or increase values. Increased monitoring of dissolved oxygen concentrations (once every four hours) began in early January 2003 and continued until additional air diffusers were added later that month.

The ability of the aeration basin to handle peak contaminant loading was considered suspect throughout the design process. From a conceptual standpoint, failure of the aeration basin was to be dealt with by diverting flow through the carbon vessels. In terms of implementation, though, funding was limited for additional carbon vessels, and the existing setup made changing carbon laborious. Prior to early December, the aeration basin handled increased contaminant loading exceedingly well. Following the installation of additional air diffusers, dissolved oxygen levels within the basin became much more stable and the system treatment capacity was increased. Ultimately, though, this limit of treatment capacity by the aeration basin was one of the major determining factors in ending the pilot study.

6.6.4 Clarifiers, Multimedia Filter, and Carbon Treatment System

From the aeration basin, water flows through a clarifier and is pumped in parallel through two multimedia filters simultaneously with split flows before being transferred to two 8,000 lb granulated activated carbon filters, arranged in series. (A third carbon filter tank was put on line in May 2003.) The effectiveness of the carbon system in removing total PAH and PCP is shown in Figures 6.6-11 through 6.6-13. The carbon system is highly effective at reducing contaminant concentrations to less than the surface water discharge limits for the site.

6.6.5 Compliance Monitoring for Treatment Plant Effluent

Treatment plant effluent must meet specific limits set in the ROD prior to discharge to Puget Sound. Effluent is monitored for PAH, PCP, pH, temperature, dissolved oxygen, and solids (total and dissolved). Discharge limits for total PAH and PCP were not exceeded during the pilot study (Figure 6.6-14). Discharge limits for pH and temperature were also not exceeded during the pilot study (Figures 6.6-15 and 6.6-16). Dissolved oxygen concentrations did not meet the discharge limit set in the ROD (>6 mg/L) (Figure 6.6-16). Total and dissolved solids were also measured in treatment plant effluent, however these results, measured in mg/L, could not be compared to discharge limits set in the ROD for turbidity, measured in NTU.

6.7 PILOT STUDY MASS REMOVAL ESTIMATES

The mass of contaminants removed from the subsurface could be measured as the following four quantities:

1. NAPL recovery. The rate of NAPL removal from the pilot area was not measured, since the effluents were combined with the liquids from the other site extraction wells located in the Former Process Area. The data on overall NAPL removal over the project period was used to determine if more than usual was recovered in the period of the pilot study. These data are shown on Figure 6.6-5. This simple analysis indicates that compared to the trend before steam injection was begun, an approximate volume of 340 gal of NAPL was recovered over the six-month operational period due to the thermal enhancements.

   It should be noted that NAPL removal was tracked through measurement of the level of liquid collected in tank 108. This methodology was inaccurate, because tank 108 collected NAPL from the combined waste streams from the FPA and the pilot test area; therefore, an estimate of the amount removed due to thermal treatment of the pilot test area alone could not be made.

2. Removal of dissolved phase contaminants. The TOC data, when combined with the liquid extraction rate data, provides a trend and allows for an estimate of the

mass removed in this phase. This estimate yields a total volume equivalent of 2,600 gal (~9,300 kg) of organics.

3. Removal in non-condensable vapor: No analytical data were recorded for the vapor stream. A mass estimate would have to rely on assumed flow rates and concentrations. Since the naphthalene concentrations were very high, leading to both crystallization in the well and pipes, and formation of waxes in the process equipment, it is likely that a substantial mass was unaccounted for in this stream. However, without chemical sampling of the stream, calculation of amount removed is not possible.

4. In-situ destruction/degradation. This could be due to oxidation, hydrolysis, pyrolysis, and be either biological or chemical reactions. The importance of such mass removal could not be evaluated due to the complexity of such measurements.

In conclusion, the volumes and masses recovered from the pilot test area over the 6 months of operations can be estimated as follows:

- Recovered as NAPL: 340 gal (~1,300 kg).
- Recovered as dissolved contaminants: 2,600 gal (~9,300 kg).
- Recovered in vapors: Unknown.
- Degraded in-situ: Unknown.
- Total: 2,900 gal (~11,000 kg) plus an unknown amount.

From other thermal remediation sites, such as the Visalia Pole Yard, it is indicated that the removal in the NAPL and vapor state are substantial contributors to the mass removal. Thus, it is likely that the true mass removal is substantially higher than the quantity listed above.

SECTION 7.0 COST SUMMARY

This section includes the costs for USACE design, installation of sheet pile walls, installation of subsurface wells and vapor cap, installation of thermal remediation and subsurface monitoring equipment, actual operation and maintenance expenses for operation of the thermal processes, USACE construction oversight, and USACE oversight of the operations and maintenance. The following table represents actual expenditures through April 15, 2003.

Contractor	Description of Work	Costs
BayWest/JD Fields/Hurlen Construction	Installation of inner sheet pile wall	$1,400,000
Marine Vacuum, Inc.	Boiler building construction, installation of vapor cap and vapor collection piping, installation of the water supply well, extraction wells, and injection wells	$1,830,000
Pease Construction, Inc.	Treatment plant upgrades, installation of the boiler and above ground piping system, startup and commissioning of the thermal treatment system	$2,414,000
SCS Engineers, Inc.	Operations and maintenance of site during steaming operations	$1,193,000
Geomation	Installation of thermocouples and automated data system	$140,000
Sensor Highway (Sensa)	Installation of distributed temperature sensor (DTS) system well field	$145,000
URS Corporation	Water quality and air monitoring	$183,000
Shannon and Wilson	Installation of subsurface instruments (nine replacement borings)	$16,000
Williams Heating Oil	Fuel supplier	$59,000
	Contractor SubTotal	**$7,380,000**

Contractor	Description of Work	Costs
USACE	Pre-award of Contracts – Design and Planning	$1,500,000
USACE	Construction Management and Oversight	$870,000
	USACE SubTotal	**$2,370,000**
	TOTAL (as of summer 2004)	**$9,750,000**

Additional costs for the disposal of product, filter cake, and carbon that would have been required during the pilot study were negotiated in the operation and maintenance contract with SCS Engineers, which included the following line items for waste disposal:

- Line Item 15 - Spent carbon removal from storage, transfer to roll-off containers, and transport for disposal in landfill. Unit price is $0.72 per lb.
- Line Item 16 - Spent carbon removal from storage, transfer to roll-off containers, and transport for disposal as F032/F034 Listed Waste for incineration. Unit price is $1.84 per lb.
- Line Item 19AA - Hazardous Waste disposal (Incineration) of filter cake and other non-NAPL items. Unit price is $1.06 per lb.
- Line Item 19AC - Hazardous Waste disposal (Incineration) of product (NAPL). Unit price is $2.05 per lb.

Due to the low volume of product removed during the pilot study operation and maintenance period, there were no expenditures for waste disposal from January 1, 2002 through April 15, 2003.

SECTION 8.0 CONCLUSIONS

The two goals of the pilot study were to assess the likelihood that a full-scale thermal remediation would achieve the cleanup goals for the site and to provide information for implementation of the potential full-scale thermal remediation. The pilot study proceeded for approximately six months, from October 2002 to April 2003. Operations were restricted by equipment problems, and the pilot study was terminated. Limited progress was made towards achieving the specific objectives of the pilot study relating to performance assessment, community and environmental impacts, and process. A significant amount of data was collected during the five months of operations, and important observations regarding system performance, impacts on the surrounding environment, and in process design and operations were made that may be useful in designing and implementing a new pilot study or full-scale remediation, if needed for the Wyckoff site, or may be useful to others for implementing thermal treatment systems at other sites.

8.1 PERFORMANCE ASSESSMENT

The pilot study was performed partly to determine the effectiveness of steam-enhanced extraction to remove mobile NAPL and reduce contaminant concentrations in groundwater and soil to acceptable risk levels. Data gathered during the pilot study show that the mass removal rate increased dramatically when the site started heating. Dissolved PAH and TOC concentrations in extracted liquids increased, and the vapor extraction system experienced problems due to fouling and precipitation related to extremely high contaminant concentrations in the vapor phase. However, the mass removal that occurred during the pilot study was minor compared with what could have been achieved with a fully functional SEE and treatment system.

The mass of contaminants removed from the subsurface was estimated as follows:

- Recovered as NAPL: 340 gal.
- Recovered in the dissolved phase: 2,600 gal.
- Recovered as non-condensable vapor: The observation of naphthalene crystals in the vapor lines suggest that significant contamination was removed in the vapor phase; however some of the planned monitoring instruments were not installed

when the vapor system was in operation, and accurate vapor flow and concentration measurements were not made.

- In-situ destruction/degradation. Based on laboratory results obtained as part of the Treatability Study, some oxidative destruction of the creosote could have been expected to occur during the pilot study. However, adequate sampling protocols were not in place during the pilot to measure the amount of oxidation that occurred.

The total estimate for the amount recovered is 2,940 gal in the NAPL and dissolved phase plus an unknown amount in the vapor phase or degraded in-situ. Prior to the pilot, the average amount of NAPL extracted per month was approximately 320 gallons with an average of approximately 24 gallons per month in the dissolved phase. Though the amount of NAPL removed did not show a marked increase during the pilot study, the amount of contaminants removed in the dissolved phase increased dramatically.

For comparison, steam injection was used by Southern California Edison to recover creosote and pentachlorophenol at their Visalia Pole Yard in Visalia, California. More than 1,200,000 pounds of creosote were recovered by the injection of approximately 700 million pounds of steam over a three year period. This was a 3500-fold increase in the extraction rate compared to the existing pump-and-treat system that had been operating since 1975 and recovering approximately 10 pounds of creosote per week. Most of the creosote was recovered as a separate phase emulsion, with significant quantities also recovered in the vapor phase and dissolved in the groundwater. Carbon dioxide in the extracted vapors indicated that some creosote was being oxidized in situ.

8.1.1 System Performance

Numerous problems were encountered during operation of the thermal remediation system that contributed by varying degrees to the failure of the system to perform as designed. These include:

- Material incompatibility: Seals and gaskets in pumps, heat exchangers, and other components failed, which required frequent attention and replacement of parts, and led ultimately to the complete failure of HX-3, the liquid-vapor heat exchanger.

- Aeration basin adaptability: The activated sludge treatment system failed to handle the contaminant load, either due to toxicity or lack of oxygen.

- PAH precipitation/condensation: The formation of various waxes and crystalline precipitates clogged valves and pipes, thereby limiting the performance of extraction wells and restricting flow through liquid and vapor conveyance lines.

- Liquid in vapor lines: Condensation points and drip legs were inadequate to handle the amount of liquid in the vapor lines, which led to slugs of liquid reaching the liquid ring vacuum pumps. The liquid most likely came from rain penetrating the membrane into the vapor collectors and was transported along the vapor extraction pipeline to the liquid ring vacuum pumps.

8.2 COMMUNITY AND ENVIRONMENTAL IMPACTS

Monitoring for impacts to the surrounding community and environment, including noise, air emissions, odors, and off-site migration of contaminated groundwater, was included in the pilot study design. Monitoring for noise, air emissions, and odors to the surrounding community were, however, not completed because the necessary equipment was not installed early enough during pilot study operations.

Upper and lower aquifer groundwater samples were collected and data were reviewed. No significant changes to groundwater concentrations outside of the pilot test area were observed that would indicate steam injection in the pilot study area was adversely impacting site groundwater or mobilizing contaminants beyond site boundaries.

During the short period of time that vapors were passed through the combustion chamber of the steam generator, stack sampling was not performed to determine if this destruction method is appropriate for full-scale treatment. A proper evaluation would have involved detailed stack profiling and analysis for destruction efficiency, and presence of dioxins and furans in the stack effluent. Such testing was planned for operation at the maximum rates. Such conditions were never reached, and the sampling was therefore omitted.

8.3 PROCESS OPERATIONS AND DESIGN

Data collected during the pilot study were to be used to evaluate operational approaches to removing NAPL, treatment plant performance, and the effectiveness of microbial degradation, and to determine oxidation rates. Each of these is discussed below.

8.3.1 Operations

The pilot study was not operated as designed and the subsurface was not heated enough to demonstrate the overall potential of the technology. The shortcomings included:

- The designed injection and extraction rates were not achieved, due to limitations of the process equipment. In particular, failures of the vacuum pumps and heat exchanger prevented vapor extraction during the 2003 operations period. This means that in the last four months of operations the dual-phase extraction system was inactive, and only liquids were extracted.

- Steam distribution was not satisfactory due to the lower than anticipated injection pressures and rates, the short steam injection time, and the failure of the overall process to be implemented as designed. This lead to uneven heat distribution in the subsurface.

- Approximately 1 pore volume of steam was injected into the site, an amount insufficient to heat it to the target temperature. Two to three pore volumes of steam were planned, as has been used at other wood-treater sites.

- The operations period was shorter than would be expected for full-site treatment, allowing less time for degradation reactions to assist in the reduction of contaminant concentrations.

- Several operational modes were defined for the period after site heating was achieved (pressure cycling and mass removal optimization phases). Since satisfactory heating was not achieved, these operational modes were never implemented.

- A good steam push across the aquitard surface was never achieved.

Due to these shortcomings, the optimal operations strategy for full-scale NAPL removal and treatment could not be determined.

8.3.2 Heating Design

One of the objectives of the pilot study was to determine if the existing steam injection design was adequate. Since the steam injection wells in the upper aquifer were not operated as designed, it cannot be concluded whether satisfactory heating can be achieved using the injection wells with single deep screens as designed for the pilot study. However, several observations support a conclusion that an improved heating strategy for the bottom of the aquifer (and the top of the aquitard) would be beneficial:

- Observations of significant steam override at several locations within the pilot test area, particularly in the northern, deep end.

- Groundwater pumping tests and temperature observations indicate that a substantial upward water flow through the aquitard takes place when the fluid level is depressed by extraction. This upward migration of cold water will keep cooling the base of the aquifer in the locations where water flows, reducing the chance of satisfactory heating. This will act to impede deep steam penetration across the top of the aquitard, where DNAPL may be accumulated.

Furthermore, if in the future there is increased focus on the potential for DNAPL penetration into and through the aquitard, then there may be additional focus on the aquitard, and potentially the aquitard could be included in the remediation volume. This would mean that a robust heating strategy should be added to the design.

The pilot design was not properly or fully implemented, and thus conclusions cannot be made about the adequacy of the heating system. It is likely that a supplemental heating approach for the base of the upper aquifer would be a benefit. The three competing techniques are:

1. Use direct electrical-resistive heating process, three-phase electrical heating, to heat the upper 5-8 ft of the aquitard and the base of the upper aquifer. This would involve 3-phase electrodes placed in a triangular pattern, with electrode separation in the 20 to 30-foot range.

2. Use In-Situ Thermal Desorption (ISTD) to heat the upper 5-8 ft of the aquitard and the base of the upper aquifer. This would include direct heating elements installed in a triangular pattern with typical separations of between 12 and 25 ft.

3. Use steam injection below the aquitard to encourage upwards steam flow through the aquitard, and to block upward water flow. This approach was used successfully at Visalia Pole Yard, but a significant amount of characterization and risk assessment would be required before trying this approach at the Wyckoff site

Further evaluation and discussion of these three alternatives are warranted before a full-scale design is prepared, or a modified and improved pilot study is performed.

8.3.3 Maximum Treatment System Loading

Since the pilot study did not achieve satisfactory subsurface temperatures, the designed steam break-through to the extraction wells, or maximum contaminant extraction levels in the liquid and vapor systems, it would be difficult to attempt to use the data to design a full-scale groundwater and vapor treatment system. The following data are still needed for design of a system for full-scale treatment:

1. Estimates of the rates of NAPL recovery during and after site heating. The site was never heated adequately, and the NAPL recovered from the pilot test area was not separated from the NAPL recovered from the FPA wells to determine the amount of NAPL recovered from the pilot test area.

2. NAPL behavior in extracted water. Density changes that change a DNAPL to an LNAPL and/or emulsification are possible, but were not determined since the liquid stream from the pilot test area was mixed with the liquid stream from the FPA wells in order to better control the temperature of the liquid in the treatment plant.

3. Maximum dissolved phase contaminant concentrations achieved during maximum mass recovery times. While the TOC readings indicated more than a 10-fold increase in dissolved organics, the maximum contaminant concentrations during times where steam breakthrough to several extraction wells occurred could not be measured because the TOC analyzer did not have adequate capacity.

4. Vapor phase flow rates and contaminant concentration. Instrumentation for measuring vapor flow rates was not installed during the pilot test, and vapor samples for chemical analysis were never obtained.

5. True extent of the PAH precipitation problem. It is possible that PAH fouling (i.e., precipitation and crystallization of naphthalene and other PAH) may have been reduced by full-capacity operation per design assumptions, which would

have lead to higher temperatures in the overall system. It is also possible that precipitation problems could have been worse during full capacity operations.

6. Condensate flow rates and contaminant levels achieved during maximum mass removal periods. Methods to separately measure condensate flow and contaminant concentration were not included in the Pilot Study design.

8.3.4 Vacuum and Vapor Flow

The pilot test area included a vapor cap with horizontal vapor collectors as well as vapor extraction from each of the seven extraction wells. The system only functioned for about one month of the pilot study period, and was erroneously operated with most of the flow originating from the surface vapor-collection system. Information sufficient to support full-scale design of an adequate vapor extraction and treatment system is therefore not available.

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SECTION 9.0 LESSONS LEARNED

During analysis of the results of the study, technical details regarding contaminant composition, design, construction, and operations were identified that may be useful in implementing a new pilot study, if needed for the Wyckoff site, or may be useful to others for implementing thermal treatment systems at other sites. Team structure, scheduling, and budgeting were also determined to have had influences on the project. This section includes these “Lessons Learned” with some suggestions on what to do differently.

9.1 SITE AND CONTAMINANT COMPOSITION CHARACTERIZATION

Naphthalene concentration. The pilot study area contained much higher concentrations of naphthalene than is typical for creosote. Baseline data collected in 2001 and 2002 from the pilot test area demonstrate this fact, however, the data were not completely analyzed prior to the start of the pilot study. Also, the physical and chemical characteristics of naphthalene were not well understood. A thorough understanding of the creosote composition, naphthalene characteristics, its distribution in the subsurface, and how it interacts with other components in the NAPL is needed prior to design and operations. A better understanding of the site conditions may have resulted in system design changes or helped to predict and/or address problems.

This problem has been solved at other creosote sites, such as the Alhambra, CA site where thermal treatment has been implemented. The vapors are kept above crystallization temperatures by insulation and heating of the manifold pipes. All the extracted naphthalene is conveyed to the thermal oxidizer for destruction in the vapor phase.

Hydrocarbon characterization. A significant fraction of the LNAPL is lighter end hydrocarbons. This fraction was not routinely tested for during site characterization activities leading up to and during the pilot study. A better understanding of what this light end is composed of and how it potentially will interact with PAH through the temperature ranges of interest during thermal remediation is needed to refine the design and operations strategy.

9.2 DESIGN

Several issues were identified related to the original design and design changes made during the pilot study that adversely affected the outcome of the pilot study. The following section includes details on how the sequencing of certain events could be improved to be more efficient and cost effective, as well as technical details about the pilot test area location, the sheet pile wall, the liquid and vapor extraction systems, the GWTP, and well and instrumentation spacing.

9.2.1 Schedule

Well Field Design. The original well field design was based on assumptions regarding aquifer hydraulic conductivity. After construction was started on the well field using the original design, a pumping test was completed on wells within the pilot study area, and a thermal multi-phase numerical model was run using these results. Modeling indicated that the well spacing (between injection and extraction wells) was at the maximum estimated to be effective for thorough heating and transfer of steam. Closer well spacing would have been better. Though no changes to the well spacing were deemed necessary, if changes had been necessary, it would have been costly to change the well spacing after construction had been partially completed since all of the 10-inch diameter wells were already installed. The pilot study itself would have determined if the well spacing was too far apart. The contract had optional bid items to add additional injection and extraction wells during the study.

Procurement. Procurement of materials and equipment (e.g., well screens) should not be initiated until after the design has been finalized.

Liquid and Vapor Extraction System. The design of the liquid and vapor extraction system should not be finalized until after the well field design has been completed. An even better lesson would be to conduct vacuum tests on the wells before designing the vacuum system. Maintaining a lag period in the schedule for the liquid and vapor extraction system design can prevent unnecessary reworking of the extraction design due to changes in the well field design.

9.2.2 Pilot Test Area Location

When attempting to determine from a pilot study if stringent remedial objectives can be achieved, the pilot test area must be isolated from the rest of the site and the contamination within the area must be treated. This is the most effective way to evaluate the success of the technology and ensure that the pilot test area will not have to be revisited during full-scale treatment. Because soil contamination and NAPL remain in the area upgradient of the pilot test area and within the sheet pile wall, recontamination of the treated area after steam injection activities are completed is expected. This will compromise evaluation of the ability of the system to reach project cleanup goals as well as the evaluation of the contribution of in-situ oxidation to the reduction of site contaminants. It was intended that this area would be re-treated during full scale operations.

A smaller-sized pilot area may have better matched the budget and still have been sufficient in size to establish design criteria for a larger-scale project. The pilot area needs to be big enough to collect data and not too large to increase the cost of operations. The pilot objectives would also need to be revised.

9.2.3 Sheet Pile Wall

The Frodingham sheet pile wall used to contain the pilot test area worked well in several respects:

- The installation procedure worked well and an intact wall was installed at the desired locations.
- Horizontal water flow was arrested/reduced substantially, allowing for some dewatering inside the pilot test area without significant horizontal recharge through the wall.
- Steam migration was effectively arrested by the wall, as evidenced by the low temperatures measured outside of the pilot test area.
- No negative effect of the steam injection on the wall integrity was observed, although steam was observed venting to the surface at one of the joints.
- The temperatures achieved in locations next to the sheet pile wall were as high or above pilot test volume average temperatures, indicating that the presence of the wall did not impede heating of the material next to it. This is consistent with the

Design Analysis thermal modeling results, and is favorable for full-scale operations, since the treatment efficacy next to the wall (close to the receptor) is important.

Other observations about the sheet pile wall include the following:

- Weep holes in the sheet pile were installed at the gravel surface. Recommend also installing additional weep holes at the liner elevation.
- The sealing of the barrier liner (membrane) to the sheet pile wall needs to be improved so there is no leakage of surface water into the vapor collection system.

This indicates that a sheet pile wall of this type will work well for containing steam (and contaminants) during full-scale treatment, without compromising the treatment efficiency.

9.2.4 Liquid and Vapor Extraction Systems

Vapor stream treatment system. The vapor stream treatment system should have adequately-sized air/liquid separators (i.e., knock-out tanks), condensate collection vessels, and transfer pumps. Other thermal projects have used a robust knock-out vessel equipped with a demister and level switches, designed specifically for condensate and with excess capacity to account for surges and fluctuations. The actual equipment installed relied on a wide vertical pipe to drop out the condensate before it reached the liquid ring vacuum pumps. The design did not have enough of a safety factor as it might have had with large condensate receiver tanks to handle a slug of water introduced into the vapor line, which by design should not have occurred, but most likely did occur.

Vapor extraction system. Vapor extraction system must be capable of handling relatively large quantities of condensate and preventing condensate from reaching the vacuum pump. The condensate collection system should have a high-level alarm located appropriately to provide enough time to shut down the vacuum pump if condensate accumulates faster than it can be removed. The Visalia SEE project used water-seal vacuum pumps, which are better able to accept water than oil-seal pumps without compromising their function.

Vapor extraction system gauges. To better understand the vapor collection in the subsurface, vacuum gauges should be installed on every branch of the system.

Heat exchangers. To account for crystallization and precipitation of naphthalene, two heat exchangers should be installed in a parallel configuration in the vapor extraction line. This would allow operation of one of the units to continue when the other unit must be taken off-line for steam cleaning. In addition, a temperature controlled system for removal of naphthalene along with the condensing of extracted vapors needs to be incorporated into any re-design.

Vapor cap. Integrity of the impermeable membrane (material compatibility, sealing of penetrations) in the vapor cap should be maintained to minimize infiltration of precipitation. A quality assurance plan to verify membrane integrity and complete grouting of all membrane penetrations should be implemented. A vacuum test should also be performed to verify that the membrane performs as needed based on the capacity of the selected vacuum pumps.

Liquid extraction line. Pneumatic pumps in the liquid extraction line need air-flow regulators.

Aboveground piping system. As constructed, the aboveground piping layout associated with the extraction pumps routed the exhaust lines outside the wellhead. During operations, rapid cooling of vapors in the exhaust line caused precipitation of PAH and fouling of the exhaust line. This resulted in significant degradation in pump performance and required frequent maintenance to correct. The manufacturer had recommended the exhaust line be inside the wellhead.

Cooling system. The capacity of the cooling system ended up being only 10% of the original design. This needs to be re-evaluated to make sure the system is robust enough.

Steam regeneration of carbon. The original design required a steam-generated carbon-adsorption system for use when the boiler was not in operation. There are issues with using the boiler for steam regeneration, which were eliminated if the thermal oxidizer were used in its place.

Material incompatibility. The chemical incompatibility between the seals and gaskets in the equipment and the wastewater constituents led to mechanical failure of the equipment on a daily basis. This issue required continuous maintenance and ultimately shut down the pilot.

9.2.5 Groundwater Treatment Plant

NAPL Removal System. The treatment system designed for dissolved-phase contaminants must be preceded by one or more processes for removal of NAPL. The Wyckoff system included a dissolved-air floatation tank (DAFT) to separate NAPL from dissolved-phase contaminants. The treatment plant also included a bioreactor along with a final activated carbon polishing step which were the principle dissolved-phase treatment processes. There are some questions regarding whether the DAFT was operating properly. Removal efficiencies for oil and grease were generally poor, and often highly variable. (The addition of polymer in the DAFT following the pilot study improved its operation.) Some of the interior piping in the DAFT was found to be corroded in the summer of 2003. Also, there were reports of build-up of naphthalene precipitate on interior surfaces of the DAFT and its cover. It is not known when (or how often) the interior of the DAFT was inspected, or whether the diffusers were operating properly.

Naphthalene Removal. Dissolved air floatation is generally recognized as being one of the best available processes for separating NAPL from the aqueous phase liquids. However, it is not clear if this process can be expected to adequately remove the naphthalene crystals that formed in the aqueous phase due to the extremely high naphthalene concentrations in the pilot test area.

The extremely high naphthalene levels might have been a temporary condition, which may have been because the project had only entered into the early stage of heat-up of the pilot test area. If the pilot study had continued according to plan, it is possible that the naphthalene-fouling problems would have dissipated when the site came up to temperature. After the site was at temperature, the DAFT might have been capable of providing adequate NAPL (and naphthalene) removal. Since the pilot study was discontinued before the site came up to temperature, the duration of the naphthalene-fouling problem and the relation to subsurface temperature remain largely unknown.

Treatment system capacity. An accurate evaluation of the true capacity of the existing treatment system should have been done prior to the start of the pilot study. Problems encountered here due to the lack of adequate treatment plant capacity could have been avoided by providing a separate temporary treatment system for the liquids extracted from the pilot test area.

Liquid conveyance system. Separate treatment and conveyance systems for the liquids from the pilot system and the FPA would have allowed determination of the amount of NAPL extracted from the pilot test area. However, these liquid conveyance systems were combined to have some control over the temperature of the water entering the treatment plant to minimize the risks to the microbial population.

Cooling capacity. The capacity of the effluent pipe down-gradient of treatment plant tank 303 to discharge the combined flow of treated water and non-contact cooling water was a constraint on the steam injection rates. The capacity of the cooling system needs to be adequate for the designed steam injection rate.

Oil/Water Separator. A properly-sized oil/water separator installed upstream of the DAFT would help in the DAFT performance.

9.2.6 Well and Instrumentation Spacing

Without having operated the pilot study at the design rates, any evaluation of how well the designed system would have worked will be inaccurate. However, the following observations are offered based on a holistic evaluation:

- The density of the subsurface temperature monitoring strings was sufficient to document the heating that occurred within the pilot test area. Vertical profiles and select transects and planar views were useful for the operators to make decisions and to follow the progress. Because this was a pilot study, the level of monitoring was higher than would normally be used during a full-scale implementation of the technology. Since the operations never proceeded to the later stages where the objective would be to heat the coolest areas, the full value of the high density of monitoring locations was not realized.

- During calculations of the energy balance for the pilot study volume, it was observed that the heat loss through the sheet pile could not be calculated based on a measured temperature gradient near the sheet-pile. If this is an objective, the line of thermocouples outside of and perpendicular to the sheet pile wall should be located closer to the wall and to each other.

- Seven of the first set of pressure transducers were lost due to damage during curing of the grout. Failure is believed to be the result of penetration of the transducer membrane by silica flour used in the grout. Determination of the failure mechanism has not been confirmed and would require excavation of the transducers. Replacement transducers were installed just before the pilot started in a way that prevented damage, and the density of the water level monitoring sensors was sufficient.

- The most appropriate spacing between injection and extraction wells for full-scale remediation could not be determined because the pilot study system was not operated at the design rates. However, several limitations to heating were noted:
    - Significant steam override of cooler fluids occurred.
    - Most heating was concentrated in the vadose zone, with only modest heating near the base of the aquifer.
    - Steam was observed to have different penetration depths and distances across the pilot test area, indicating that spatial variations in permeability control heat distribution.
    - The base of the water-bearing zone stayed relatively cool, which was partially attributed to upward flow of cold water through the aquitard. As a consequence, a smaller average well spacing, combined with an additional method for heating the base of the upper water-bearing zone and the upper part of the aquitard, would add confidence to the design, and allow for a more uniform and predictable heating than was observed during the pilot study.

Overall, the well and instrument spacing used for the pilot study were appropriate for the objectives. However, the full value was not realized due to the shortening of the test and operation at injection rates that were much lower than the design rates.

9.3 CONSTRUCTION AND EQUIPMENT

Well development. Wells should be thoroughly developed with several hours of vigorous surging until negligible sediment is removed even though they have filter packs.

Geo-membrane integrity. Holes were poked through the geo-membrane of the cap and may not have been completely sealed. Water infiltrating the cap and the vapor collection system may have been one reason for the inundation of the liquid ring vacuum pumps.

Contractor-requested design changes. Need design engineers to review any contractor-initiated design changes and be present during commissioning of the equipment to verify project was built as designed.

Equipment selection. Install only the equipment needed for the pilot test and do not prematurely anticipate moving on to full scale. Investing in the larger boiler used up part of the budget that could have been used to support some other aspects of the pilot study that were eliminated.

9.4 OPERATIONS

Shakedown period. Allow for a proper shakedown period and do not start operations until all equipment, including instrumentation, is installed, tested, and modified (if necessary). Testing equipment in isolation does not necessarily provide reliable indications of performance when all components of the system are operated together. Some instrumentation equipment, which had been deleted during the bidding period on the construction contract, was not purchased nor installed until after the pilot study had started.

Changing conditions. Initial operation of the system should be according to the management plan. A process should be developed for addressing changing conditions that includes Internal Technical Review staff and system designers to deal with conditions encountered in the field that necessitate changes.

Steam injection rate. Injecting steam at less than the maximum possible design rate has several significant disadvantages. Maximum horizontal steam flow (minimum override) requires maximum injection pressure, maximum vacuum, and maximum pumping rate. It is possible that there will be less PAH precipitation and encrustation at maximum capacities due to higher overall temperatures in the system. Design flows should be reached as quickly as possible. Costs of labor and expenses are the same regardless of level of operation, making reduced rate operations an inefficient use of money due to the less-than-maximum effort.

Vapor extraction. With the decreased vapor extraction system size, the vacuum should be reduced at the surface collectors, per design assumptions, so almost all of the vapor extraction is from the wells.

Thermal Oxidizer. The thermal oxidizer was needed on the project for the period when the boiler was not operating. Bringing the equipment to the project earlier than scheduled in lieu of burning the non-condensable vapors in the boiler may have eliminated any boiler stack emission issues.

Treating the aquitard. As previously noted in Section 8.3.2, a substantial upward water flow through the aquitard occurred during extraction in the northeast corner of the pilot area. This cooling will impede the treatment of the aquifer. Therefore, additional treatment of the aquitard may be required to successfully remove the contaminants.

9.5 MONITORING PROGRAM

9.5.1 Chemical Monitoring Data Needs And Methods

Monitoring plan. The monitoring plan for the system chemistry was too intense and at a micro-scale for the majority of the operations. The approach towards system performance monitoring needs to meet the data and timing needs of operations and performance assessment. For example, daily extraction well samples were unnecessary; biweekly samples likely would have been adequate, until closer to the end of the injection phase. As another example, while the TOC data clearly showed slugs of contaminants and were instrumental in diagnosing problems with the aeration basin, the instrument was too sensitive for its use during this test. Additionally, the timing of some of the monitoring efforts needs to be re-evaluated. For example, measuring natural attenuation parameters in hot extraction well water samples is unnecessary until after the steam injection phase has ended.

Equipment installation schedule. The pilot study was started before all monitoring equipment was installed and before methods for sample collection and analysis were finalized. For example, systems were never installed for measuring non-condensable gas flow and composition or stack emissions.

Review of monitoring system. The monitoring system should be reviewed and updated to include all parameters needed for daily performance monitoring and to evaluate the overall system performance after the completion of the pilot study. For example, better measurement methods need to be established for determining which contaminants are removed, how much, and in which phase. Additionally, if the in-situ degradation pathway is to be monitored, an analysis of what the potential breakdown products will be needs to be done and appropriate sample collection and analysis methods determined.

9.5.2 Automated Monitoring System

Geomation Operating Software (Intellution Fix). Due to the complexity of the iFix software, it is recommended that simpler options be considered on future projects. Geomation has one additional possibility on the market and is developing an easier interface software package that should be available for purchase. Neither of these options was available at the time of purchase of the equipment for this project.

Power Outages. The Geomation RTUs were AC powered and plugged into an adjacent GFI receptacle. The GFI would occasionally trip due to moisture intrusion. It would therefore be advantageous to have battery backup at the RTUs for future similar installations. A rechargeable battery is a standard option supplied by Geomation. Another way to handle the power outages would be to feed the power circuit for the RTUs from a panel inside the building with a GFI breaker to eliminate the nuisance tripping.

DTS Operating System. Communication between the controller and the PC would occasionally lock up, requiring someone to close and restart the software and/or reboot the controller. The graphics on the pc monitor would also occasionally not display properly. The display problem was solved by reconfiguring the video mode selection for pcAnywhere to compatibility mode. The communication problem was never solved even after swapping out the laptop twice. This problem appeared to be related to the Windows 98 operating system. The DTS operating software has now been upgraded to run under Windows 2000/XP, but has not been tested.

Additionally, by comparing the temperature in instrumentation boring T-7 it was noted that temperatures read by the DTS were about 3 °C higher than the temperatures read by the thermocouples. To verify this manual temperatures were taken with a portable probe in extraction well E-5 before it was sealed. The readings verified the 3 °C offset. Sensa explained that the calibration of the system could be modified to correct this, but it was never done. The offset was constant and independent of temperature so it was easy to correct for.

DTS versus Thermocouples (Geomation 3300). The USACE decided to operate two different subsurface temperature-monitoring systems at the Wyckoff site. One was composed of a series of thermocouples; the other was a DTS system using fiber optic technology. This decision was based on the fact that since the Wyckoff project was a pilot test site, it would be a good idea to test a promising new technology, DTS. The DTS worked very well except for the communication problem discussed above. Assuming this problem is solved with upgraded software, DTS is an excellent option for monitoring temperatures in future projects. The thermocouples and Geomation 3300 system also worked very well. Although the installation was more complex, it functioned almost perfectly. A few (6-10) thermocouple modules failed but were easily repaired or replaced. The main advantage of the system is that it is also capable of reading other types of instruments (i.e., 4-20mA, pulse counters, vibrating wire). Geomation 3300 systems also have the capability of communicating via radio to meet more complex site requirements. A combination of the two systems would be an ideal solution for future projects; DTS to monitor temperatures and Geomation 3300 to monitor everything else.

Silica Grout. The ITTAP panel recommended that silica grout be used in areas where steam would be injected. Seven of the pressure transducers failed when installed with silica grout. The use of standard grout or a sand filter pack around the transducer should be investigated to see if either are acceptable alternatives.

Pump Stroke Counters. The pump stroke counters on the extraction wells manufactured by Severn Trent did not function properly. Both the rotating dial and the digital output failed routinely.

9.5.3 Data Management

Automated data collection. This part of the project worked extremely well. Little lag time was noticed for those monitoring systems where data were generated automatically and managed by the USACE. Generally the daily process was completed in about an hour. The most time consuming task was the creation of the sections and slices showing temperature distributions in GMS.

Non-automated data collection. There was a lag time between data collection and posting to the web page. Data such as steam injection rates and well pumping rates were not transferred to the webpage fast enough for daily decision making, therefore, the data were compiled every morning and reported verbally to the team during the daily operations call. When data became available, it was posted, making the webpage more effective as an accessible data archive, but less effective as a real-time source of data. The manual nature of this data gathering was inefficient. Better data collection tools need to be designed for this part of the project.

Web page. Having data and communications logs posted to the project web page was an effective method for team communication.

9.6 TEAM STRUCTURE AND COMMUNICATION

Having an appropriate team structure and effective communication methods are vital to project success. Issues regarding team structure and communication surfaced during design and operations. During analysis of the results of the study, it was determined that these issues had had a strong influence on the project, beginning during the design phase and continuing throughout the implementation of the pilot study. Issues that were identified fell into four main categories: team continuity, the right resource for the job, the decision making process, and the problem resolution process. This section includes recommendations on characteristics of a team that should be considered when implementing a pilot study.

When utilizing a complex, innovative technology such as steam injection, technical people who are experienced with the technology should be utilized throughout the project. Utilizing the experience and expertise of these people will reduce the time needed for design, will increase the efficiency of the operation, and will likely reduce the overall costs. For continuity through the project life cycle, managers, system designers, outside technical advisors, and lead technical staff should be involved through design, construction and operations. The team should maximize the use of industry expertise, project knowledge and hard-won field experience in its team membership.

To implement a highly technical study, resources with the appropriate knowledge and skill set should be selected and retained for the life cycle of the project. The requirements for each project role should be defined early in the project and individuals should be selected to best fit those roles. When appropriate resources are not available within present staff, outside resources should be investigated.

The team should be structured in a way that allows decisions to be made at the appropriate level. Major design changes and cost issues should be raised to appropriate management prior to decision-making. Effort should be made to minimize bottlenecks in decision making so day-to-day decisions can be made in a timely manner. Major decisions affecting design, construction, and operations should involve and be approved by the system designers. Once decisions are made, they should be accepted by the entire team, unless changing conditions require re-analysis of the decision.

A problem and/or conflict resolution process should be established to resolve issues in a timely manner. Communication channels should be open so ideas from all team members will be heard, discussed, and acted upon as necessary. Failure to resolve issues in a timely manner leads to internal team dissension and lack of clarity on the goals of the project. In this situation, goals should be re-visited with appropriate management to reach agreement prior to proceeding with the project.

9.7 SCHEDULE AND BUDGET

- The project schedule and budgets should be based on the anticipated level of effort needed to complete the scope of work and meet the project objectives.
- Field investigation work should be completed before the design is started.
- The project schedule should account for adequate time to test, and modify if needed, all new equipment prior to starting the official pilot study.
- Schedule and budget demands should not restrict the ability of the project team to raise and resolve issues effectively.
- Due to the inherent uncertainty in implementing the pilot study, a contingency plan should have been in place to cover schedule changes and potential increases in project costs.

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Tables

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TABLE 3.2-1 PHYSICAL CHARACTERISTICS AND THERMODYNAMIC PROPERTIES OF SOIL SAMPLES

		T-1	T-22	T-30
		6-7 ft bgs	13.5-14 ft bgs	22-22.5 ft bgs
		Silty sand & silt	Clay	Sand
Porosity (%)	Total	30.8	50.5	28.6
	Effective	2.39	9.27	23.67
Specific retention		92.23	81.65	17.17
Bulk density (g/cc)	Before TC	2.066	1.663	2.082
	After TC	2.187	1.753	2.146
Thermal Conductivity (BTU/hr-ft-^{o}F)	at 30 ^{o}C	0.7186	0.5964	0.5114
	at 60 ^{o}C	0.7848	0.6640	0.6188
	at 90 ^{o}C	0.8458	0.7531	0.6976
	at 120 ^{o}C	0.8635	0.7717	0.7503
Specific heat capacity (BTU/lb-^{o}F)	at 30 ^{o}C	0.399	0.382	0.334
	at 60 ^{o}C	0.307	0.290	0.236
	at 90 ^{o}C	0.281	0.280	0.265
	at 120 ^{o}C	0.338	0.306	0.282

Notes:
bgs – below ground surface
TC – thermal conductivity analysis

TABLE 3.5.1 EXTRACTION WELL BASELINE CHARACTERIZATION SAMPLING RESULTS

Analyte Name	GW Cleanup Level	E-1 (11/7/02)	E-2 (11/7/02)	E-3 (11/7/02)	E-4 (11/5/02)	E-4 (11/7/02)	E-5 (11/7/02)	E-6 (11/5/02)	E-6 (11/7/02)	E-7 (11/7/02)
Naphthalene	83	**2300** J	**1700** J	**2900** J	**882**	**430** J	2 J	0.39 U	**1100** J	**1400** J
2-Methylnaphthalene		400 J	27 J	360 J	46.7	51 J	5 UJ	0.012 J	110 J	1000 J
Acenaphthylene		500 UJ	25 UJ	10 UJ	2.7	5 UJ	5 UJ	0.39 U	5 UJ	33.5 UJ
Acenaphthene	3	280 J	300 J	250 J	180	260 J	40 J	0.071 J	180 J	380 J
Anthracene	9	500 UJ	19 J	15 J	10.2	100 UJ	5 UJ	0.29 J	100 UJ	51 J
Phenanthrene		130 J	120 J	150 J	102	100 J	5 UJ	0.084 J	75 J	370 J
Fluoranthene	3	500 UJ	11 J	300 UJ	16	11 J	3 J	0.24 J	100 UJ	82 J
Pyrene	15	500 UJ	250 UJ	5 J	7.4	100 UJ	1 J	0.17 J	100 UJ	53 J
Benzo(a)anthracene	0.0296	500 UJ	25 UJ	10 UJ	0.43 U	5 UJ	5 UJ	0.39 U	5 UJ	11 J
Chrysene	0.0296	500 UJ	25 UJ	10 UJ	**0.34** J	5 UJ	5 UJ	0.39 U	5 UJ	10 J
Benzo(a)pyrene	0.0296	500 UJ	25 UJ	10 UJ	0.39 U	5 UJ	5 UJ	**0.032** J	5 UJ	33.5 UJ
Benzo(b)fluoranthene	0.0296	500 UJ	25 UJ	10 UJ	**0.081** J	5 UJ	5 UJ	0.39 U	5 UJ	33.5 UJ
Benzo(k)fluoranthene	0.0296	500 UJ	25 UJ	10 UJ	0.39 U	5 UJ	5 UJ	0.39 U	5 UJ	33.5 UJ
Benzo(g,h,i)perylene		500 UJ	25 UJ	10 UJ	0.39 U	5 UJ	5 UJ	0.39 U	5 UJ	33.5 UJ
Indeno(1,2,3-cd)pyrene	0.0296	500 UJ	25 UJ	10 UJ	2 U	5 UJ	5 UJ	2 U	5 UJ	33.5 UJ
Dibenzo(a,h)anthracene	0.007	500 UJ	25 UJ	10 UJ	0.78 U	5 UJ	5 UJ	0.78 U	5 UJ	33.5 UJ
Pentachlorophenol	4.9	65 UJ	650 UJ	750 UJ	0.78 U	12.5 UJ	12.5 UJ	0.58 J	22 J	85 UJ

Notes:
Concentrations in µg/L
Bold indicates detected concentration exceeds Groundwater Cleanup Level

TABLE 3.5-2 UPPER AQUIFER BASELINE CHARACTERIZATION GROUNDWATER SAMPLING RESULTS

Analyte Name	**GW Cleanup Level**	**MW17 (11/7/2002)**	**MW18 (11/7/2002)**	**MW18 Dup (11/7/2002)**	**MW19 (11/6/2002)**
Naphthalene	83	**2940**	**12600**	**12800**	13.6
Naphthalene, 1-methyl-		166	779	800	0.74
Naphthalene, 2-methyl-		50.1	1080	1100	0.91
Acenaphthylene		3.2	9.8	8.9	0.079J
Acenaphthene	3	**247**	**291**	**300**	0.35J
Anthracene	9	**10.2**	**13.8**	**12.7**	0.56
Phenanthrene		36.7	102	101	0.097J
Fluoranthene	3	**19.1**	**9.4**	**9.1**	0.19J
Pyrene	15	8.9	4.9	4.9	0.2J
Benzo(a)anthracene	0.0296	**0.87**	0.71U	**0.76**	0.37U
Chrysene	0.0296	**0.66**	**0.63**	**0.68**	**0.17**J
Benzo(a)pyrene	0.0296	**0.25**J	**0.18**J	**0.21**J	**0.15**J
Benzo[b]Fluoranthene	0.0296	**0.34**J	**0.31**J	**0.35**J	**0.28**J
Benzo[k]fluoranthene	0.0296	**0.15**J	**0.13**J	**0.11**J	**0.075**J
Benzo(g,h,i)perylene		0.079J	0.39U	0.056J	0.12J
Indeno(1,2,3-cd)pyrene	0.0296	**0.086**J	2U	**0.062**J	**0.13**J
Dibenzo[a,h]anthracene	0.007	0.74U	0.78U	0.77U	0.74U
Pentachlorophenol	4.9	0.59J	**1930**	**1920**	1.2

Notes:

Concentrations in µg/L

Bold indicates detected concentration exceeds Groundwater Cleanup Level

TABLE 3.5-3 LOWER AQUIFER BASELINE CHARACTERIZATION GROUNDWATER SAMPLING RESULTS

Analyte Name	GW Cleanup Level	CW05 (11/6/2002)	CW09 (11/6/2002)	CW15 (11/6/2002)	MW02 (11/7/2002)	MW04 (11/7/2002)	CW05 Dup (11/6/2002)
Naphthalene	83	0.49	8.6	**98.8**	0.38U	0.37U	0.55
Naphthalene, 1-methyl-		0.17J	1.1	16.4	0.38U	0.37U	0.16J
Naphthalene, 2-methyl-		0.23J	0.22J	10.1	0.38U	0.37U	0.21J
Acenaphthylene		0.36U	0.37U	0.36J	0.38U	0.37U	0.38U
Acenaphthene	3	0.43	1.3	**41.3**	0.021J	0.37U	0.35J
Anthracene	9	0.19J	0.21J	2.7	0.38U	0.034J	0.22J
Phenanthrene		1.1	2	38.9	0.38U	0.02J	0.85
Fluoranthene	3	1.4	0.98	**9.6**	0.11J	0.039J	1.6
Pyrene	15	0.76	0.61	5.2	0.12J	0.37U	0.94
Benzo(a)anthracene	0.0296	0.36U	0.37U	**1.2**	0.38U	0.37U	0.38U
Chrysene	0.0296	**0.054**J	**0.16**J	**0.96**	0.38U	0.37U	**0.1**J
Benzo(a)pyrene	0.0296	0.36U	**0.045**J	**0.2**J	0.38U	0.37U	0.38U
Benzo[b]Fluoranthene	0.0296	0.36U	**0.084J**	**0.41**	0.38U	0.37U	0.38U
Benzo[k]fluoranthene	0.0296	0.36U	**0.032**J	**0.14J**	0.38U	0.37U	0.38U
Benzo(g,h,i)perylene		0.36U	0.37U	0.046J	0.38U	0.37U	0.38U
Indeno(1,2,3-cd)pyrene	0.0296	1.8U	1.9U	1.9U	1.9U	1.9U	1.9U
Dibenzo[a,h]anthracene	0.007	0.73U	0.74U	0.74U	0.75U	0.74U	0.75U
Pentachlorophenol	4.9	0.73U	0.95	0.54J	0.52J	0.74U	0.75U

Notes:
Concentrations in µg/L
Bold indicates detected concentration exceeds Groundwater Cleanup Level

TABLE 4.1-1 DESIGN CRITERIA SUMMARY

System, Process or Parameter	Original Design	Redesign
Treatment Duration	Eight to 14 months of active steam injection, followed by contaminant extraction for six to eight months	Six to eight months (with an optional two-month steam injection period) followed by contaminant extraction for six months (plus a two-month optional period)
Steam injection pressure	0.5 psi per foot of soil above the center of the injection screen	Unchanged
Extraction well vacuum	7.3 psi (0.5 atm)	3.7 psi. (0.25 atm)
Vapor collector vacuum	1 psi	0.2 psi.
Well field arrays	Well field arrays should cover the entire NAPL-contaminated portion of the Pilot Test Area, with the southern-most (upgradient) injection wells outside the NAPL area. Included 25 injection wells and 16 extraction wells.	The southernmost row of arrays was eliminated leaving 16 injection wells and seven extraction wells
Average maximum steam injection rate	2 gpm liquid equivalent (l.e.) per well (1000 lb/hr).	Unchanged
Total steam requirement	44 gpm l.e. (22,000 lb/hr)	32 gpm l.e. (16,000 lb/hr).
Average liquid extraction rate	5 gpm per extraction well, for total of 45 gpm	Unchanged per well but with a total of 25 gpm
Average condensable vapor extraction rate	1.2 gpm l.e. per well (640 lb/hr), for a total of 16.2 gpm l.e. (7,780 lb/hr)	Unchanged
Non-condensable gas (primarily air) flow rate	350 scfm, about 40% of which was vapor cap leakage recovered from surface vapor collectors.	250 scfm with only 13% from surface vapor collectors.
Total enthalpy of extracted gas	50% to 100% of injected enthalpy (ITTAP recommended that 30% be used for design purposes)	10%

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Table 4.2-1 Liquid Conveyance and Treatment System

Equipment [1]		Design Analysis	Contract	Initial Installation	Final Installation	Impacts on Pilot[2]
Liquid Conveyance						
Extraction well pumps	EWP1 (DNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No impact
	EWP2 (LNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Optional item, 11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Not installed		Delayed LNAPL recovery
	EWP3 (DNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No impact
	EWP4 (LNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Optional item, 11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Not installed		Delayed LNAPL recovery
	EWP5 (DNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No impact
	EWP6 (LNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Optional item, 11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Not installed		Delayed LNAPL recovery
	EWP7 (DNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No impact
	EWP8 (LNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Optional item, 1 gpm, 0.275 gal pump stroke, Blackhawk pump	Not installed		Delayed LNAPL recovery
	EWP9 (DNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	11 gpm, 0.275 gal pump stroke, Blackhawk pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No testing of different pump performance could occur
	EWP10 (LNAPL)	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump	Optional item, 1 gpm, 0.275 gal pump stroke, Blackhawk pump	Not installed		Delayed LNAPL recovery
	EWP11 (DNAPL)	11 gpm, 0.275 gal pump stroke, Blackhawk pump	11 gpm, 0.275 gal pump stroke, Blackhawk pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No testing of different pump performance could occur
	EWP12 (LNAPL)	11 gpm, 0.275 gal pump stroke, Blackhawk pump	Deleted			Delayed LNAPL recovery
	EWP13 (DNAPL)	11 gpm, 0.275 gal pump stroke, Blackhawk pump	Renamed EWP12, 11 gpm, 0.275 gal pump stroke, Blackhawk pump	11 gpm, 0.275 gal pump stroke, QED Hammerhead pump		No testing of different pump performance could occur

Table 4.2-1 Liquid Conveyance and Treatment System

Equipment [1]		Design Analysis	Contract	Initial Installation	Final Installation	Impacts on Pilot[2]
	EWP14	11 gpm, 0.275 gal pump stroke, Blackhawk pump	Deleted			Inability to test pump performance at these site conditions
	EWP15	11 gpm, 0.275 gal pump stroke, Blackhawk pump				
	EWP16	11 gpm, 0.275 gal pump stroke, Blackhawk pump				
	EWP17	11 gpm, 0.275 gal pump stroke, Blackhawk pump				
	EWP18	11 gpm, 0.275 gal pump stroke, Blackhawk pump				
	EWP19	11 gpm, 0.275 gal pump stroke, Blackhawk pump				
Air compressors	RSAC-1 (for extraction well pumps)	89 CFM delivery, 100 psig, 20 hp (with 100 SCFM air dryer)	89 CFM delivery, 100 psig, 20 hp (with 100 SCFM air dryer)	80 CFM, 125 psig, 20 hp (with 100 SCFM air dryer)		No impact
	RSAC-2 (backup)	89 CFM delivery, 100 psig, 20 hp (with 100 SCFM air dryer)	Deleted			No impact on pilot; however no backup
Piping from well field		3-inch to 2-inch main line	3-inch main line			No impact
Liquid Treatment						
Treatment Plant Feed Pumps	TPFP-1	78.5 gpm, 55 ft head, 2 hp Grundfos TP50-240 ODP	78.5 gpm, 55 ft head, 2 hp Grundfos TP50-240 ODP	78.5 gpm, 125 ft head, 5 hp, TACO VM0202B		No backup. Material imcompatibility in seals exists. Installed pump has no alternative seals available.
	TPFP-2 (backup)	78.5 gpm, 55 ft head, 2 hp Grundfos TP50-240 ODP	Deleted			
	TPFP-3	20 gpm, 49 ft head, 0.75 hp Grundfos CR8-20/IU ODP	20 gpm, 49 ft head, 0.75 hp Grundfos CR8-20/IU ODP	20 gpm, 180 ft head, 0.75 hp TACO VM0202B		No backup. Material imcompatibility in seals exists. Installed pump has no alternative seals available.
Heat Exchangers (Plate and Frame type)	HX-1	2.5 MBTU/hr	50 gpm, both sides	50 gpm, both sides; EPDM gaskets	50 gpm; EPDM gaskets	Material incompatibility resulted in a bypass around equipment
	HX-2	2.5 MBTU/hr	50 gpm, both sides	50 gpm, both sides; EPDM gaskets	50 gpm; EPDM gaskets	

Table 4.2-1 Liquid Conveyance and Treatment System

Equipment[1]	Design Analysis	Contract	Initial Installation	Final Installation	Impacts on Pilot[2]
Cooling tower	Wet induced draft, 425 gpm	Deleted			Limited the ability to use less groundwater and reduced ability to reject heat; however no impact on the pilot.
Float skimmer	Retrofitted at tank T-401	Deleted			No impact
Dissolved air flotation tank (Replaced depurator)	New unit downstream of T-401	New unit, 120 gpm capacity, 85 sf floatation area with recycle	120 gpm capacity, 85 sf flotation area with recycle		No impact
Additional bioreactor	Convert existing clarifier by adding spargers	Deleted			Reduced treatment capacity
Dissolved air flotation tank (DAF-205)	New unit, downstream of additional bioreactor	Deleted			Reduced treatment capacity
Caustic chemical tank	1000 gallons (auto feed)		1000 gallons (manual feed)		Not used therefore no impact. However, manual operation would have required additional labor
Acid chemical tank	500 gallons (auto feed)		500 gallons (manual feed)		Not used therefore no impact. However, manual operation would have required additional labor
New Piping w/in Treatment Plant	85 ft HDPE piping between T-402 and aeration basin (T-203)	85 ft HDPE piping between T-402 and aeration basin (T-203)	85 ft HDPE piping between T-402 and aeration basin (T-203)		No impact
New Multimedia filter (T-206C)	6-ft. diameter	Deleted			Reduced treatment capacity
Tank T-303	Replaced with new tank (damaged in 2/28/01 earthquake)	Repaired			No impact
Flow Measurement					
Flow meters	19 in extraction wells	13 in extraction wells (stroke counters)	7 in extraction wells (stroke counters)		Stroke counters not as accurate as flow meters
	None specified for product tank	1 at inlet to product tank	1at inlet to product tank		No impact
	1 in Condensate line	None specified	1at HX-1 and HX-2 outlet; 1 at HX-3 condensate		No impact

1: Equipment in process order except for flow meters

2: Impacts shown are due to design changes throughout project and not by impacts due to site conditions

Table 4.2-2 Steam Generation and Conveyance System

Equipment [1]		**Design Analysis**	**Contract**	**Initial installation**	**Final Installation**	**Impacts on Pilot**[2]
Steam Generation						
Water Well Pump (DWP-1)		400 gpm, 500 head, 5 in diameter column, 75 hp	400 gpm, 200 head, 5 in diameter column, 200 ft setting depth in well, 30 hp	225 gpm, 200 head, 4 in diameter column, 215 ft setting depth in well, 30 hp		No impact
Deaerator Feed Pumps	DFP-1	109 gpm, 92 ft head, 5 hp, Grundfos HS150 5050 ODP	Deleted			No backup; No impact on pilot
	DFP-2	50 gpm, 77ft head, 2 hp, Grundfos CR8-2OU	50 gpm, 77ft head, 2 hp, Grundfos CR8-2OU	80 gpm, 180 ft head, 7.5 hp, TACO VM0603B		Operational problems due to oversize pump (increased labor for operation and maintenance)
	DFP-3	10 gpm, 36 ft head, 0.5 hp, Grundfos CR2-20/IU ODP	10 gpm, 36 ft head, 0.5 hp, Grundfos CR2-20/IU ODP	80 gpm, 180 ft head, 7.5 hp, TACO VM0603B		Operational problems due to oversize pump (increased labor for operation and maintenance)
Feed Water Softeners	Tank size	36X70 in.	36x72 in.	36x60 in.		No impact
	SFT-1	100 gpm and 8 psi drop at continuous flow	97 gpm and 15 psi drop at continuous flow.	175 gpm and 15 psi drop at continuous flow.		No impact
			125 gpm and 25 psi drop at peak flow.	250 gpm and 25 psi drop at peak flow.		
	SFT-2	100 gpm and 8 psi drop at continuous flow	97 gpm and 15 psi drop at continuous flow.	175 gpm and 15 psi drop at continuous flow.		No impact
			125 gpm and 25 psi drop at peak flow.	250 gpm and 25 psi drop at peak flow.		
	Brine tank	39x48 in tank; 2500 lb salt capacity	39x48 in tank; 2050 lb salt capacity	39x60 in tank; 1900 lb salt capacity		No impact
Deaerator		25,000 lbs/hr rating, 600 gal tank, 3714 lbs/hr steam flow				No impact
Air compressors	BAC-1 (for boiler)	Air deliver and pressure as needed, 7.5 hp	Air deliver and pressure as needed, 7.5 hp	177 CFM, 125 psig, 40 hp		Excessive operator time to maintain performance; needed redesign
	BAC-2 (backup)	Air deliver and pressure as needed, 7.5 hp	Deleted			No impact; however no backup

Table 4.2-2 Steam Generation and Conveyance System

Equipment [1]		Design Analysis	Contract	Initial installation	Final Installation	Impacts on Pilot[2]
Boiler Feed Pumps	BFP-1	50 gpm, 160 ft head, 5 hp Grundfos CR8-4OU ODP	50 gpm, 160 ft head, 5 hp Grundfos CR8-4OU ODP	84 gpm, 227 ft head, 7.5 hp, EPDM O-rings, Grundfos CR16-4OU ODP		Operational problems due to oversize pump (increased labor for operation and maintenance)
	BFP-2	10.6 gpm, 181 ft head, 1.5 hp Grundfos CR2-5OU ODP	Deleted			No impact
	BFP-3	50 gpm, 160 ft head, 5 hp Grundfos CR8-4OU ODP	10.6 gpm, 181 ft head, 1.5 hp Grundfos CR2-5OU ODP	84 gpm, 227 ft head, 7.5 hp, EPDM O-rings, Grundfos CR16-4OU ODP		Operational problems due to oversize pump (increased labor for operation and maintenance)
Boiler		25,000 lb/hr	800 hp, 27,600 lb/hr, 86% efficiency	800 hp, 27,600 lb/hr, 86% efficiency		No impact
Steam Conveyance						
Piping to well field		6-inch to 3-inch black steel, insulated	6-inch to 5-inch black steel, insulated	6- inch black steel, insulated		No impact
Expansion Joints		47, 3-inch to 8-inch diameter.	35, 3-inch to 6-inch diameter	12, 3-inch to 6-inch diameter		No impact
Flow Measurement						
Flow meters		25 at injection wellheads	16 at injection wellheads (automated averaging pitot tubes);	16 at injection wellheads (manual combination calibrated flow valves)		Increased time for labor to read and record.
		None specified at boiler inlet	1 at boiler inlet (Water into boiler) (averaging pitot tube)	1 at boiler inlet (automated meter on water softening sytem; however was not calibrated during pilot)		No accurate measure of water flow to boiler
		None specified at boiler outlet	1 at boiler outlet (steam to injection wells) (pressure compensated differential pressure or orifice plate)	1 at boiler outlet (orifice plate - could not calibrate during pilot and therefore not used)		No accurate measure of steam flow from boiler

1: Equipment in process order except for flow meters

2: Impacts shown are due to design changes throughout project and not by impacts due to site conditions

Table 4.2-3 Vapor Treatment System

Equipment[1]		**Design Analysis**	**Contract**	**Initial installation**	**Final Installation**	**Impacts on Pilot**[2]
Vapor cap						
Vapor collection layer		8-inch gravel layer with a 6-inch protective soil layer	8-inch gravel layer with a 6-inch protective soil layer	8-inch gravel layer with a 6-inch protective soil layer		Unknown impact; Excessive perforation in vapor barrier; Because no soil partitions constructed, no experimentation of vapor extraction rates occurred.
Vapor collector laterals		4-inch diameter slotted steel pipe	3-inch diameter slotted steel pipe	4-inch diameter slotted steel pipe		
Vapor barrier		HDPE geomembrane with a 12-inch protective soil layer above geomembrane	HDPE geomembrane with 12-inch layer of select fill above geomembrane	HDPE geomembrane with 12-inch layer of select fill above geomembrane. Geomembrane perforated due to instrument and well installation occurring after vapor barrier placement		
Vapor cap partitions		Soil partition cells	Soil partition cells	Not installed		
Vapor conveyance						
Piping from well field		8-inch to 6-inch main, black steel with insulation	6-inch black steel with no insulation; piping sloped toward each pipe support	6-inch black steel with no insulation; piping sloped toward one low point resulting in concurrent flow of condensate and vapor.		The combination of a single low point, a single over-sized condensate pump, and the pipe sloping in the vapor conveyance system allowed vapor line to fill with water which entered vapor treatment system.
Vapor Line Condensate Receiver		4 at drip legs at main pipe anchors	4 at drip legs at main pipe anchors	1 at drip leg in vapor main (low point) near boiler building		
Condensate pump	PDP-1, vapor extraction main	4, 0.5 gpm at 50 psi head, 0.5 hp	4, Positive Displacement Pumps; 0.5 gpm, 50 psi head, 0.5 hp	1, Centrifugal pump; 15 gpm, 18 psi head, 0.33 hp		
Oil Sealed Liquid Ring Vacuum Pumps	LRVP-1	450 ACFM capacity, 25 hp	450 ACFM capacity, 25 hp	450 ACFM capacity, 25 HP, EPDM seals	450 ACFM capacity, 25 HP, Teflon seals (Seals replaced after pilot)	Material incompatibility impacted pump performance
	LRVP-2	450 ACFM capacity, 25 hp	450 ACFM capacity, 25 hp (became backup)	450 ACFM capacity, 25 HP, EPDM seals	450 ACFM capacity, 25 HP, EPDM seals	Not operated during pilot; no impact
	LRVP-3 (backup)	450 ACFM capacity, 25 hp	Deleted			No impact; however no backup
Condensate pump	PDP-3, vacuum pump header	1, 0.5 gpm at 50 psi head, 0.5 hp	1, Positive Displacement Pumps; 0.5 gpm at 50 psi head, 0.5 hp	Not installed (piping configuration revised eliminating this pump)		Unknown impact; the addition of this pump could have prevented liquid from entering the vacuum pump
LRVP condensate receiver (drains LRVP filters)		Not in original design		Not installed	15 gal tank; 10 gpm @ 25 ft head (installed after pilot)	Unknown impact

Table 4.2-3 Vapor Treatment System

Equipment[1]		**Design Analysis**	**Contract**	**Initial installation**	**Final Installation**	**Impacts on Pilot**[2]
Vapor Treatment						
Heat Exchangers	HX-3	2.5 MBTU/hr	Plate and Frame or Shell and Tube Type, 50 gpm liquid side, 2,500 lb/hr vapor side	Plate and Frame Type, 50 gpm liquid side, 2,500 lb/hr vapor side, EPDM gaskets	Shell and Tube type, 50 gpm liquid side, 2,851 lb/hr vapor side (installed after pilot study ended)	The following contributed to the eventual vapor system shut down: Liquid in the vapor system; Material incompatibility in the heat exchanger and pumps; condensate tank too small for plate and frame type heat exchanger.
	HX-4 (backup)	2.5 MBTU/hr	Deleted			
Condensate pump	PDP-2, heat exchanger (HX-3)	2, 30 gpm, 50 psi head, 3 hp	2, Positive Displacement Pumps; 30.0 gpm, 50 psi head, 3.0 hp	2, Centrifugal pumps; 30.0 gpm, 100 psi head, 1.5 hp (these pumps became named CP-2A and CP-2B)		
HX-3 condensate tank		2 ft x2 ft x2 ft (60 gal) tank	2 ft x2 ft x2 ft (60 gal) tank (initially to be used as a condensate receiver)	15 gal tank; 10 gpm @ 25 ft head	30-inch diameter x 48-inch length (47 gal) steel vacuum rated (installed after pilot - to be used as a separator (knockout tank))	
Vapor GAC sorber		Steam regenerated. Used only when boiler is not in operation.	Deleted			No impact
Thermal Oxidizer (replaced GAC sorber)		Not in original design		250 SCFM (not operated during pilot)	250 SCFM (installed after pilot)	No impact
Flow Measurement						
Flow meters		14 at extraction wells	8 at extraction wells (flow calculated from pressure differentials from pressure valves);1 at EW-4 (automated averaging pitot tube);	7 at extraction wells (flow calculated from pressure differentials from pressure valves - not installed) ; 1 at EW-4 (automated averaging pitot tube);		No flow information available during pilot
		8 at vapor cap branch	8 at vapor cap branch (TASCO flow control valves);	8 at vapor cap branch (TASCO flow control valves)		No impact
		1 for non-condensable gases	1 at HX-3 inlet (calibrated combination flow control valve); 1 at HX-3 outlet (calibrated combination flow control valve)	1 at HX-3 inlet (averaging pitot tube); 1 at HX-3 outlet (averaging pitot tube) (HX-3 meters were installed after pilot; not calibrated.)		No flow information available during pilot

1: Equipment in process order except for flow meters

2: Impacts shown are due to design changes throughout project and not by impacts due to site conditions

ACRONYMS used in Tables 4.2-1 through 4.2-3	
acfm	Actual cubic feet per minute
BAC	Boiler air compressor
BFP	Boiler feed pump
cfm	Cubic feet per minute
DFP	Dearator feed pump
DNAPL	Dense non-aqueous phase liquid
DWP	Deep water pump
EPDM	Ethylene propylene diamine monomer
EW	Extraction well
EWP	Extraction well pump
GAC	Granular activated carbon
gal	Gallons
gpm	Gallons per minute
HDPE	High density polyethylene
hp	Horsepower
HX	Heat exchanger
LNAPL	Light non-aqueous phase liquid
LRVP	Liquid ring vacuum pump
MBTU/hr	Million British Thermal Units/hr
ODP	Open drip proof
PDP	Positive displacement pump
psi	Pounds per square inch
RSAC	Rotary screw air compressor
scfm	Standard cubic feet per minute
sf	Square feet
SFT	Softener
TPFP	Treatment plant feed pump
NOTE: Acronyms not defined here are manufacturer names	

TABLE 4.2-4 MASS-AVERAGED COMPONENT PROPERTIES AT 25° C

Component group	Solubility (mg/L)	Vapor pressure (Pa)
LPAH[1]	2910	14
HPAH[2]	2	3
Aliphatic	52	47

[1] Light Polycyclic Aromatic Hydrocarbons - Includes the substituted-PAH compounds.

[2] Heavy Polycyclic Aromatic Hydrocarbons

TABLE 4.3-1 PILOT AREA WELL FIELD AUTOMATED MONITORING SUMMARY

Media	Locations	Parameter	Frequency	Implemented?
Subsurface Soil	Injection Wells (16)	Temperature (Thermocouples)	Automated Collected continuously Stored daily	Yes
	Instrument Strings (55)			
	Extraction Wells (7)	Temperature [Fiber optic Distributed Temperature Sensor (DTS) System]	Automated Collected continuously Stored daily	Yes
	Instrument Strings (10)			
	Instrument Strings (1)	Temperature (Thermocouples and DTS)	Automated As above for thermocouples and DTS	Yes
Groundwater	Instrument Strings (9) – Not co-located with DTS or Thermocouples	Water Level (Vibrating Wire Pressure Transducer)	Automated Collected continuously Stored daily	Yes
	Extraction Wells (7)	Water Level (Vibrating Wire Pressure Transducer)	Automated Collected continuously Stored daily	Yes
		Flow (Stroke Counters)	Automated Strokes counted & stored hourly Flow calculated & stored daily	Yes

TABLE 4.3-2 INJECTION AND EXTRACTION SYSTEM MONITORING SUMMARY

Media	Locations	Parameter	Frequency	Implemented?
Steam	Injection Wells (16)	Pressure/Flow (Pressure gauges around orifice valve)	Daily	Yes
	From boiler to injection wells	Temperature	Daily	Yes
		Pressure/Flow (Orifice plate)	To be Daily, but readings unreliable	Yes
Extracted vapor	Extraction Wells (7)	Pressure/Flow (Pressure gauges around orifice valve)	Daily	No
	Vapor Cap Branch	Pressure/Flow (Pressure gauges around orifice valve)	Daily	Yes
	Vapor inlet to HX-3	Pressure/Flow (Pitot tube)	Daily	Yes
	Vapor outlet from HX-3	Pressure/Flow (Pitot tube)	Daily	Yes
		Temperature	Daily	Yes
Condensed liquid	Condenser	Total condensate production	Daily	No
	Vapor line and HX-3 drip leg condensate	Combined flow (flow meter)	Daily	No
	HX-3 condensate to GWTP	Flow (flow meter)	Daily	No
	Condenser (HX3)	Temperature drop across	Daily	Yes
Non-condensable gases	Between the heat exchangers and the vapor treatment system	PAH, PCP, total hydrocarbons, CO2 and O2	Weekly	No

Media	Locations	Parameter	Frequency	Implemented?
Extracted liquid	Combined liquid line in boiler building before the condenser	Total Organic Carbon	Automated (Originally every 20 minutes; changed to every 30 minutes and then every hour)	Yes
Extracted liquid	Extraction wells (7)	Flow (Stroke Counter)	Daily	Yes
		Semivolatile organics	Daily	Yes
		Dissolved Oxygen and Carbon Dioxide	Daily	Yes
		Temperature	Daily	Yes
	Inlet to Product Tank in boiler building	Flow (Flow meter)		Yes
	Outlet of HX-1, HX-2 to GWTP	Flow (Flow meter)		Yes
	Inlet/outlet HX-1/HX-2	Temperature		Yes

TABLE 4.3-3 TREATMENT SYSTEM MONITORING SUMMARY

Media	Locations	Parameter	Frequency	Implemented?
NAPL	Product Tanks: T-105 and T-108	Volume	Weekly	Yes
Treatment Plant	SP-0: Treatment Plant Inlet	Oil & Grease	Weekly	Yes
	SP-1: Equalization Tank (T-401) Outlet	PAH/PCP	Weekly	
	SP-3: DAF-104 Outlet	Oil & Grease	Weekly	
	SP-4: T-402 Effluent	PAH/PCP	Weekly	
		Temperature	Daily	
		Mass Flow Rate	Daily	
	SP-5: Aeration Tank (T-203)	ML TS & VS	Weekly	
		Digester TS & VS	Weekly	
		RAS TS & VS	Weekly	
		Temperature	Daily	
		D.O.	Daily	
		PH	Weekly	
	SP-6: Clarifier Effluent (T-204)	TS	Weekly	
		VS	Weekly	
		COD	Weekly	
		TPH	Weekly	
		PAH/PCP	Weekly	
		NH_3	Weekly	
		Orthophosphate, dissolved	Weekly	

Media	Locations	Parameter	Frequency	Implemented?
	SP-8: Multi-Media Filter Effluent (T-206A, T-206B)	TS	Weekly	
		TPH	Weekly	
		PAH/PCP	Weekly	
	SP-9: Lead Carbon Filter	TPH	Weekly	
		PAH/PCP	Weekly	
	SP-10: Lag Carbon Filter	TPH	Weekly	
		PAH/PCP	Weekly	
GWTP Effluent	SP-11: Effluent storage tank	PAH[a]	Daily effluent sampling during weeks 1 and 2. Twice weekly sampling for week 2 to 3 months	Yes
		PCP[a]		
		Discharge Flow Rate		
		TSS[a]		
		TDS		
		Temperature		
		pH		
		Dissolved Oxygen		
		PAH[a]		
		Acute survival test - *Menidia beryllina* (Inland Silversides)	Annually	
		Chronic test - *Mytilus Sp.* (blue mussel) or *Crassostrea gigas* (Pacific oyster)	Quarterly	
Groundwater Monitoring	Upper Aquifer: MW-17, MW-18, MW-19, EW-04, EW-06, EW-08	Alkalinity	One round of sampling in November 2002	Yes
		Total Organic Carbon		
		Nitrate/Nitrite		
		Sulfate/Sulfide		
		Chloride		

Media	Locations	Parameter	Frequency	Implemented?
		Total Metals (Ca, Mn, Mg, Na and K)		
		Petroleum Hydrocarbons		
		Semivolatile Organics with TICs		
	Lower Aquifer: CW-05, CW-09, CW-15, 99CD-MW02, 99CD-MW04, 02-CD-MW-01	Alkalinity	Three rounds of sampling in November 2002, December 2002, and January 2003	Yes
		Total Organic Carbon		
		Nitrate/Nitrite		
		Sulfate/Sulfide		
		Chloride		
		Petroleum Hydrocarbons		
		Semivolatile Organics with TICs		
Key to Parameters				
PCP = Pentachlorophenol			VS = Volatile solids	
COD = Chemical oxygen demand			NH_3 = Ammonia as nitrogen	
TSS = Total suspended solids			TPH = Total Petroleum Hydrocarbon	
D.O. = Dissolved oxygen			pH = Hydrogen ion	
PAH = Polynuclear aromatic hydrocarbon			ML = Mixed liquor	
RAS = Return activated sludge				
[a] 24-hour composite sample.				

TABLE 4.3-4 WORKER SAFETY AND PERIMETER MONITORING SUMMARY

Media	Locations	Parameter	Frequency	Implemented?
Noise	Various: on and off site	dBA	Four times during first 6 mos of operations	No
Air Quality	2 monitoring stations will be placed around the perimeter of the treatment plant (one upwind of operational activity and one downwind of the area).	Total Suspended Particles	Samples will be collected every 24 hours. Baseline sampling followed by three monitoring events once groundwater temperatures stabilize.	No
		PCP		
		PAH		
		Naphthalene		
Worker Safety Air Quality	Treatment Plant DAF-104	PAH and PCP	Samples to be collected once at startup and once during operations	Yes
	Treatment Plant T-203			
	Treatment Area			
Boiler Air Emissions	Stack	Dioxins/Furans, PAHs, Volatile Organics, Semivolatile Organics, Total Hydrocarbons, Hydrogen chloride, Chlorine, Particle Size	Up to 12 samples throughout operations	No
Joint Observation Well Groundwater	J09, J10, J11	Semivolatile organics (including naphthanols and quinones)	Within three months of sheet pile wall installation and after active steam injection	No

TABLE 5.2-1 SUPPORTING GROUPS AND CONTRACTORS

Support Groups/ Subcontractor	Service
Bay West, Inc.	Installation of Sheet Pile Walls
SCS, Inc./OMI	Operations and maintenance contractor
MarVac, Inc.	Construction of the boiler building and the subsurface (belowground) portion of the pilot study's elements, including the installation of the water supply well, and the steam injection and extraction wells
Pease Construction, Inc.	Pilot system construction and start up
URS Corporation	Sampling and analysis of perimeter, source and fugitive air emissions – not implemented
SteamTech Environmental Services	Expert consultant services for steam injection operations
Sensa, Inc.	Installation support for DTS
Holt FASP/Techlaw Shannon & Wilson/ESN Northwest	Soil boring and monitoring well installations
Environmental Resource Associates	Performance evaluation samples
USACE	Subsurface instrumentation and ADAS
USEPA Region 10 CLP	Groundwater analysis for water supply well and extraction well sampling
USEPA Region 10 Manchester Environmental Laboratory	Analysis of Groundwater Treatment Plant Monitoring samples
USEPA Office of Research and Development (Battelle Memorial Institute and Microbial Insights, Inc.)	Soil analysis for microbiological baseline testing (microcosm studies and phospholipid fatty acid (PLFA) analyses)

TABLE 5.2-2 PROJECT WEB PAGE CONTENTS

Data Source	Data Type	
Subsurface Data:	Temperature:	3D Views
		Vertical Sections
		Horizontal Slices
		Individual Well Profiles
	Pressure:	Water Level Contours
		Time History
Injection Well Data:	Injection Rate Summary Table	
	Rate and Mass of Steam	
	Cumulative Rate and Mass of Steam	
Extraction Well Data:	***Vapor Flow Rate***	
	Temperature	
	Dissolved Oxygen and Carbon Dioxide of Extracted Liquid	
	PAH/PCP	
	Automated Pumping Rates	
	Contractor Pumping Rates	
	Extraction Rate Summary Table	
Vapor Collector Lines:	***Pressure***	
	Flow	
Heat Exchanger:	***Flow***	
	Temperature	
Thermal Remediation Totals:	Total Organic Carbon	
	Liquid Flow Rate	
	Contaminants	
Reports:	Operations Report – This report included the daily hours of operation for the boiler, treatment plant, vapor extraction system, injection wells, and extraction wells. This report also included meteorological data.	
	Operations Log – Daily operations meeting minutes were posted on this message board by the Team Coordinator. Additionally, updates on the status of particular systems and repairs were posted by technical team members.	
	Message Board – Technical discussions on monitoring or system performance were posted on this message board by technical team members.	

Links shown as ***bold italics*** were never activated, either because instruments were not installed (or not monitored) or a format was not developed for posting to the website before operations ceased.

TABLE 6.1-1 AVERAGE STEAM INJECTION RATES FOR EACH INJECTION WELL DURING THE TWO MAJOR INJECTION PERIODS

Well	Oct 30-Dec 14 (lb/hr)	Jan 12-Mar 22 (lb/hr)
I-1	193	67
I-2	233	132
I-3	244	81
I-4	311	102
I-5	275	84
I-6	224	111
I-7	327	210
I-8	366	136
I-9	373	220
I-10	266	203
I-11	160	80
I-12	143	189
I-13	193	199
I-14	378	213
I-15	302	198
I-16	199	150

Table 6.6-1. Groundwater Treatment Plant Data Summary

		SP-0: Combined Extracted Liquid Influent to GWTP			SP-3: DAFT Effluent	SP-4: T-402 Effluent		SP-6: Clarifier Effluent		SP-8: Multi-Media Filter Effluent		SP-9: Lead Carbon		SP-12: Mid Carbon		SP-10: Lag Carbon		SP-11: Treated Effluent					Compliance Levels					DAFT Efficiency		Aeration Basin Efficiency		Carbon Treatment System Efficiency	
		2113			2102	2103		2104		2105		2106		2116		2107		2108															
Date	Week Number	Total PAH (ug/L)	PCP (ug/L)	O&G (mg/L)	O&G (mg/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	Total PAH (ug/L)	PCP (ug/L)	pH	Temp. (deg. C)	D.O. (mg/L)	Total PAH (ug/L)	PCP (ug/L)	pH	Temp. (deg. C)	D.O. (mg/L)	O&G Removal (%)	PAH Removal (%)	PAH Removal (%)	PCP Removal (%)	PAH Removal	PCP Removal
10/7/02	41	9443.59	300	6.21	5.71	499.09	460	0.858	7.2	0.796	3.3	0.14	0.12	- -	- -	0.01	0.074	0.01	0	7.96	15.6	3.9	20	6	6 - 9	< 25	> 6	8.05	94.72	99.83	98.43	99.99	99.98
10/14/02	42	11028.33	340	6.41	5.86	618.57	340	0.35	22	0.211	12	0.21	0.27	- -	- -	0.01	0.074	0.01	0.0088	8.24	13.6	3.9	20	6	6 - 9	< 25	> 6	8.58	94.39	99.94	93.53	99.95	99.99
10/21/02	43	9803.71	220	5.65	5.93	717.56	290	0.929	7.3	0.444	3.2	0.19	0.11	- -	- -	0.052	0.074	0.01	0.0048	7.92	15.8	3.8	20	6	6 - 9	< 25	> 6	-4.96	92.68	99.87	97.48	99.88	99.98
10/28/02	44	13266.02	310	6.75	5.75	398.22	320	1.871	6.6	0.526	2.2	0.273	0.11	- -	- -	0.05	0.074	0.01	0.074	7.91	13.2	4.1	20	6	6 - 9	< 25	> 6	14.81	97.00	99.53	97.94	99.90	99.97
11/4/02	45	12106.72	330	5.6	5.41	424.65	400	2.615	14	0.35	6.7	0.243	0.23	- -	- -	0.121	0.074	0.01	0.074	8.07	10.5	4.7	20	6	6 - 9	< 25	> 6	3.39	96.49	99.38	96.50	99.65	99.99
11/11/02	46	11648.97	270	10.7	6.1	4041.61	290	3.992	9.8	1.634	4.1	0.26	0.0059	- -	- -	0.091	0.0069	0.01	0.074	8.26	13.8	4.2	20	6	6 - 9	< 25	> 6	42.99	65.31	99.90	96.62	99.94	100.00
11/18/02	47	36467	260	34.9	22.9	21301.200	240	7.344	11	3.404	9.1	0.59	0.0064	- -	- -	0.327	0.074	0.15	0.074	7.79	13.8	4.7	20	6	6 - 9	< 25	> 6	34.38	41.59	99.97	95.42	99.90	99.99
11/25/02	48	24697.4	220	14.9	10.8	11830.800	250	5.498	14	2.1	10	0.33	0.014	- -	- -	0.01	0.0084	0.01	0.074	7.75	15.8	3.8	20	6	6 - 9	< 25	> 6	27.52	52.10	99.95	94.40	100.00	100.00
12/2/02	49	2628477.5	220	1570	50.7	32181.600	260	5.021	15	2.989	13	0.23	0.012	- -	- -	0.01	0.074	5.84	0.074	7.73	13.5	3.8	20	6	6 - 9	< 25	> 6	96.77	98.78	99.98	94.23	100.00	99.99
12/9/02	50	133908	190	205	92.2	86415.700	250	365.2	84	628.99	79	24.12	7	- -	- -	10.114	0.23	2.459	0.083	7.38	13.8	4.1	20	6	6 - 9	< 25	> 6	55.02	35.47	99.58	66.40	99.98	100.00
12/16/02	51	27069.800	270	28.6	13.1	75339	290	1945.04	190	0.52	180	132.97	52	- -	- -	5.187	0.29	6.55	0.36	7.31	14.8	3.1	20	6	6 - 9	< 25	> 6	54.20	-178.31	97.42	34.48	90.03	100.00
12/23/02	52	24244.4	347	31.8	140	5037.02	385	4.095	154	3.788	146	0.01	0.0895	- -	- -	0.01	0.0681	0.01	0.0851	7.74	11.3	4.2	20	6	6 - 9	< 25	> 6	-340.25	79.22	99.92	60.00	100.00	100.00
12/30/02	1	25924.9	440	17	7.38	7839.67	440	3.21	220	3.1	0	0.613	0.051	- -	- -	0.526	0.029	0.542	0.034	7.92	10.4	5.8	20	6	6 - 9	< 25	> 6	56.59	69.76	99.96	50.00	99.83	
1/6/03	2	109017.9	610	103	729	52132.4	510	7.31	120	1.997	110	0.209	0.029	- -	- -	0.087	0.021	0.93	0.031	7.91	12.1	4.8	20	6	6 - 9	< 25	> 6	-607.77	52.18	99.99	76.47	99.96	100.00
1/13/03	3	42316.6	570	54.4	13.3	33866.1	660	8.95	81	4.69	73	1.297	0.22	- -	- -	0.01	0.047	0.17	0.064	7.54	14.2	3.4	20	6	6 - 9	< 25	> 6	75.55	19.97	99.97	87.73	100.00	100.00
1/20/03	4	24,876.30	680	20.1	30.5	32190.3	700	8.79	15	6.31	0	3.296	0.42	- -	- -	0.635	0.036	2.8	0.063	7.52	15.1	4	20	6	6 - 9	< 25	> 6	-51.74	-29.40	99.97	97.86	99.90	
1/27/03	5	31589.4	760	34.5	21.5	31017	560	5.649	18	3.15	10	1.238	0.82	- -	- -	0.39	0.046	1.59	0.041	7.55	16.7	5.5	20	6	6 - 9	< 25	> 6	37.68	1.81	99.98	96.79	99.88	100.00
2/3/03	6	78047.6	1000	76.8	694	66412.1	930	5.94	11	5.94	11	1.73	0.98	- -	- -	1.25	0.053	2.276	0.066	7.45	17	3.7	20	6	6 - 9	< 25	> 6	-803.65	14.91	99.99	98.82	99.79	100.00
2/10/03	7	29700.8	550	18.9	19.5	32846.39	970	5.24	9	3.723	4.8	2.154	0.97	- -	- -	1.36	0.053	0.68	0.058	7.56	14.5	4.3	20	6	6 - 9	< 25	> 6	-3.17	-10.59	99.98	99.07	99.63	99.99
2/17/03	8	64357.7	900	90	17.2	33835.3	1100	3.84	9.2	2.561	7.5	1.001	1.4	- -	- -	0.7	0.053	0.69	0.062	7.7	14.1	4.7	20	6	6 - 9	< 25	> 6	80.89	47.43	99.99	99.16	99.73	99.99
2/24/03	9	51327.2	920	50.3	34.1	41505	1000	3.35	9.7	0	6.7	1.288	0.11	- -	- -	0.32	0.014	1.4	0.051	7.81	13.7	4.9	20	6	6 - 9	< 25	> 6	32.21	19.14	99.67	99.03		100.00
3/3/03	10	113134.4	1000	67.4	26.7	35742.7	910	7.254	9.7	5.645	5.8	2.438	0.066	- -	- -	1.895	0.016	0.01	0.0063	7.72	14.1	4.9	20	6	6 - 9	< 25	> 6	60.39	68.41	99.98	98.93	99.66	100.00
3/10/03	11	35476.3	720	36.6	21.3	30386	1100	3.606	5.9	2.963	5.7	1.496	0.073	- -	- -	0.237	0.0061	0.29	0.073	7.78	15.3	4.5	20	6	6 - 9	< 25	> 6	41.80	14.35	99.99	99.46	99.92	100.00
3/17/03	12	55207.69	630	87.8	394	65211.1	850	9.973	3	6.93	3.2	2.17	0.12	- -	- -	0.7	0.0084	1.12	0.074	7.49	16.2	4.1	20	6	6 - 9	< 25	> 6	-348.75	-18.12	99.98	99.65	99.90	100.00
3/24/03	13	36445.4	1000	46.9	21.8	33601.2	950	4.1	14	3.49	12	2.09	0.13	- -	- -	1.54	0.0043	1.2	0.074	7.61	16.8	4.7	20	6	6 - 9	< 25	> 6	53.52	7.80	99.99	98.53	99.56	100.00
3/31/03	14	65675.9	970	101	113	26952	770	4.651	9.5	3.109	9	3.58	0.23	- -	- -	1.24	0.011	1.25	0.073	7.69	18.7	4	20	6	6 - 9	< 25	> 6	-11.88	58.96	99.98	98.77	99.60	100.00
4/7/03	15	28350.2	970	20.6	46.4	24080.4	920	2.74	24	3.17	25	2.55	0.35	- -	- -	0.33	0.074	2.374	0.079	7.94	15	5.1	20	6	6 - 9	< 25	> 6	-125.24	15.06	99.99	97.39	99.90	100.00
4/14/03	16	28378	700	23.5	21.6	22390.9	870	2.52	20	2.67	17	1.68	0.21	- -	- -	0.85	0.004	0.88	0.02	7.65	16	4.1	20	6	6 - 9	< 25	> 6	8.09	21.10	99.99	97.70	99.68	100.00
4/21/03	17	27519.8	520	21.9	10.9	13816.8	660	3.587	13	1.72	17	1.89	13	- -	- -	0.01	0.073	0.818	0.074	8.05	15.6	4	20	6	6 - 9	< 25	> 6	50.23	49.79	99.97	98.03	99.99	100.00
4/28/03	18	29030.8	630	23.2	10.1	12580.92	880	1.4	9.2	1.07	5.2	0.63	0.0055	- -	- -	0.54	0.074	0.01	0.074	7.98	15.7	4.4	20	6	6 - 9	< 25	> 6	56.47	56.66	99.99	98.95	99.50	99.99
5/5/03	19	18903.1	930	14.5	8.9	13700	1200	0.24	3.1	1.32	1.3	0.0077	0.0077	- -	- -	0.074	0.074	0.01	0.074	7.79	16.3	4.8	20	6	6 - 9	< 25	> 6	38.62	27.53	100.00	100.00	99.94	99.94
5/12/03	20	21411.1	530	30.1	10.4	10839.5	780	1.77	1.9	1.83	0.81	0.73	0.064	- -	- -	0.01	0.073	0.2	0.073	7.57	16.9	3.5	20	6	6 - 9	< 25	> 6	65.45	49.37	99.98	99.76	99.99	99.91
5/19/03	21	23816.4	620	16	8	7561.72	990	0.81	2.5	0.46	1	0.29	0.38	1.39	0.0066	0.01	0.074	0.01	0.073	7.81	15.4	4.3	20	6	6 - 9	< 25	> 6	50.00	68.25	99.99	99.75	99.98	99.93
5/26/03	22	17818.3	560	57.9	6.8	3691.74	770	0.3	3.1	1	1.9	0.53	0.049	0.09	0.074	0.01	0.074	0.01	0.025	7.74	18	4.4	20	6	6 - 9	< 25	> 6	88.26	79.28	99.99	99.60	99.99	99.96
6/2/03	23	21475.2	600	22.6	7	6814.81	610	4.185	13	0.87	12	0.46	0.048	0.14	- -	0.01	0.074	0.01	0.0039	7.72	18.4	4.5	20	6	6 - 9	< 25	> 6	69.03	68.27	99.94	97.87	99.99	99.99
6/9/03	24	37119.8	600	23.8	5.9	5094.05	600	0.86	2.5	1.03	1.6	0.19	0.057	0.01	0.0079	0.01	0.074	0.01	0.0078	7.88	20.4	4.5	20	6	6 - 9	< 25	> 6	75.21	86.28	99.98	99.58	99.99	99.95
6/16/03	25	11091.4	450	13.9	5.8	1514.83	600	1.663	2.8	0.559	1.8	0.01	0.046	0.22	0.0041	0.01	0.074	0.01	0.0076	7.84	19.3	4.5	20	6	6 - 9	< 25	> 6	58.27	86.34	99.89	99.53	99.98	99.96
6/23/03	26	32063.6	560	14.6	5.3	675.82	500	0.53	2.5	0.733	1.8	0.379	0.032	0.18	0.004	0.12	0.074	0.41	0.0093	7.75	18.4	5.8	20	6	6 - 9	< 25	> 6	63.70	97.89	99.92	99.50	99.84	99.96
6/30/03	27	19238.2	430	13.7	7.3	810.57	510	1.78	4.8	0.49	2.1	0.031	0.031	0.13	0.074	0.075	0.075	0.973	0.0094	7.74	20.1	4.5	20	6	6 - 9	< 25	> 6	46.72	95.79	99.78	99.06	99.85	99.96
7/7/03	28	17212.1	450	9.6	5	660	670	2.06	4.4	0.66	1.9	0.22	0.031	0.13	0.0044	0.17	0.074	0.088	0.0096	7.81	19.7	4.1	20	6	6 - 9	< 25	> 6	47.92	96.17	99.69	99.34	99.74	99.96
7/14/03	29	17768.5	560	18.8	9.4	688.03	530	2.4	2.8	0.41	1.6	0.21	0.03	9.17	0.011	0.14	0.074	0.01	0.0035	7.78	21	4.2	20	6	6 - 9	< 25	> 6	50.00	96.13	99.65	99.47	99.66	99.95
7/21/03	30	14477.77	430	9.1	5.1	652.54	600	1.96	1.7	0.4	1.5	0.21	0.047	0.14	0.073	0.01	0.074	0.01	0.074	7.84	21.8	4	20	6	6 - 9	< 25	> 6	43.96	95.49	99.70	99.72	99.98	99.95
7/28/03	31	13737.4	720	13.3	5.1	589.61	650	1.37	2.7	0.14	2	0.037	0.037	0.01	0.0055	0.074	0.074	0.24	0.074	7.79	21.1	3.9	20	6	6 - 9	< 25	> 6	61.65	95.71	99.77	99.58	99.47	99.96
8/4/03	32	20452.6	550	28.6	6.4	556.42	650	1.19	4	0.13	3.9	0.01	0.033	0.01	0.073	0.01	0.073	0.01	0.073	7.9	20.4	5.1	20	6	6 - 9	< 25	> 6	77.62	97.28	99.79	99.38	99.92	99.98
8/11/03	33	152153.2	490	8.4	6.6	491.35	540	0.34	4.5	0.6	3.2	0.22	0.039	0.16	0.0046	0.15	0.075	0.15	0.074	7.9	18.9	6.9	20	6	6 - 9	< 25	> 6	21.43	99.68	99.93	99.17	99.75	99.98
8/18/03	34	13661.9	450	31.2	3.2	602.44	450	1.92	11	0.64	9.6	0.83	0.032	0.31	0.0067	0.16	0.073	0.14	0.0087	7.8	21.1	4	20	6	6 - 9	< 25	> 6	89.74	95.59	99.57	97.56	99.75	99.99
8/25/03	35	20460.1	510	18.3	7.1	682.84	550	1.18	9.8	0.35	8	0.12	0.04	0.01	0.011	0.01	0.0076	0.01	0.074	8	20	3.6	20	6	6 - 9	< 25	> 6	61.20	96.66	99.83	98.22	99.97	100.00
9/1/03	36	12767.1	470	10.2	8.6	751.63	420	1.36	11	0.24	7.9	0.11	0.043	0.17	0.012	0.01	0.014	0.01	0.0072	7.9	20	4.3	20	6	6 - 9	< 25	> 6	15.69	94.11	99.82	97.38	99.96	100.00
9/8/03	37	23331.6	450	30.4	4.2	633.36	390	0.62	14	0.28	9.8	0.11	0.046	- -	- -	0.01	0.074	0.01	0.007	7.9	20	3.7	20	6	6 - 9	< 25	> 6	86.18	97.29	99.90	96.41	99.96	99.99
9/15/03	38	13470.2	340	11.6	5	563.43	420	1.02	22	0.15	21	0.01	0.063	0.01	0.015	0.01	0.074	0.01	0.0052	8	17	3.3	20	6	6 - 9	< 25	> 6	56.90	95.82	99.82	94.76	99.93	100.00
9/22/03	39	77840.8	480	146	5	840.8	370	0.38	16	0.36	13	0.23	0.075	0.01	0.074	0.21	0.0049	0.8	0.0056	7.9	17	4.7	20	6	6 - 9	< 25	> 6	96.58	98.92	99.95	95.68	99.42	100.00
9/29/03	40	12309.17	340	7	5	566.27	380	0.45	18	0.036	16	0.01	0.099	0.01	0.0095	0.01	0.0076	0.24	0.074	7.8	19	3.2	20	6	6 - 9	< 25	> 6	28.57	95.40	99.92	95.26	99.72	100.00
10/6/03	41	30697.5	470	16.5	7.4	521.47	410	0.44	14	0.1	14	0.01	0.17	0.01	0.011	0.01	0.074	0.01	0.074	8	17	3.5	20	6	6 - 9	< 25	> 6	55.15	98.30	99.92	96.59	99.90	99.99
10/13/03	42	9394.94	340	5	5	281.86	450	0.01	19	0.11	15	0.01	0.28	0.17	0.0043	0.01	0.073	0.01	0.073	7.9	20	6.6	20	6	6 - 9	< 25	> 6	0.00	97.00	100.00	95.78	99.91	100.00
10/20/03	43	20228.2	470	10.9	5	752.34	440	0.24	16	0.21	14	0.01	0.29	0.01	0.074	0.01	0.0055	0.01	0.074	8	17	3.2	20	6	6 - 9	< 25	> 6	54.13	96.28	99.97	96.36	99.95	100.00
10/27/03	44	40244.7	780	52.2	5.2	1050.04	750	0.01	32	0.47	24	0.18	0.43	0.01	0.0047	0.01	0.074	0.27	0.0048	7.8	16	4.3	20	6	6 - 9	< 25	> 6	90.04	97.39	100.00	95.73	99.98	100.00
11/3/03	45	18928.9	740	25.8	5	714.57	660	0.9	96	0	83	0.01	3.4	0.01	0.012	0.01	0.0093	0.01	0.0049	8.1	12	4.1	20	6	6 - 9	< 25	> 6	80.62	96.22	99.87	85.45		100.00
11/10/03	46	27564	560	34.9	7.9	2781.3	650	0.61	82	0.7	65	0.47	3.2	0.01	0.012	0.01	0.009	0.01	0.009	7.7	14	4.1	20	6	6 - 9	< 25	> 6	77.36	89.91	99.98	87.38	99.99	100.00
11/17/03	47	20720.7	480	20.5	5	576.84	480	1.63	67	0.73	83	0.22	3.9	0.01	0.0092	0.01	0.0056	0.21	0.0074	7.91	15	3.7	20	6	6 - 9	< 25	> 6	75.61	97.22	99.72	86.04	99.99	100.00
11/24/03	48	20768.9	670	27.9	7.1	953.49	840	0.81	180	0.33	180	0.36	21	0.18	0.033	0.01	0.012	0.01	0.0075	7.88	13	5.5	20	6	6 - 9	< 25	> 6	74.55	95.41	99.92	78.57	99.97	100.00
12/1/03	49	25305.1	1000	51.8	6.8	1704.3	860	0.78	85	0.809	99	0.19	9.1	0.21	0.026	0.42	0.075	0.01	0.0069	7.8	12	5.3	20	6	6 - 9	< 25	> 6	86.87	93.26	99.95	90.12	99.48	100.00
12/8/03	50	14521.1	650	25.8	5	14468.33	870	0.01	88	0.98	69	0.34	7.3	0.33	0.029	0.01	0.011	0.39	0.0064	7.7	12	4.7	20	6	6 - 9	< 25	> 6	80.62	0.36	100.00	89.89	99.99	100.00
12/15/03	51	22055.9	810	25.9	11.9	3236.8	820	0.11	72	1	50	0.59	5.8	0.71	0.034	0.28	0.011	0.26	0.037	7.8	12	4.5	20	6	6 - 9	< 25	> 6	54.05	85.32	100.00	91.22	99.72	100.00
12/22/03	52	19708.2	660	15.9	8.9	1201.61	730	2.35	28	0.15	31	0.25	3.8	0.18	0.033	0.13	0.062	0.27	0.022	7.7	13	4.1	20	6	6 - 9	< 25	> 6	44.03	93.90	99.80	96.16	99.13	100.00
12/29/03	1	16597.9	790	22.6	7	957.74	680	1.5	29	0.65	25	0.24	3.7	0.57	0.028	0.26	0.0088	0.1	0.00084	7.8	11	5.2	20	6	6 - 9	< 25	> 6	69.03	94.23	99.84	95.74	99.60	100.00
1/5/04	3	21332.2	700	15.4	5	991.75	900	0.78	110	0.33	85	0.16	17	0.52	0.11	0.093	0.018	0.14	0.0003	7.7	12	4	20	6	6 - 9	< 25	> 6	67.53	95.35	99.92	87.78	99.72	100.00
1/12/04	4	29478.4	600	14.3	6.7	1994.07	620	1.05	16	1.07	14	0.49	2.8	0.16	0.053	0.16	0.0055	0.01	- -	7.68	14	3.7	20	6	6 - 9	< 25	> 6	53.15	93.24	99.95	97.42	99.85	100.00

Note: Total PAH does not include those values with a U qualifier

Figures

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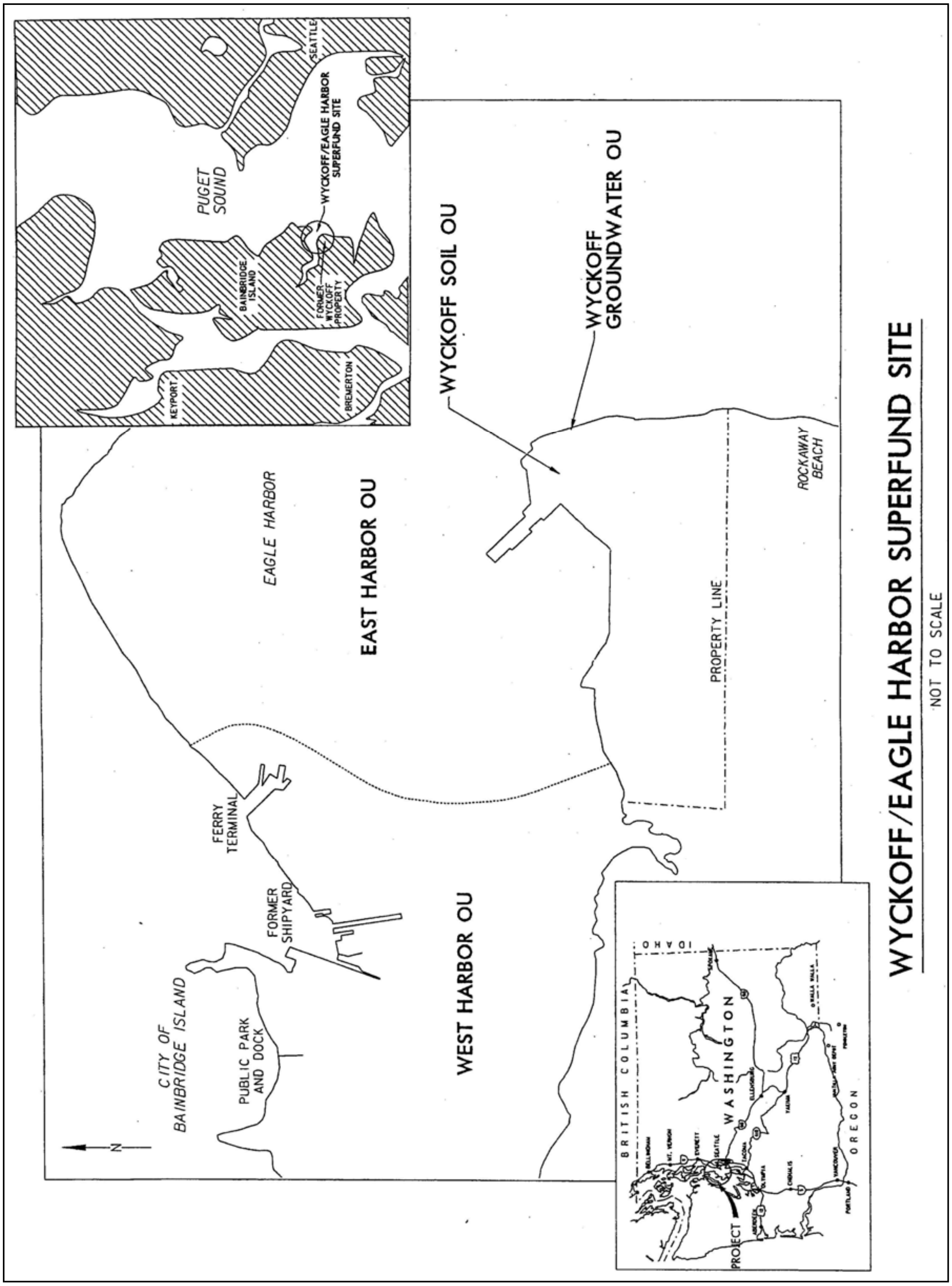
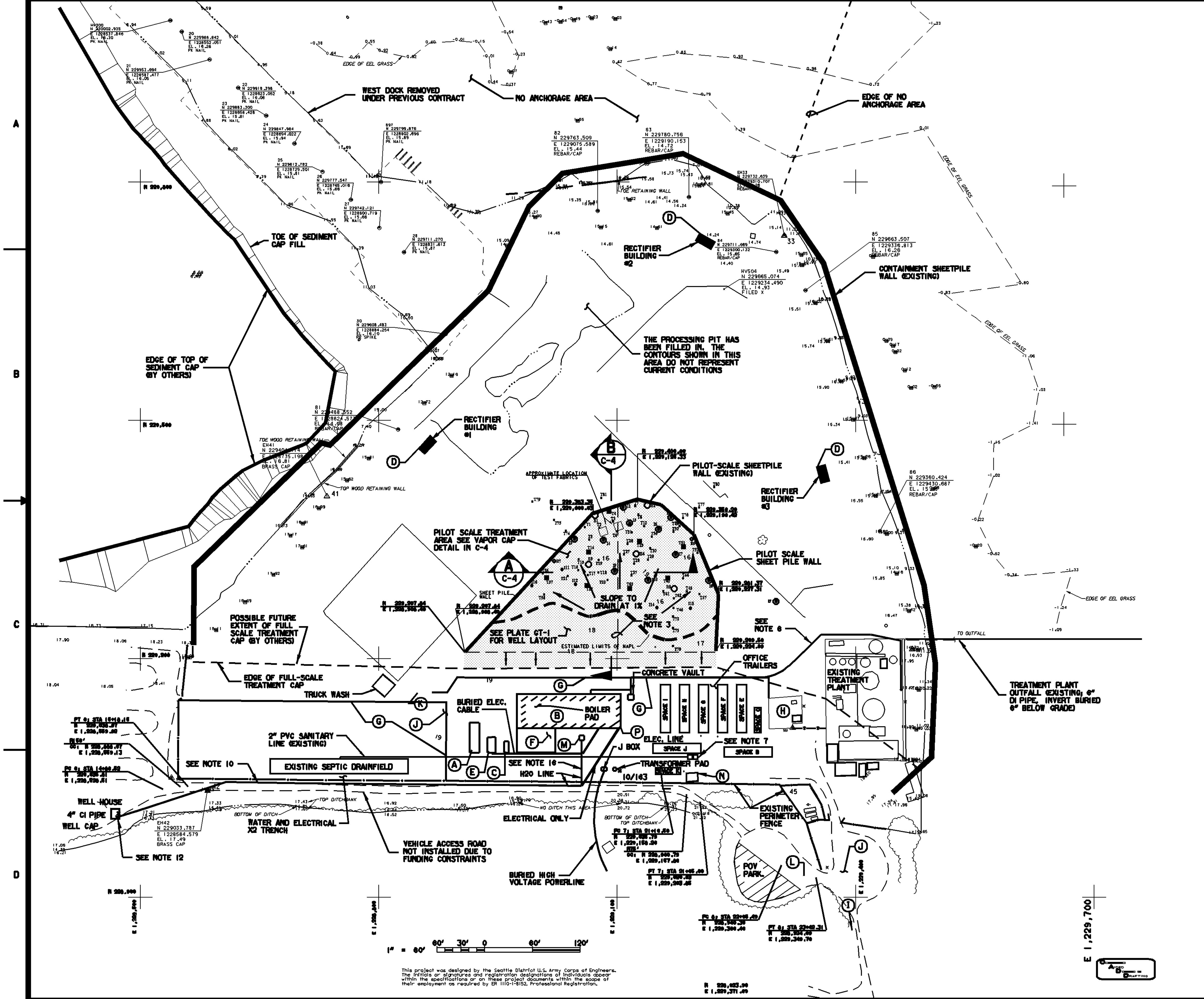
Figure 1.0-1. Site Vicinity Map.





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REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		ADDED AS-BUILT ABOVE TITLE BLOCK	16JUL03	MV
A1		ADDED EXISTING FENCE AND REFERENCE TO SPECS.	16JUL03	MV
A2		ADDED NOTE ON EXISTING FENCE	16JUL03	MV
A3		ADDED EXISTING FENCE AND REFERENCE TO SPECS.	16JUL03	MV
A4		ADDED AS-BUILT FEATURES	16JUL03	MV

NOTES:

1. CONTOUR MAP COMPILED FROM AERIAL PHOTOGRAPHY FLOWN 18-DEC-1996. SUPPLEMENTED BY FIELD SURVEY PERFORMED 31-JAN, 01-FEB AND 15-FEB-1997. FIELD BOOK FILE NO. 41-003.
2. HORIZONTAL CONTROL BASED ON WA. COORDINATE SYSTEM, NORTH ZONE, NAD83/91. VERTICAL CONTROL BASED ON MEAN LOWER LOW WATER (MLLW).
3. ~~GRADE TOP OF VAPOR CAP TO CREATE A HIGH RIDGE IN CENTER OF TREATMENT AREA TO ALLOW DRAINAGE OF SURFACE WATER AWAY FROM CENTER TOWARDS SHEETPILE WALL (1% MIN SLOPE).~~ DRAINAGE SURFACE FLOW DIRECTION ON VAPOR CAP CHANGED AS INDICATED. BREAKLINE OF SLOPE CHANGE IS UNKNOWN.
4. EXISTING GROUND SURFACE SHOWN IN THE AREA DESIGNATED AS "PILOT SCALE TREATMENT AREA" HAS BEEN ALTERED BY RECENT GRADING ACTIVITIES. CONTRACTOR SHALL ASSUME THESE ELEVATIONS TO BE APPROXIMATE. THE CONTRACTOR SHALL GRADE THE SUBGRADE TO EL 16 BEFORE CONSTRUCTING VAPOR CAP.
5. NOT USED.
6. INSTALL 2" CPVC PIPE FROM BOILER ROOM TO EXISTING TREATMENT PLANT MANIFOLD AND 2" CPVC PIPE FROM BOILER ROOM TO EXISTING SUMP IN TREATMENT PLANT. SEE PLATE C-4 FOR TRENCHING DETAIL A.
7. EXISTING SEPTIC TANKS (2).
8. ~~SEE PLATE C-5 FOR PARTITIONING OF TREATMENT AREA VAPOR CAP.~~ DELETED DUE TO DESIGN CHANGE AND FUNDING CONSTRAINTS.
9. ~~INSTALL 4" SUPPLY PIPE FROM COOLING TOWER TO BOILER ROOM, 4" RETURN PIPE FROM BOILER ROOM TO COOLING TOWER, 2" WATER PIPE FROM BOILER ROOM TO COOLING TOWER, AND 1" DISCHARGE PIPE FROM COOLING TOWER TO BOILER ROOM. SEE PLATE C-5 FOR TRENCHING DETAIL B. NOT INSTALLED DUE TO DESIGN CHANGES.~~ THE COOLING TOWER PAD AND PIPING WERE NOT INSTALLED DUE TO DESIGN CHANGES ON THE THERMAL REMEDIATION PILOT CONSTRUCTION CONTRACT.
10. INSTALL 4" WATER LINE AND ELECTRICAL UTILITIES FROM WATER SUPPLY WELL TO BOILER ROOM. SEE PLATE C-5 FOR TRENCHING DETAIL C. PIPELINE SLOPED BACK TO WELL (SLOPE UNKNOWN)
11. ABANDON 6 MONITORING WELLS INSIDE THE PILOT AREA. SEE SPEC. SECTION 01710 FOR DRILLING LOGS FOR DEPTHS. REMOVE BOLLARDS (2 TYPICAL PER WELL).
12. CONTRACTOR SHALL PROVIDE 10'-0" X 12'-0" TEMPORARY PRE-MANUFACTURED METAL SHED. SHED SHALL BE OF A CONSTRUCTION TYPE TO SUPPORT LOCAL WIND AND SNOW LOADS. SHED SHALL BE ANCHORED ON A CONCRETE SLAB TO WITHSTAND WIND UPLIFT. THE CONCRETE SLAB'S SURFACE SHALL BE 6" ABOVE FINISH GRADE. CONTRACTOR SHALL CONSTRUCT SHED IN A MANNER THAT WILL ALLOW A CRANE TO SAFELY AND SECURELY LIFT THE ENTIRE SHED FROM THE SLAB.

Ⓐ	12'x37' CONCRETE PAD FOR 20,000 GAL. FUEL STORAGE TANK (FF EL=18'). #5 REBAR ● 12" O.C.
Ⓑ	BOILER BUILDING (FF EL=18')
Ⓒ	14'x8' CONCRETE PAD FOR DIESEL GENERATOR (FF EL=18'). #5 REBAR ● 12" O.C.
Ⓓ	ELECTRICAL RECTIFIER BUILDING (20'x10') PROVIDED BY OTHERS. NOT IN THIS CONTRACT.
Ⓔ	10'x19' CONCRETE PAD FOR 6,000 GAL. FUEL STORAGE TANK (FF EL=18'). #5 REBAR ● 12" O.C.
Ⓕ	CONCRETE PAD FOR BOILER ROOM ACCESS. SEE PLATE C-4 FOR ADDITIONAL INFORMATION. #5 REBAR ● 12" O.C.
Ⓖ	EXISTING PLASTIC CONSTRUCTION FENCING
Ⓗ	EXISTING DECONTAMINATION PAD (PROTECT)
Ⓘ	ACCESS TO EAGLE HARBOR DRIVE (500FT)
Ⓙ	CONSTRUCT 6" LAYER OF AGGREGATE SURFACE COURSE ON TOP OF COMPACTED, EXISTING SUBGRADE
Ⓚ	18'x10' CONCRETE PAD FOR COOLING TOWER (FF EL=18') NOT INSTALLED
Ⓛ	R75'. CC: N 228,999.64; E 1,229,352.44
Ⓜ	6'x8' CONCRETE PAD FOR 1,500 GAL WATER STORAGE TANK (FF EL=18). #5 REBAR ● 12" O.C.
Ⓝ	EXISTING ELECTRICAL SHED
Ⓟ	COORDINATES: E 1,229,104.26 N 229,112.49

EXISTING TRAILER SPACE NOTES:

13. UTILITY (WATER, SEWER, ELECTRICAL, PHONE) HOOKUPS ARE IN PLACE AT EACH TRAILER SPACE EXCEPT SPACE K WHICH DOES NOT HAVE ANY UTILITY CONNECTIONS.
14. THE CONTRACTOR MAY OCCUPY TRAILER SPACES F, K, AND J DURING CONSTRUCTION ACTIVITIES.
15. ~~DOCUMENT CHANGE TO ROAD DESIGN DUE TO FUNDING CONSTRAINTS.~~ VEHICLE ACCESS ROAD NOT CONSTRUCTED DUE TO FUNDING CONSTRAINTS
16. WATER LINE HAS MINIMUM 6" CONCRETE ENCASEMENT 5' BOTH DIRECTIONS OF SEWER LINE CROSSING.

FIGURE 2.0-1 AS-BUILT

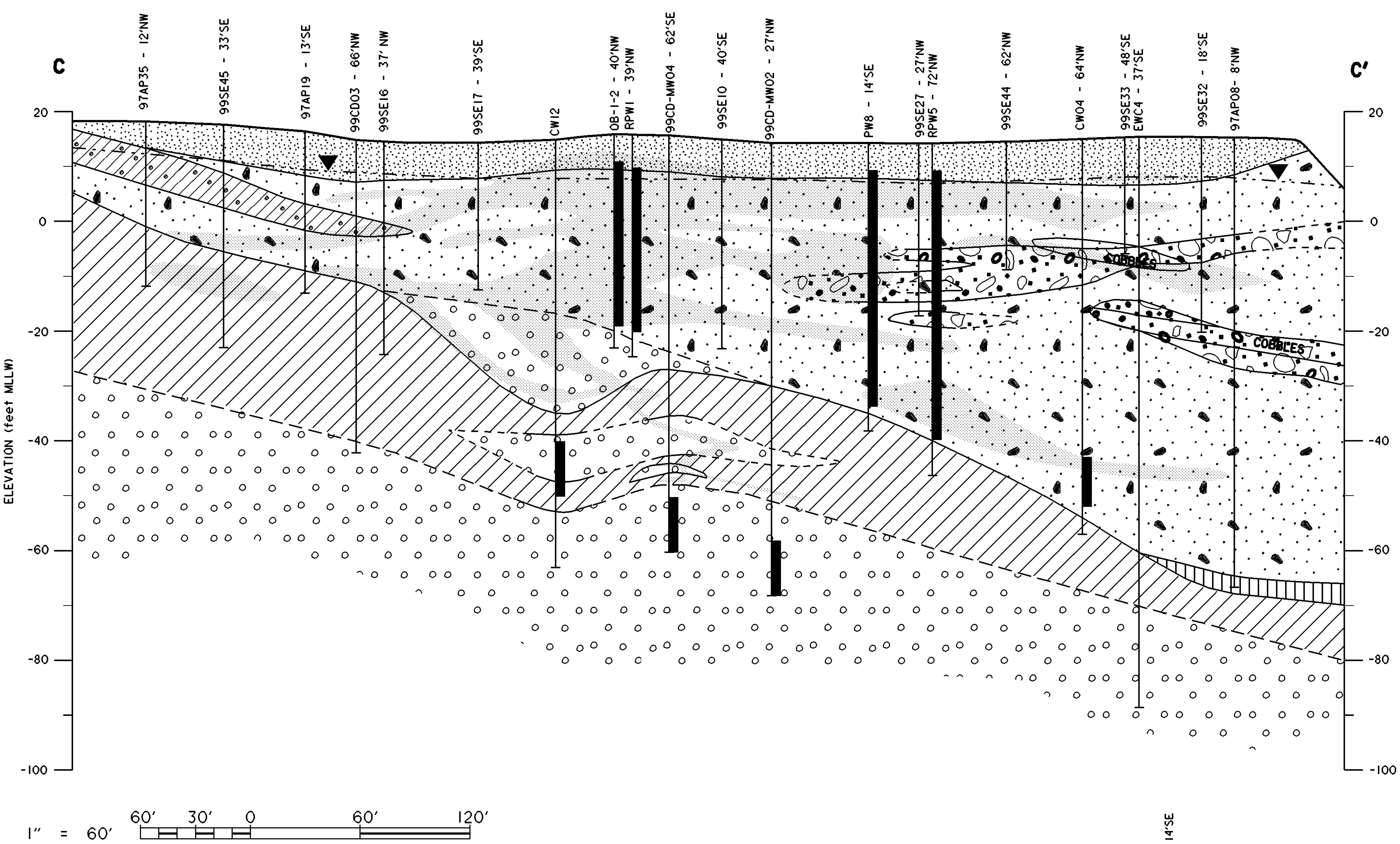
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

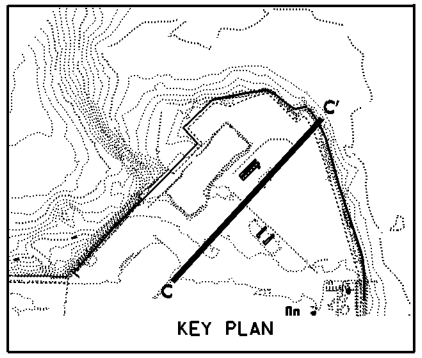
WYCKOFF/EAGLE HARBOR SUPERFUND SITE
SITE INFRASTRUCTURE SUPPORT

SITE PLAN 2

BAINBRIDGE ISLAND PN C1896 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-18	16JUL03	C-2
DSGN. NAHER		CHK.	SHEET 5	





GEOLOGIC UNITS

FILL:
BROWN, FINE SAND. RARE SHELL FRAGMENTS, WOOD DEBRIS AND MAN-MADE DEBRIS.

NON-MARINE CLAY:
GRAY TO BROWN, SOFT TO MEDIUM CLAY WITH PLANT FIBERS, WOOD AND ROOTS, AND BROWN CLAYEY FINE SAND.

MARINE SAND AND GRAVEL:
GRAY TO DARK GRAY, LOOSE TO DENSE SAND AND GRAVEL WITH OCCASIONAL COBBLES (COBBLE-RICH AND GRAVEL ZONE SHOWN SEPARATELY). LOW SILT CONTENT AND ABUNDANT SHELL FRAGMENTS.

MARINE SILT:
OLIVE-GRAY SILTY SAND (WITH THIN LAYERS OF SAND AND GRAVEL) TO SILT OR CLAY. ABUNDANT SHELL FRAGMENTS.

GLACIAL CLAY, SILT AND SAND:
GRAY BROWN SILTY SAND WITH GRAVEL, BLUE-GRAY SILT/CLAY, AND GRAY-BROWN SILT/CLAY; DENSE, NO ORGANIC MATTER.

FLUVIAL SAND:
DENSE TO VERY DENSE, GRAY-BROWN TO BROWN, WELL GRADED TO POORLY GRADED SAND WITH VARIABLE GRAVEL AND COBBLES.

SURFICIAL MARINE SEDIMENT:
OFFSHORE HARBOR-BOTTOM SILT AND CLAY, DARK OLIVE TO BLACK, OFTEN WITH ABUNDANT WOOD CHIPS AND WOOD AND PLANT DEBRIS.

MOBILE NAPL
(SEE DEFINITION IN TEXT)

PW8 - 14'SE ← BORING ID NUMBER AND DISTANCE OF OFFSET FROM ALIGNMENT

WELL SCREEN

▼ APPROX WATER TABLE

FIGURE 2.2-1

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

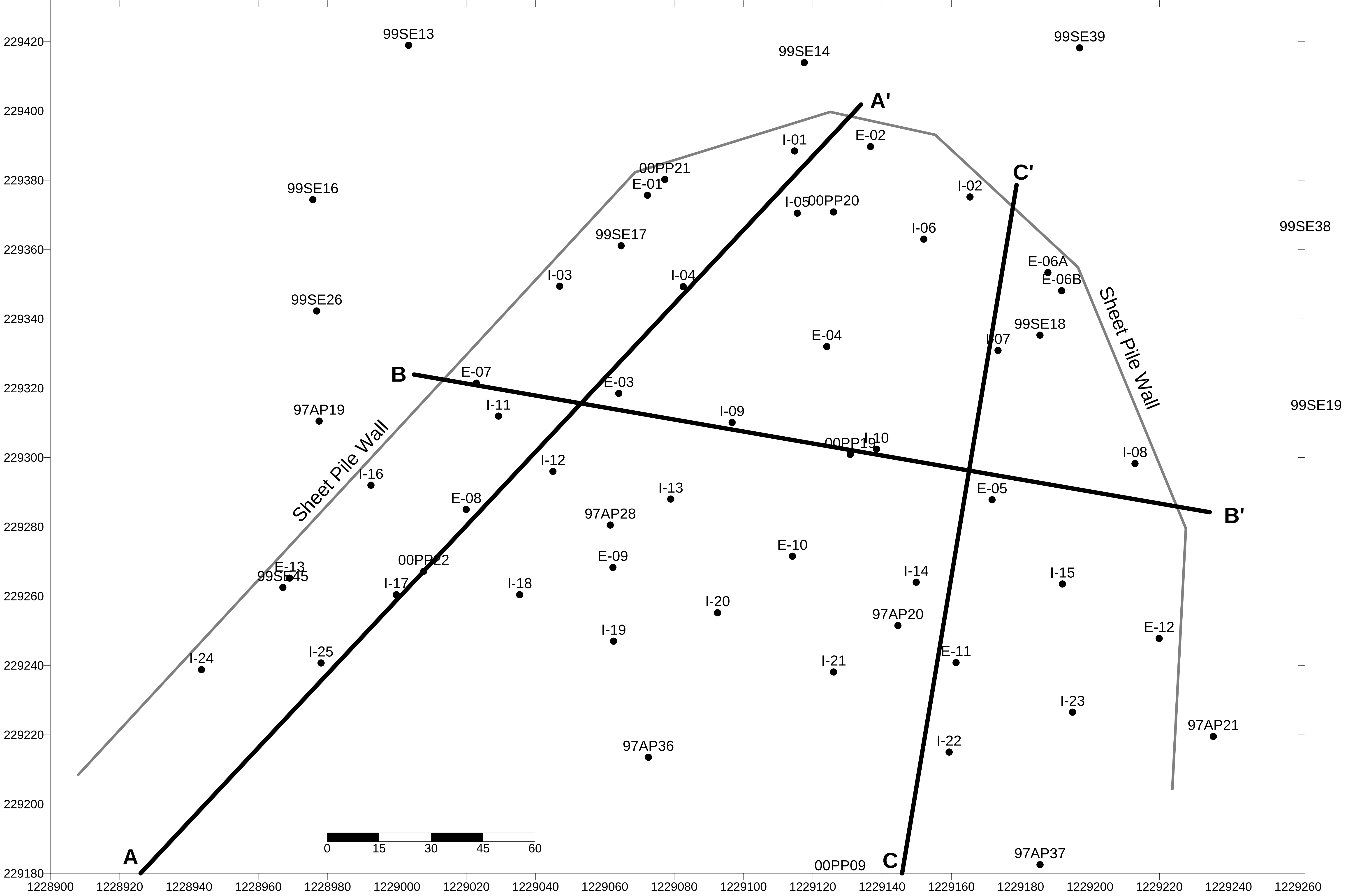
SITE GEOLOGIC PROFILE

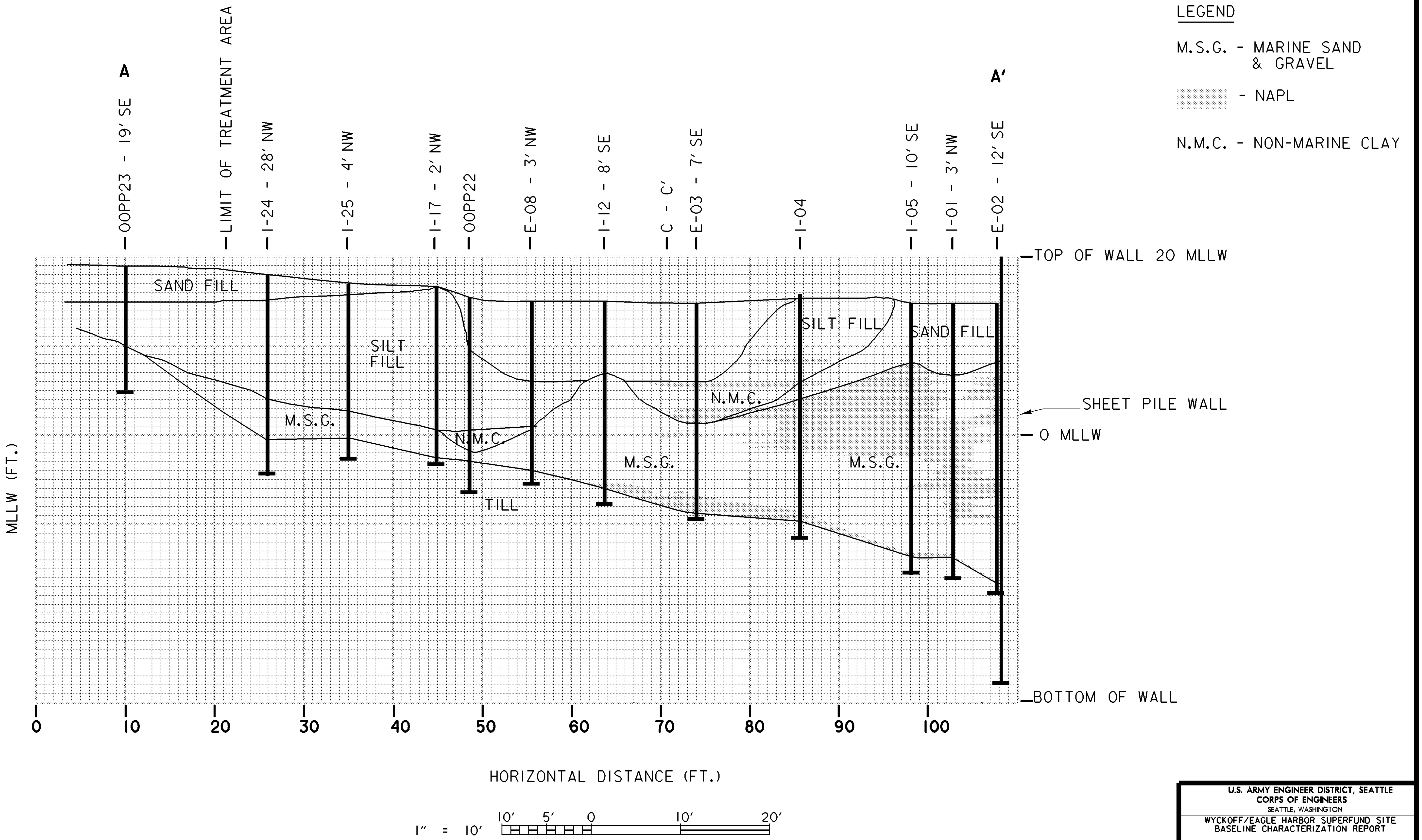
SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D				8
DSGN. BROOKSHIER		CHK. EASTERLY	FIGURE	

DATE AND TIME PLOTTED: 27-JUL-2004 21:33
DESIGN FILE: P:ØGeotechØGEOLOGYØLOLAØwyckoff_report_mk_jUL04Øcopy o

DATE AND TIME PLOTTED: 27-JUL-2004 21:33
DESIGN FILE: P:ØGeotechØGEOLOGYØLOLAØwyckoff_report_mk_jUL04Øcopy of wyfecs0f.dgn

Figure 3.2-1. Location map showing profiles through the Pilot Study Area.





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DATE AND TIME PLOTTED: 27-JUL-2004 21:29
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U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
BASELINE CHARACTERIZATION REPORT

FIGURE3.2-2
PROFILE A - A′

BAINBRIDGE ISLAND WASHINGTON

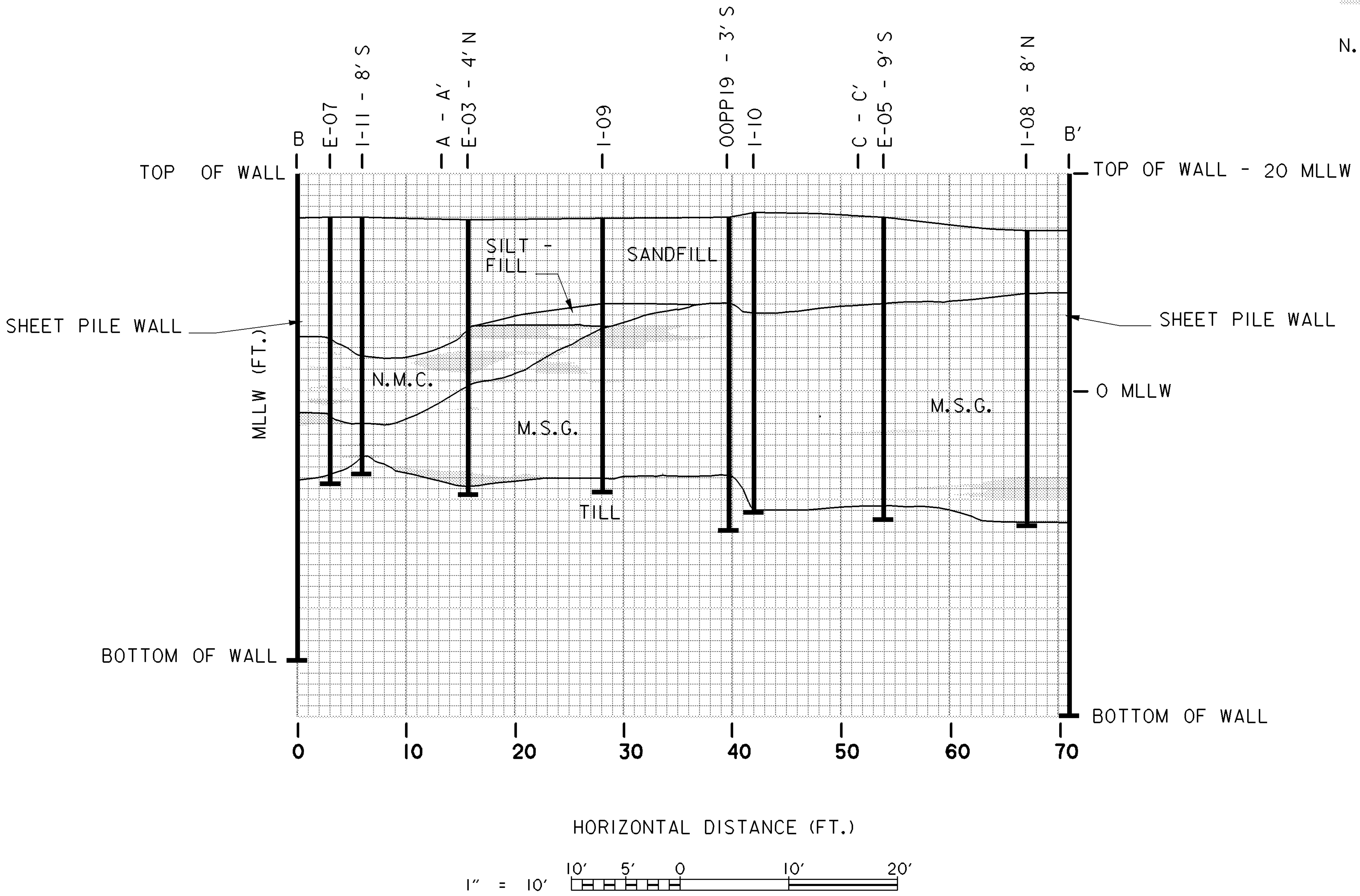
SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D			30 SEP 02	
DSGN. BROOKSHIER/ SCHIEFFELBEIN		CHK. BAILEY	SHEET	

LEGEND

M.S.G. - MARINE SAND & GRAVEL

▨ - NAPL

N.M.C. - NON-MARINE CLAY



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DATE AND TIME PLOTTED: 27-JUL-2004 21:27
DESIGN FILE: P:\GEOTECH\GEOLOGY\LOLA\WYCKOFF_REPORT_MK_JUL04\WYCKOFFBASEB.DGN

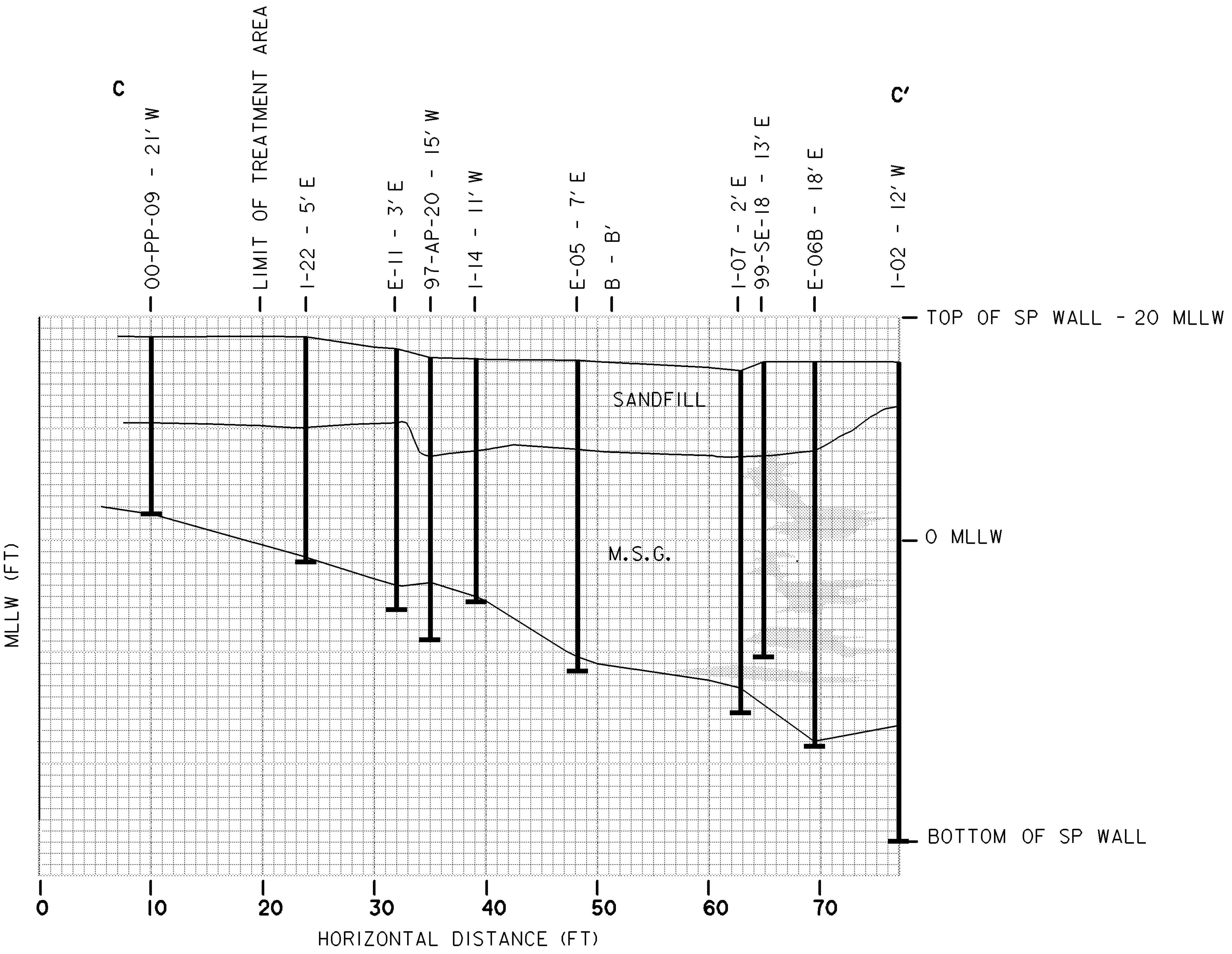
COMPUTER AIDED DESIGN & DRAFTING

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
WYCKOFF/EAGLE HARBOR SUPERFUND SITE

FIGURE 3.2-3
PROFILE B – B'

BAINBRIDGE ISLAND WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE: 30 SEP 02	PLATE
DSGN. BROOKSHIER/ SCHIEFFELBEIN		CHK. BAILEY	SHEET	



LEGEND

M.S.G. - MARINE SAND & GRAVEL

▨ - NAPL

NOTE:

I-02 IS SUPERIMPOSED OVER SP WALL, WHERE SECTION LINE CROSSES WALL ALIGNMENT

1" = 10'   10' 5' 0 10' 20'

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

FIGURE 3.2-4
PROFILE C - C'

BAINBRIDGE ISLAND   WASHGINTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D			30 SEP 02	
DSGN. BROOKSHIER/ SCHIEFFELBEIN		CHK. BAILEY	SHEET	

DATE AND TIME PLOTTED: 27-JUL-2004 21:27
DESIGN FILE: P:\GEOTECH\GEOLOGY\LOLA\WYCKOFF_REPORT_MK_JUL04\WYCKOFFBASEC.DGN

Figure 3.5-1. Wyckoff/Eagle Harbor Superfund Site Monitoring Well Network

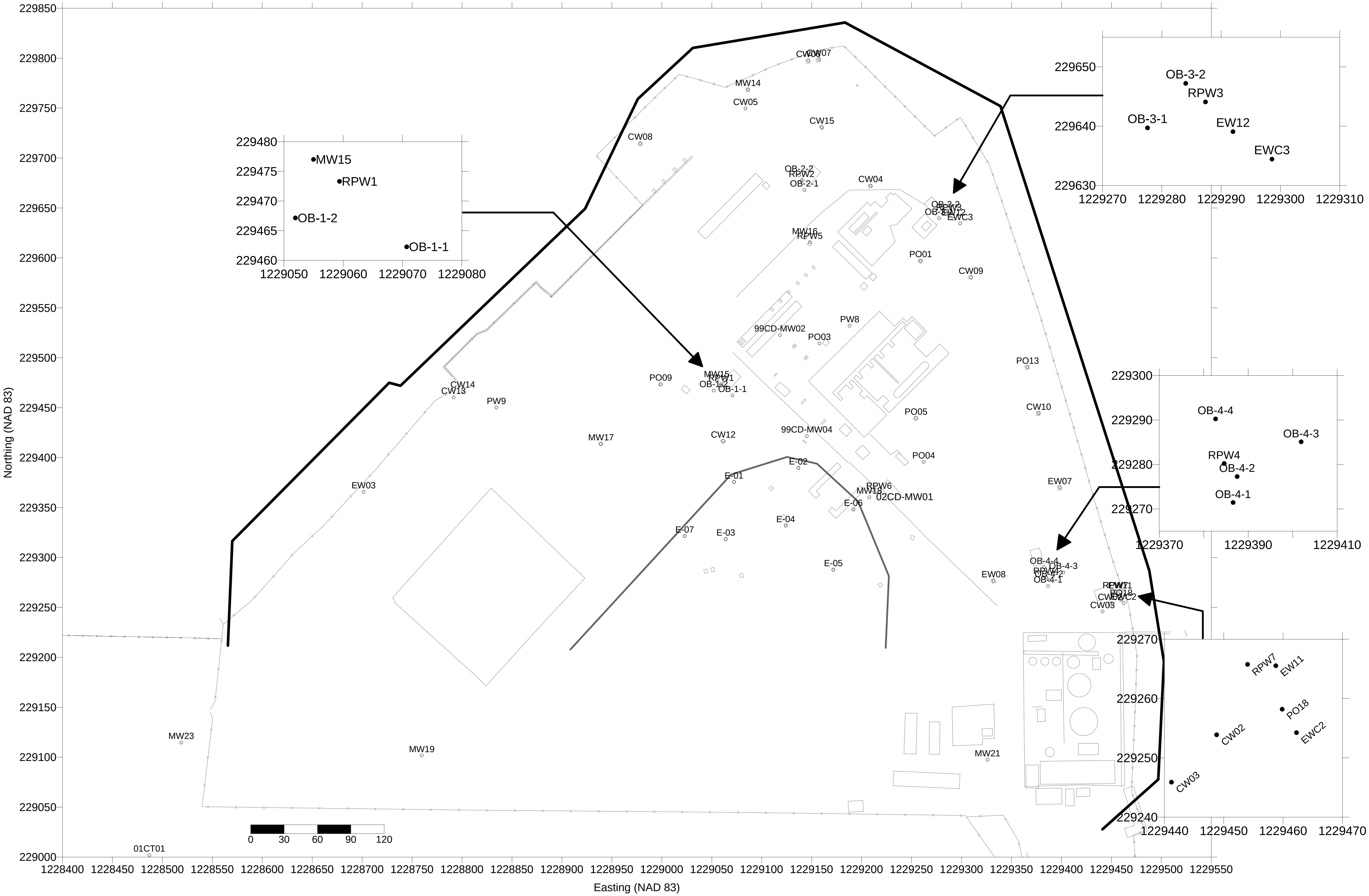
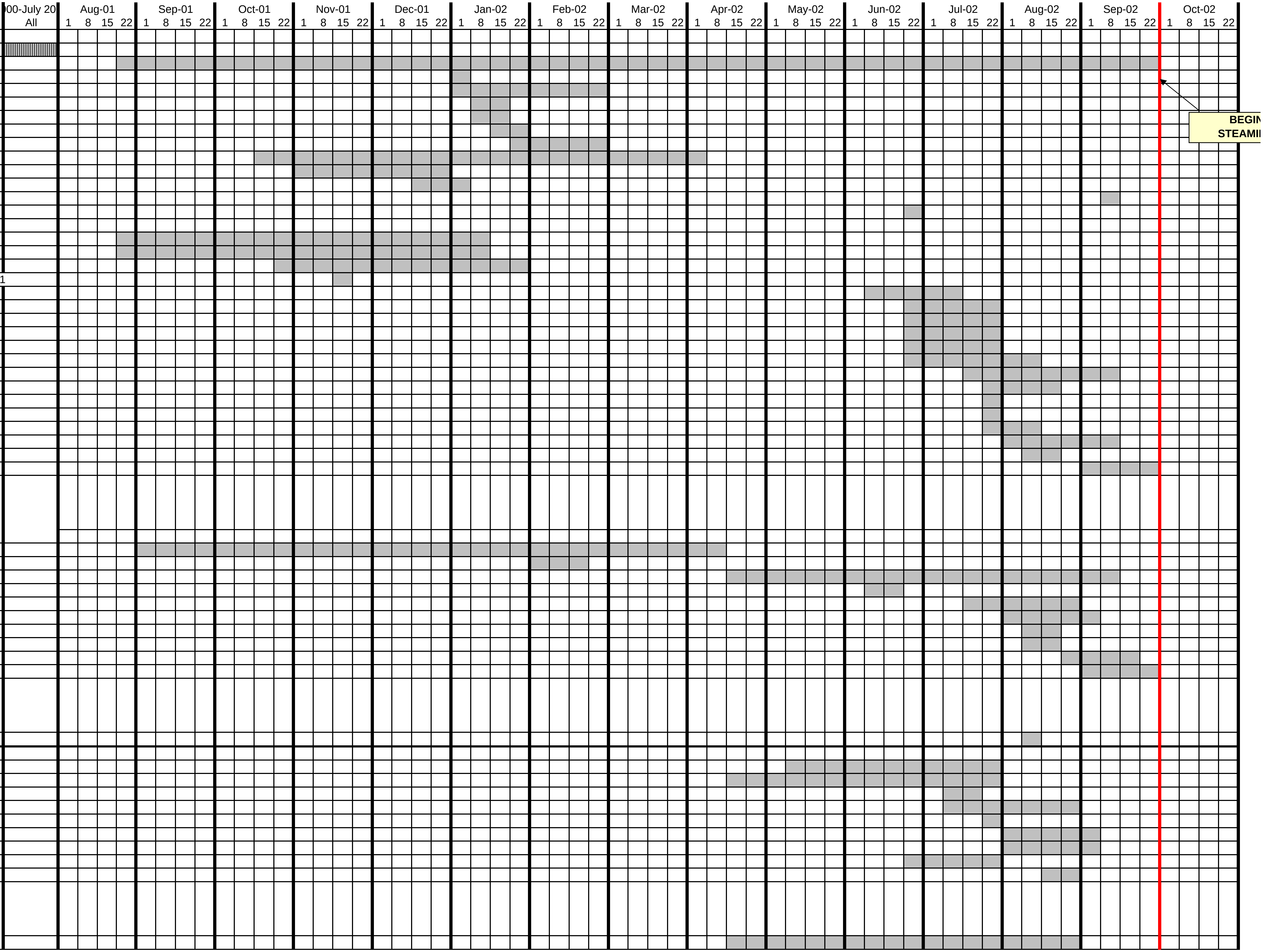


Figure 4.0-1 Construction Timeline



Prime Contractor	Task	Month/Year Date
	Site Infrastructure	
Bay West	Sheet Pile Wall	11/01/00-2/14/01
MarVac	Vapor Cap Installation	8/29/01-9/24/02
MarVac	Boiler Room Access Pad	1/2/02-1/7/02
MarVac	Boiler Building Erection	1/2/02-2/27/02
MarVac	Fuel Storage Tank Pads	1/10/02-1/16/02
MarVac	Water Storage Tank Pad	1/10/02-1/16/02
MarVac	Piping to TP	1/18/02-1/23/02
MarVac	Pump House Shed	1/27/02-2/24/02
MarVac	Water Well Utilities	10/17/01-4/1/02
MarVac	Building Foundation Slab	11/6/01-12/23/01
MarVac	Electrical Utilities	12/21/01-1/7/02
Pease	PSE Power to Mechanical Bldg	9/10/2002
Pease	Transformer	6/25/2002
	Steam Generation/Conveyance	
MarVac	Water Well Installation/Development	8/20/01-1/14/02
MarVac	Water Well Pump	8/20/01-1/14/02
MarVac	Injection Wells	10/31/01-1/28/02
MarVac	Remove Exposed West Dock Pilings	11/15/01-11/17/01
Pease	Water Tank	6/13/02-7/11/02
Pease	Expansion Joints	6/25/02-7/24/02
Pease	Air Compressors	6/25/02-7/29/02
Pease	St. Inj. Piping to Well Field	6/26/02-7/24/02
Pease	Steam Injection Piping	6/26/02-7/24/02
Pease	Boiler	6/26/02-8/8/02
Pease	Blow Down Tank	7/18/02-9/11/02
Pease	Water Well/Feed Piping	7/23/02-8/16/02
Pease	Boiler Feed Pumps	7/30/02-7/31/02
Pease	Deaerator Feed Pumps	7/30/02-7/31/02
Pease	Treatment Plant Feed Pumps	7/30/02-8/9/02
Pease	Boiler Stack	8/6/02-9/10//02
Pease	Deaerator	8/12/02-8/16/02
Pease	Feed Water Softeners	9/2002
Pease	Flow Meters	Installed at various times prior to and during pilot
	Liquid Conveyance/Treatment	
MarVac	Extraction Wells	9/2/01-5/6/02
Pease	Tank T-303	2/7/02-2/15/02
Pease	Piping from Well Field	4/16/02-9/10/02
Pease	Extraction Well Pumps	6/10/02-6/17/02
Pease	New TP Piping	7/19/02-8/22/02
Pease	Heat Exchangers	8/1/02-9/4/02
Pease	Caustic Chemical Tank	8/14/02-8/21/02
Pease	Acid Chemical Tank	8/14/02-8/21/02
Pease	DAF-104 (Dissolved Air Flot. Tank)	8/23/02-9/16/02
Pease	Multimedia Filter	9/2002
Pease	Flow Meters	Installed at various times prior to and during pilot
Pease	Demolish T-101, Sep-102 in TP	8/9/2002
	Vapor Treatment	
Pease	Vapor Collector Laterals	5/9/02-7/22/02
Pease	Piping from Well Field	4/16/02-7/29/02
Pease	Sour Gas Line Condensate Receiver	7/12/02-7/17/02
Pease	Sour Gas Piping	7/12/02-8/23/02
Pease	Condensate Pumps	7/30/02-7/31/02
Pease	Heat Exchanger (HX-3)	8/1/02-9/4/02
Pease	HX-3 Condensate Tank	8/1/02-9/4/02
Pease	Oil Sealed LRV Pumps	6/28/02-7/30/02
Pease	Thermal Oxidizer	8/16/02-8/23/02
Pease	Flow Meters	Installed at various times prior to and during pilot
Pease	Pilot Area Piping	4/19/02-8/20/02

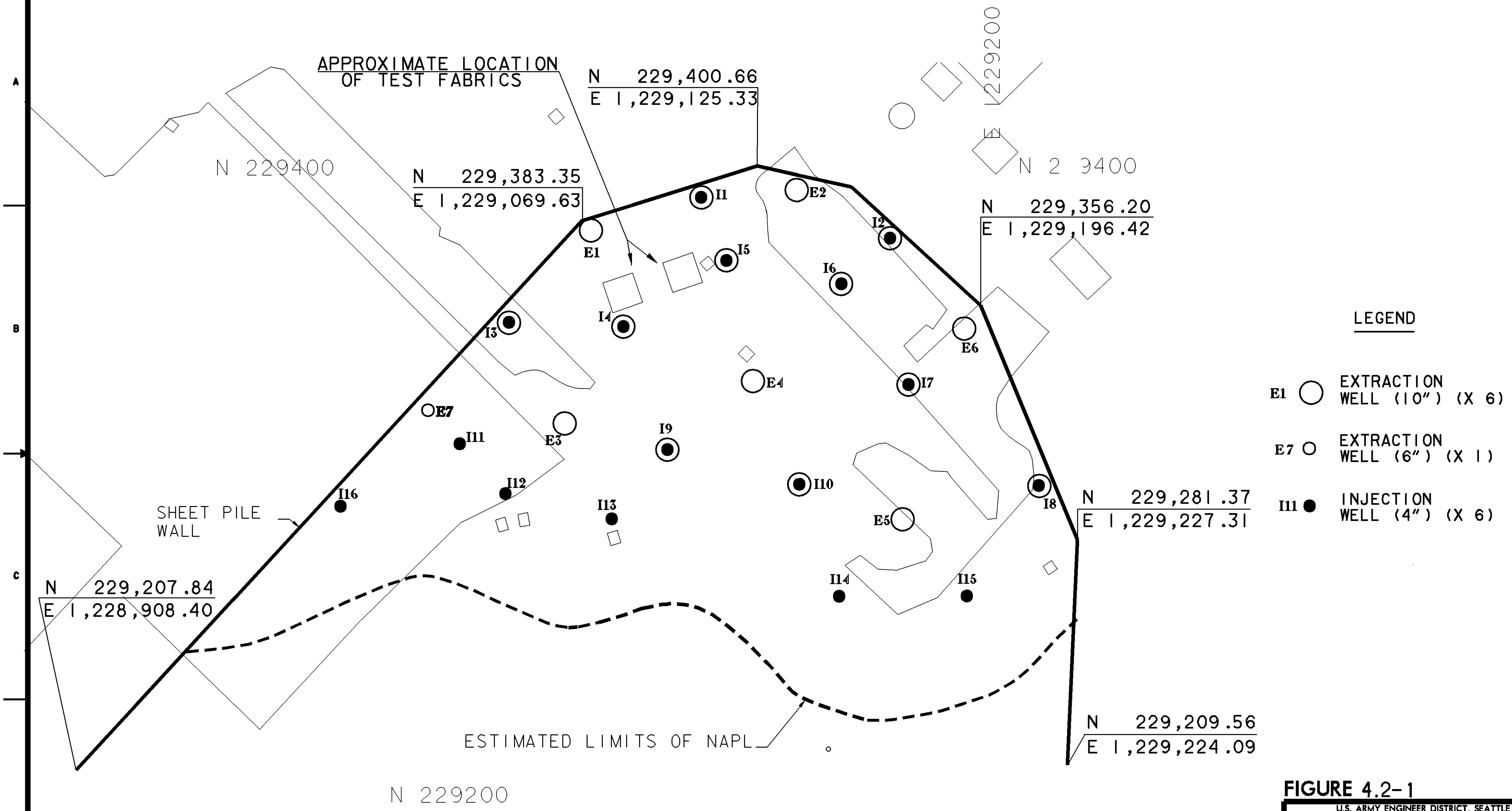


FIGURE 4.2-1

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
SITE INFRASTRUCTURE SUPPORT

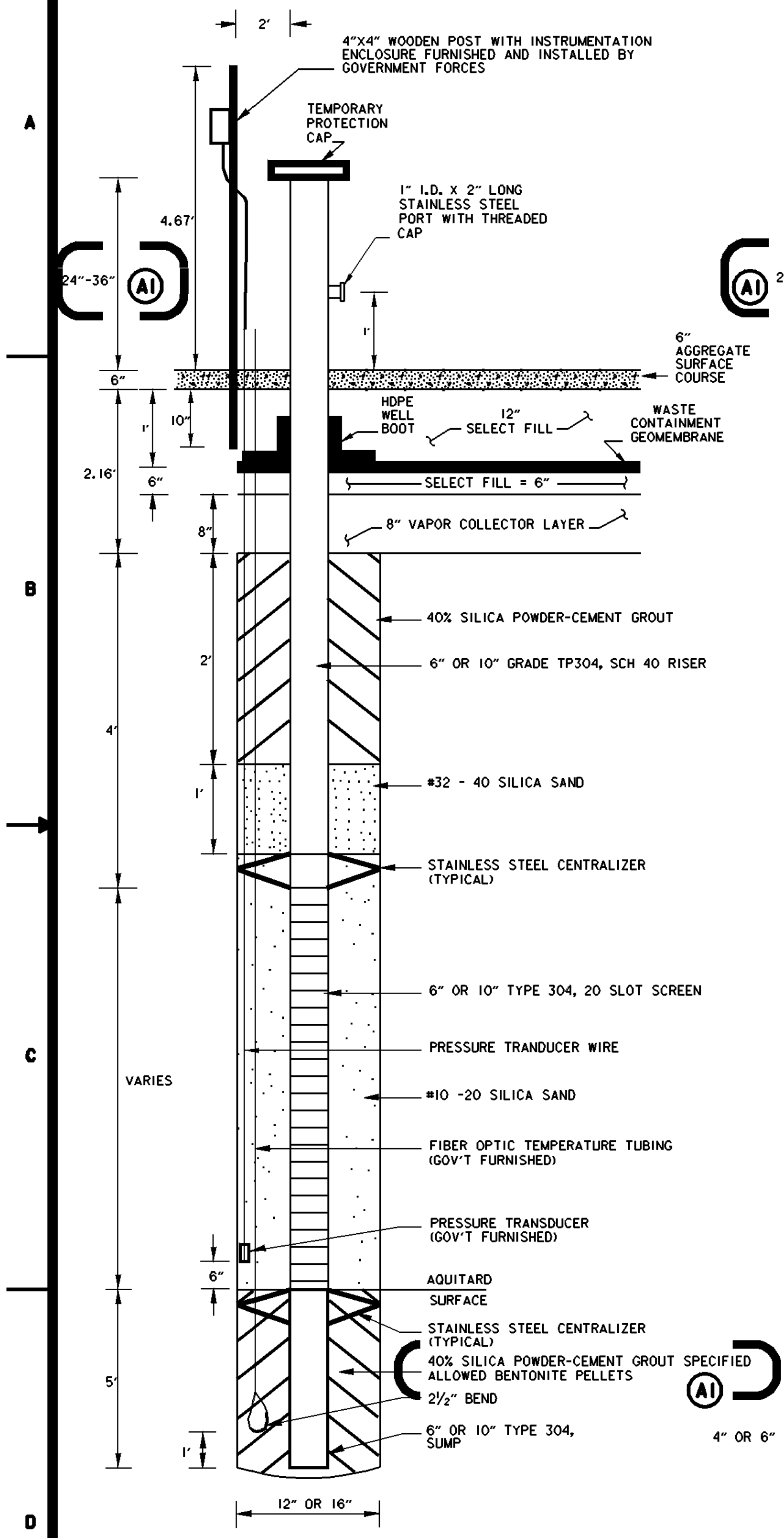
WELL LAYOUT

BAINBRIDGE ISLAND PN C1896 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-18	16JUL03	
DSGN. EASTERLY/ BROOKSHIER/SCHEFFLEIN		CHK. EASTERLY/ BROOKSHIER	SHEET 2	

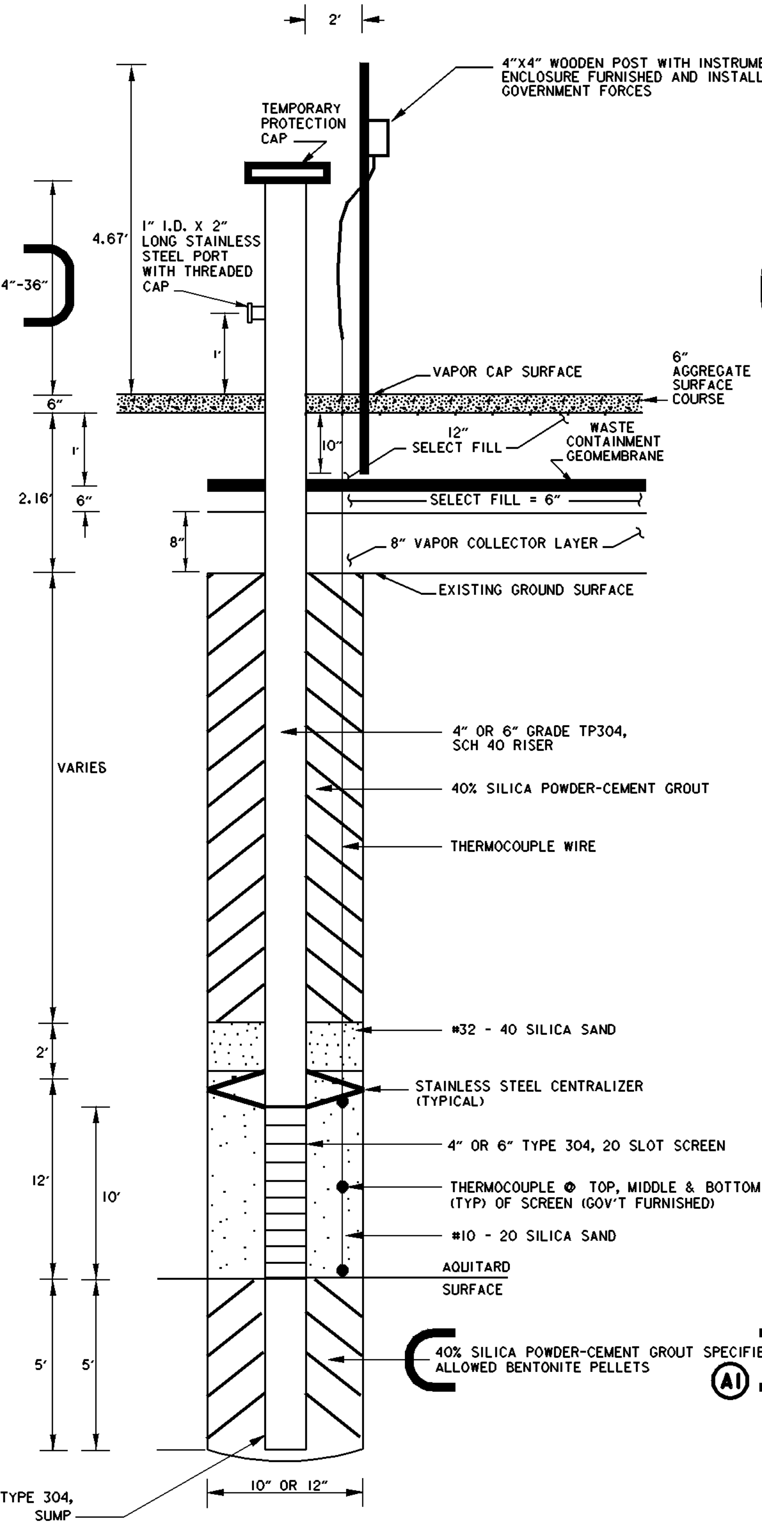
NOTES: 1. AVERAGE SPACING = 1.6 X DEPTH.
2. TOTAL WELLS = 23.

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		ADDED AS-BUILT ABOVE TITLE BLOCK	16JUL03	MV
A1	A,D-2,3,4	NOTE AND DIMENSION REVISIONS	16JUL03	MV



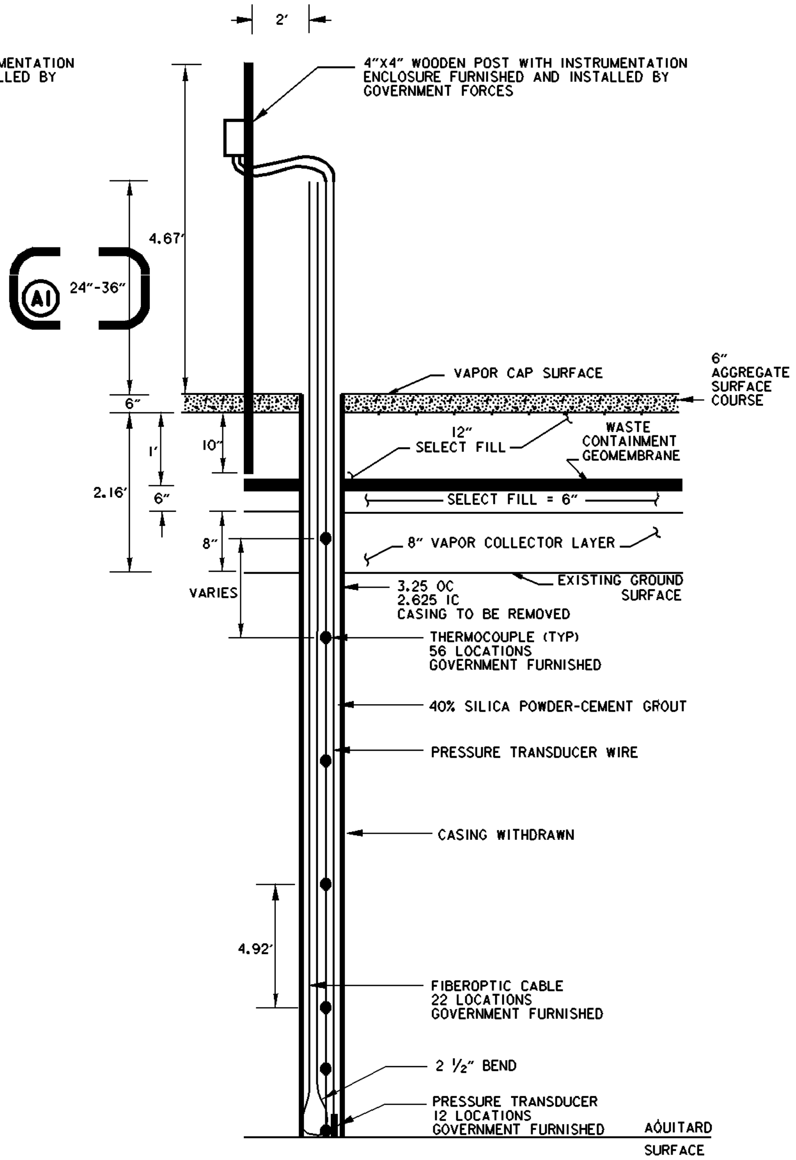
EXTRACTION WELL DETAIL

NOT TO SCALE



INJECTION AND DUAL-PURPOSE WELL DETAIL

NOT TO SCALE



INSTRUMENTATION STRING DETAIL*

NOT TO SCALE

NOTE:

1. SEE PLATE GT-1 FOR WELL AND TEMPERATURE STRING LOCATIONS.
2. *TO BE INSTALLED UNDER SEPARATE CONTRACT.

This project was designed by the Seattle District U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear within the specifications or on these project documents within the scope of their employment as required by ER 1110-1-8152, Professional Registration.

FIGURE 4.2-2

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
SITE INFRASTRUCTURE SUPPORT

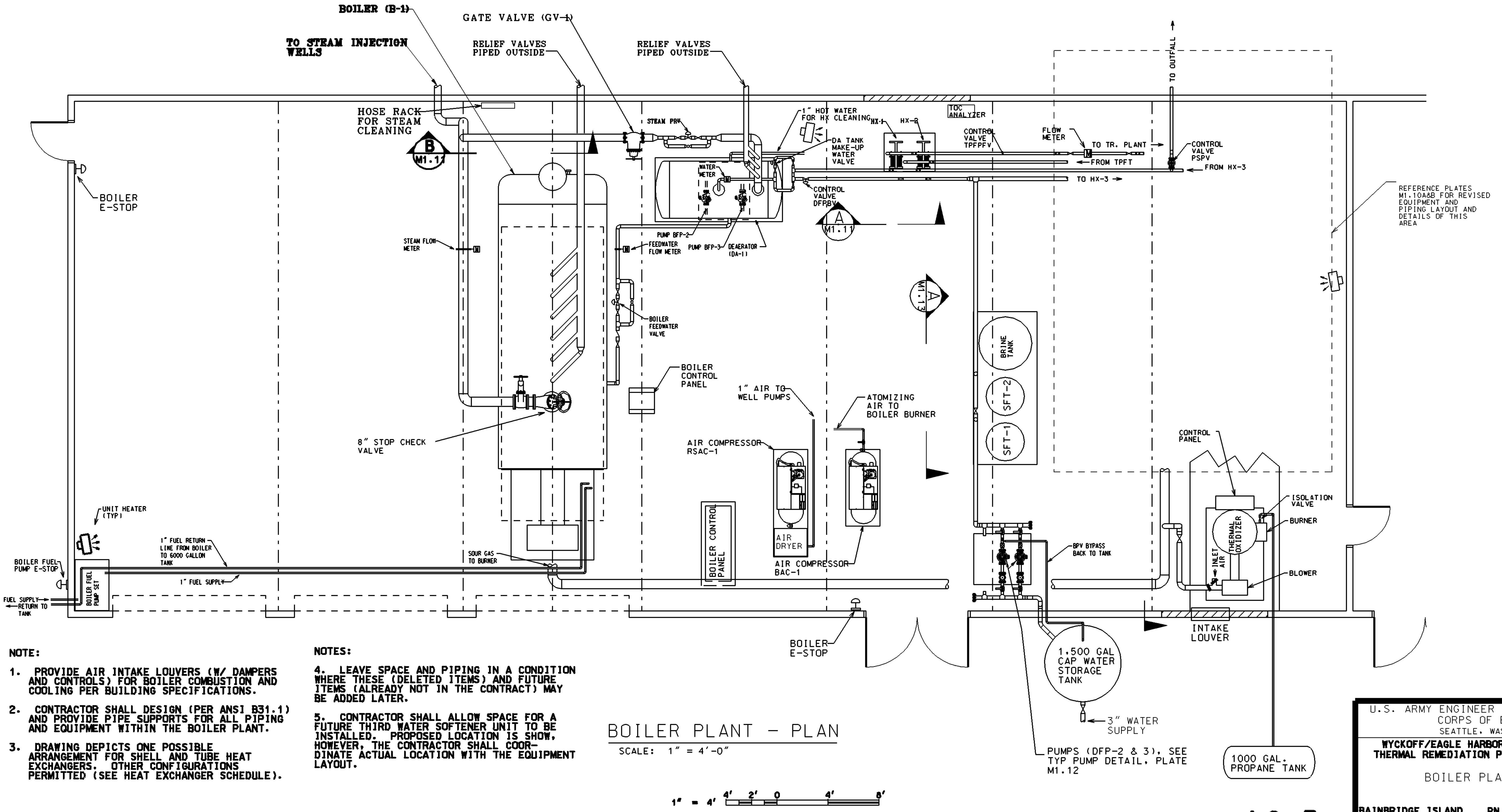
INJECTION AND EXTRACTION WELLS
AND INSTRUMENTATION STRING DETAIL

BAINBRIDGE ISLAND PN C1896 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-18	16JUL03	

DSGN. BROOKSHIER/ NEYERHOLTZ/SCHEFFLEIN
CHK. BROOKSHIER/ NEYERHOLTZ
SHEET 3

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		REVISED AS-BUILT	01DEC03	JJK



BOILER PLANT - PLAN

SCALE: 1" = 4'-0"

NOTE:

1. PROVIDE AIR INTAKE LOUVERS (W/ DAMPERS AND CONTROLS) FOR BOILER COMBUSTION AND COOLING PER BUILDING SPECIFICATIONS.
2. CONTRACTOR SHALL DESIGN (PER ANSI B31.1) AND PROVIDE PIPE SUPPORTS FOR ALL PIPING AND EQUIPMENT WITHIN THE BOILER PLANT.
3. DRAWING DEPICTS ONE POSSIBLE ARRANGEMENT FOR SHELL AND TUBE HEAT EXCHANGERS. OTHER CONFIGURATIONS PERMITTED (SEE HEAT EXCHANGER SCHEDULE).

NOTES:

4. LEAVE SPACE AND PIPING IN A CONDITION WHERE THESE (DELETED ITEMS) AND FUTURE ITEMS (ALREADY NOT IN THE CONTRACT) MAY BE ADDED LATER.
5. CONTRACTOR SHALL ALLOW SPACE FOR A FUTURE THIRD WATER SOFTENER UNIT TO BE INSTALLED. PROPOSED LOCATION IS SHOW, HOWEVER, THE CONTRACTOR SHALL COORDINATE ACTUAL LOCATION WITH THE EQUIPMENT LAYOUT.

FIGURE **4.2- 3**

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

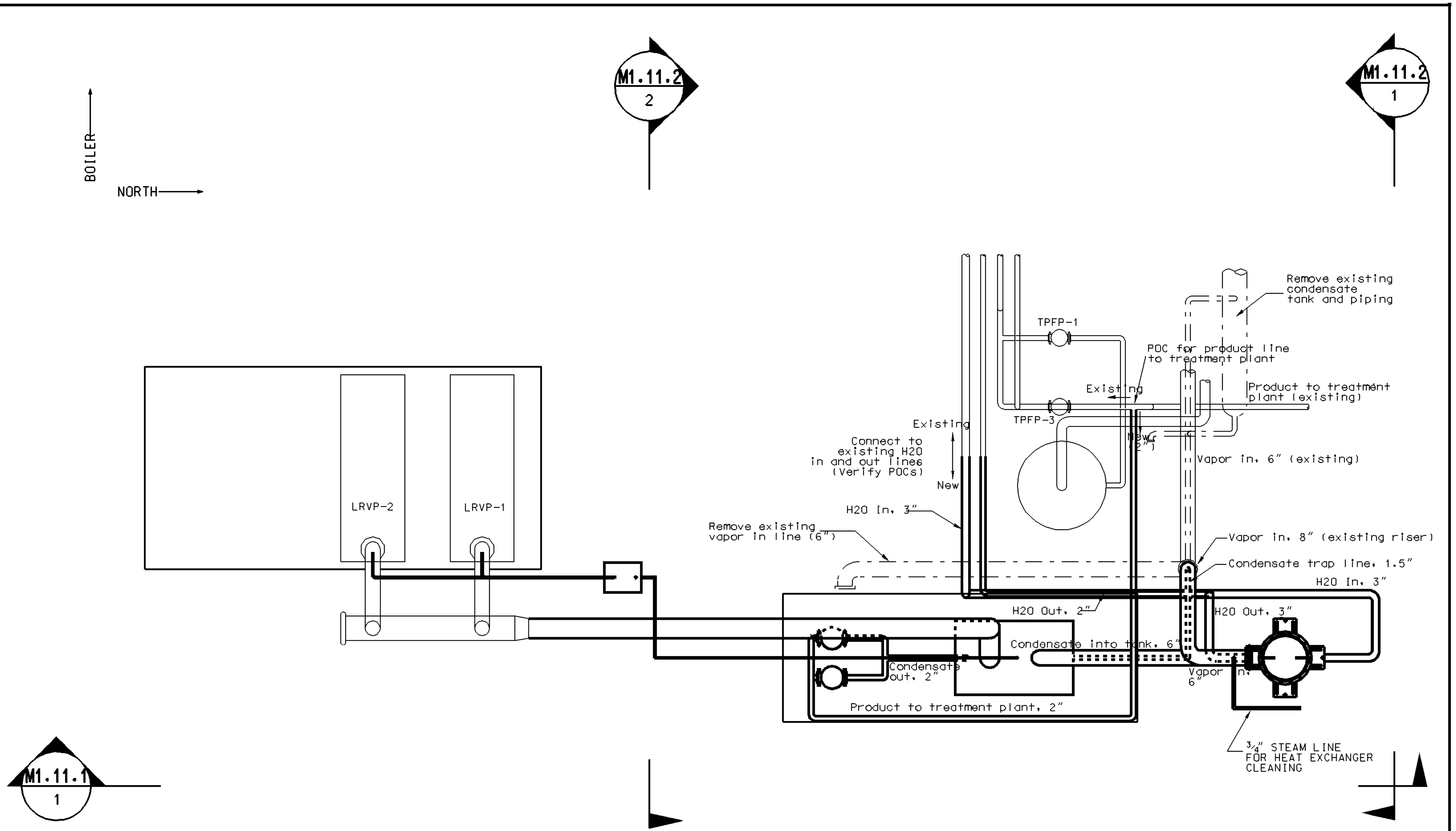
WYCKOFF/EAGLE HARBOR SUPERFUND SITE
THERMAL REMEDIATION PILOT CONSTRUCTION

BOILER PLANT LAYOUT

BAINBRIDGE ISLAND PN C1911 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-20	16NOV01	
DSGN. LJE		CHK. DANJELS	SHEET 13	

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		REVISED AS-BUILT	12-1-03	JJK



PLAN VIEW

Legend	
Dimension lines	
Existing pipe/equipment	———
Existing pipe/equipment (hidden lines)	- - - - -
New pipe/equipment	━━━
New pipe/equipment (hidden lines)	▪▪▪▪▪
Existing pipe/equipment to be removed	— - —

NOTES:

1. VALVES AND METERS NOT SHOWN ON PLAN VIEW - SEE SCHEMATIC.

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PREPARED:

SVEN H. LIE, P.E.
CHIEF, MECHANICAL SECTION

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

Wyckoff Superfund Site
Thermal Remediation Pilot Study

BOILER PLANT LAYOUT - PLAN MODIFICATIONS

SIZE	INVITATION NO.	FILE NO.		PLATE
				M1.10.1
DSGN: AMM	CHK:		SHEET	

FIGURE **4.2-4**

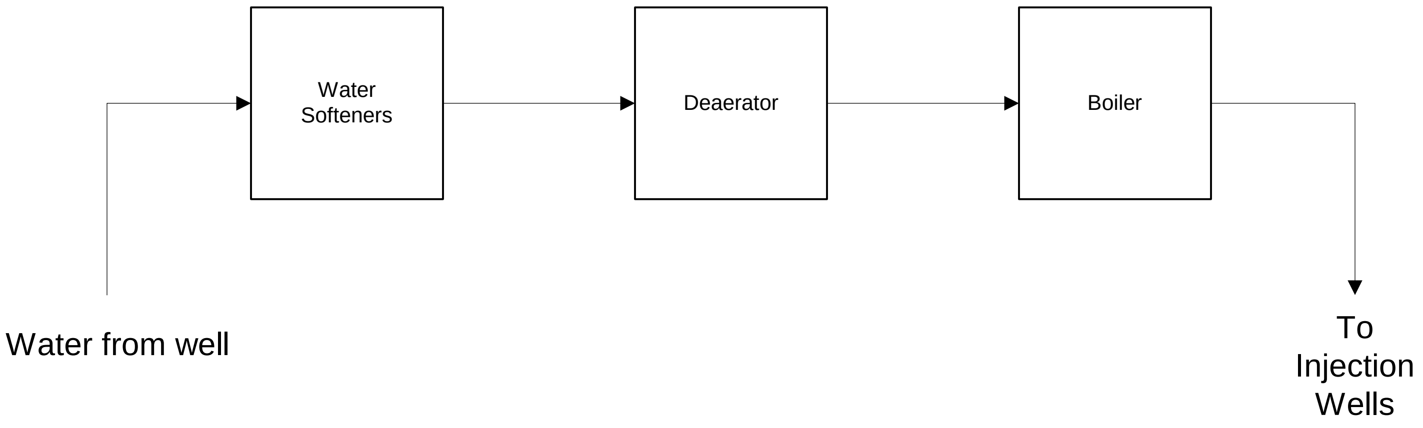
U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
THERMAL REMEDIATION PILOT CONSTRUCTION

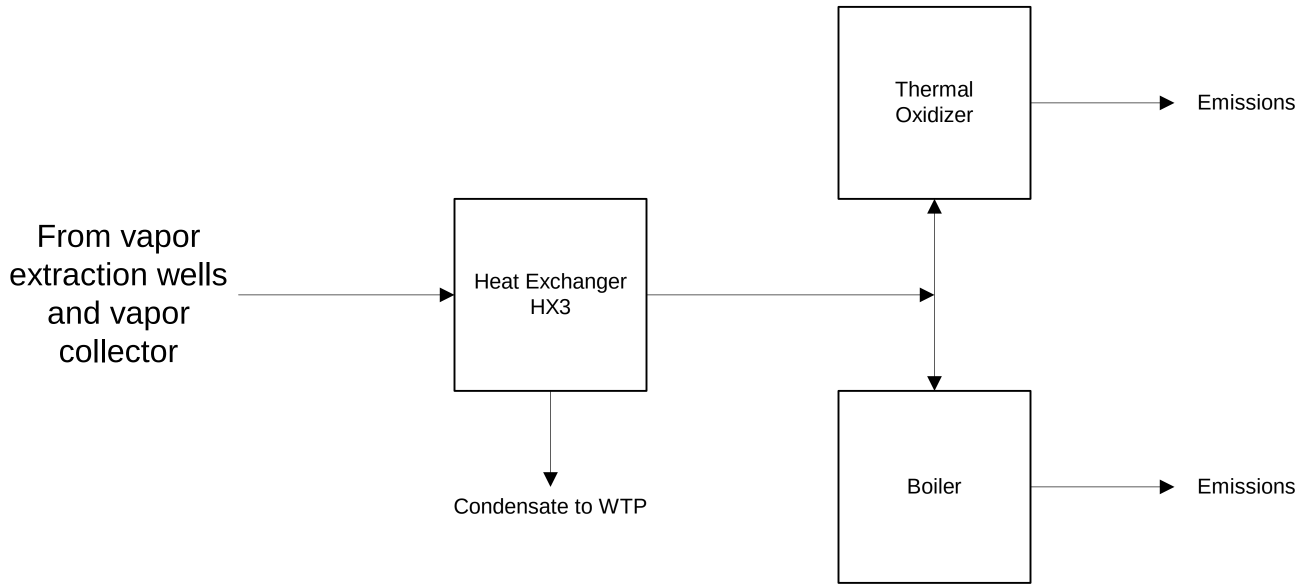
REVISED HX-3 LAYOUT
AND DETAILS

BAINBRIDGE ISLAND PN C1911 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D				
DSGN.		CHK.	SHEET 13A	



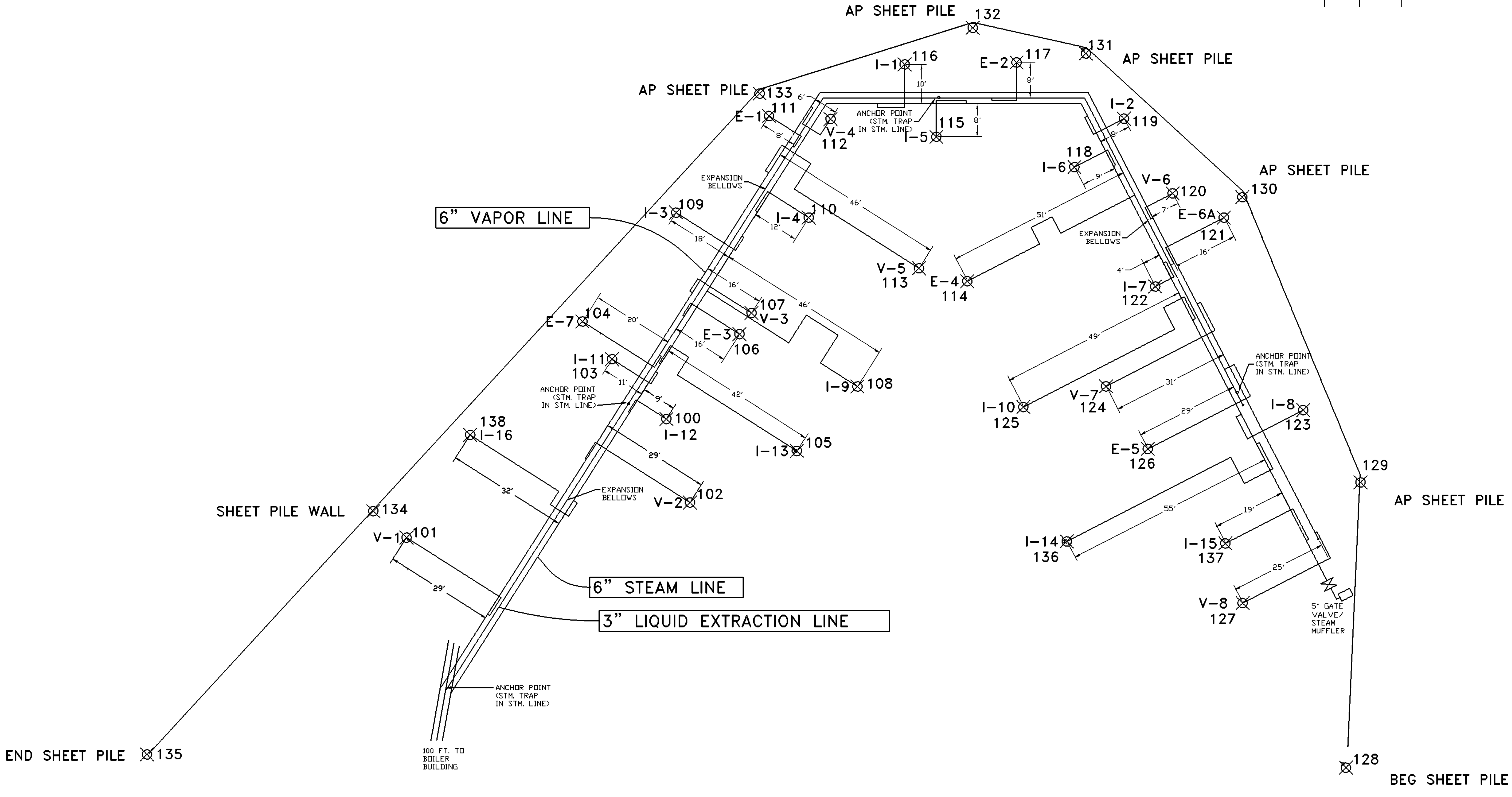
Steam Generation Process Flow Diagram



Vapor Treatment Process Flow Diagram

FIGURE 4.2-5 STEAM AND VAPOR PROCESS FLOW DIAGRAMS

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		REVISED AS-BUILT	01DEC03	JJK



1" = 15' 15' 7.5' 0 15' 30'

FIGURE 4.2-6

U.S. ARMY ENGINEER DISTRICT, SEATTL
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

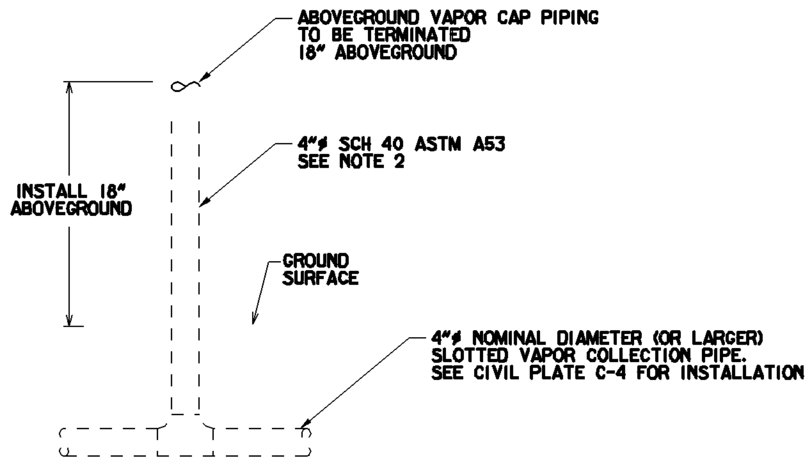
WYCKOFF/EAGLE HARBOR SUPERFUND SITE
THERMAL REMEDIATION PILOT CONSTRUCTION

ABOVEGROUND PIPING- REVISED

BAINBRIDGE ISLAND PN C1911 WASHINGTON

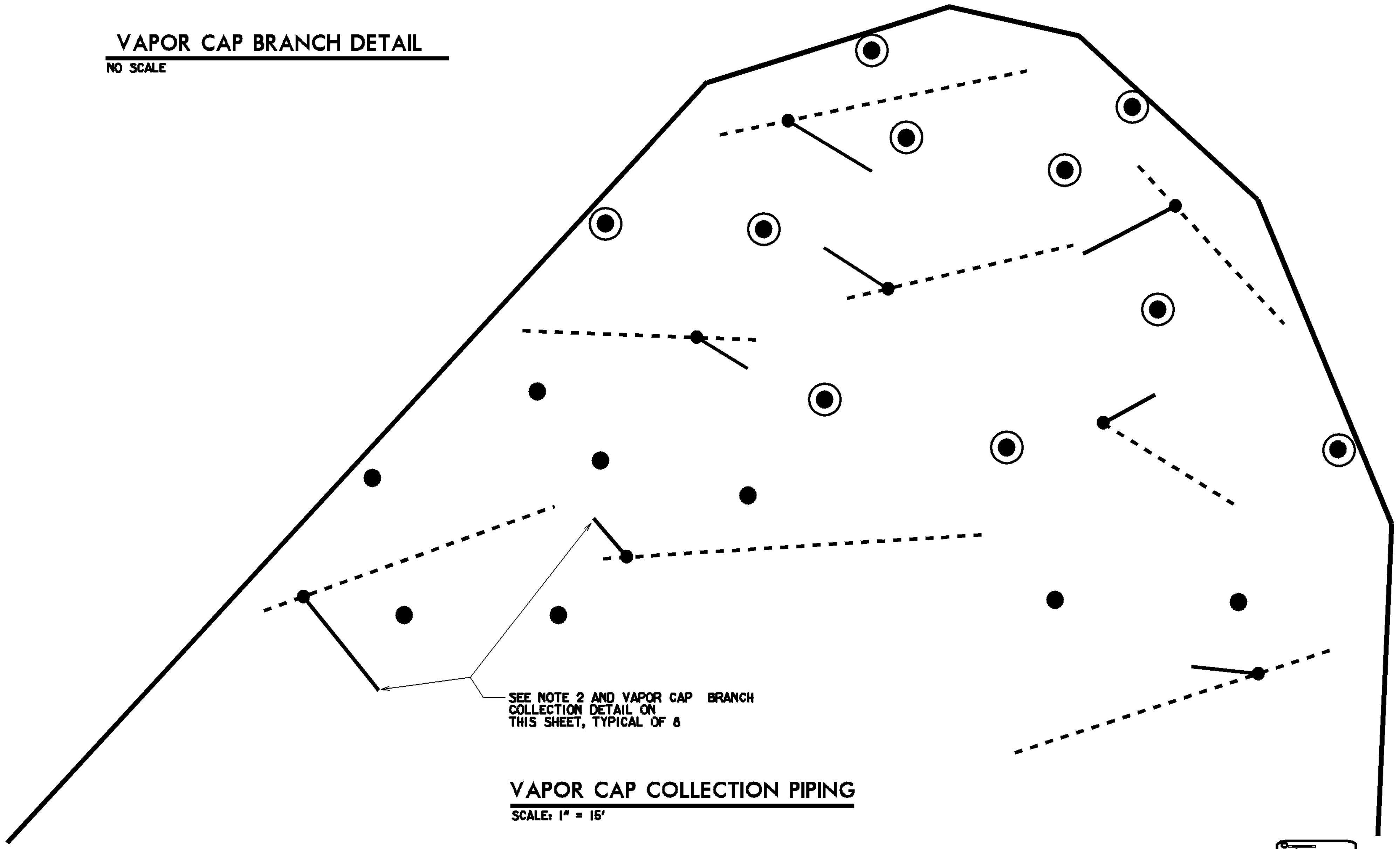
SIZE D	INVITATION NO.	FILE NO.	DATE: 25AUG03	PLATE
DSGN.		CHK.	SHEET 8A	

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		ADDED AS-BUILT ABOVE TITLE BLOCK	16JUL03	MV



VAPOR CAP BRANCH DETAIL

NO SCALE



VAPOR CAP COLLECTION PIPING

SCALE: 1" = 15'

LEGEND

———	ABOVE GROUND PIPING (VAPOR CAP BRANCH) NOT IN CONTRACT
- - - -	BELOW GROUND PIPING (VAPOR CAP COLLECTION PIPING) NOT IN CONTRACT
●	CONNECT THIS END OF VAPOR CAP BRANCH TO VAPOR EXTRACTION MAIN NOT IN CONTRACT

NOTES:

1. LENGTH OF BELOW GROUND PIPING SHALL BE SCALED FROM THE DRAWING.
2. VAPOR COLLECTION PIPING BELOW GRADE SHALL BE INSTALLED UNDER THIS CONTRACT. ABOVE GROUND HORIZONTAL PIPING IS FOR FUTURE WORK.

1" = 15'   15' 7.5' 0 15' 30'

FIGURE 4.2-7

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
SITE INFRASTRUCTURE SUPPORT

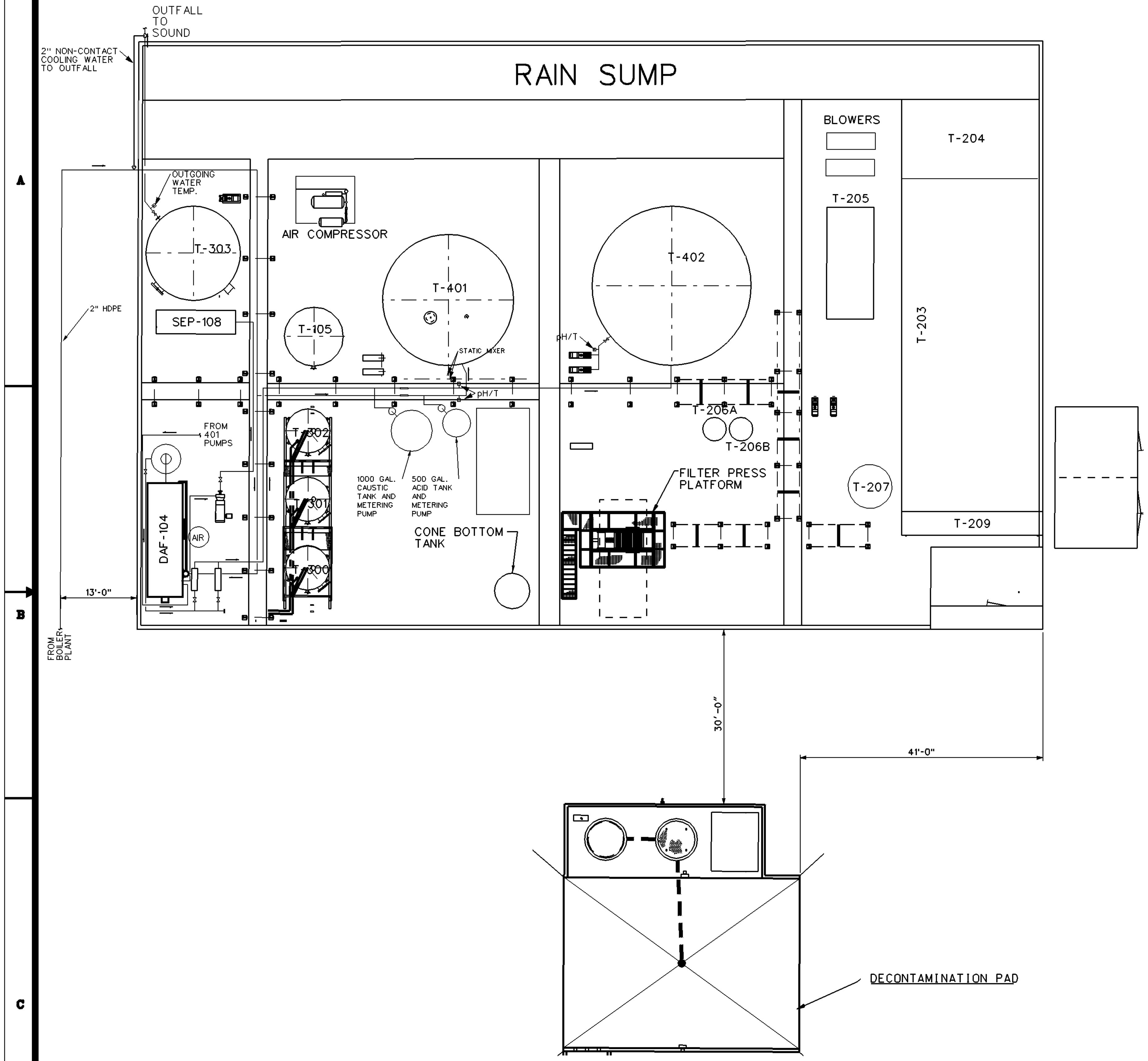
VAPOR COLLECTION PIPING

BAINBRIDGE ISLAND PN C1896 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-18	16JUL03	
DSGN. LIE		CHK.	SHEET 11	

N 229200

SYMBOL	ZONE	DESCRIPTION	DATE	BY
		REVISED AS-BUILT	01DEC03	JJK



SITE PLAN
$^3/_{32}$"=1'-0"

WATER TREATMENT PLANT EQUIPMENT

ID	CAPACITY	DIMENSIONS	DESCRIPTION
DAF-104	120 gpm	85 ft^2 FLOTATION AREA	DISSOLVED AIR FLOTATION UNIT WITH RECYCLE, COVERED
STATIC MIXERS (2)	120 gpm	3" X 6 ELEMENTS	MOTIONLESS MIXERS WITH ANSI 150# FLANGE
CHEMICAL STORAGE TANK	1,000 gal.		CAUSTIC STORAGE TANK
CHEMICAL STORAGE TANK	500 gal.		ACID STORAGE TANK
CHEMICAL FEED PUMP	2 g.p.m.		CAUSTIC FEED PUMP
CHEMICAL FEED PUMP	1 gpm.		ACID FEED PUMP

DEMOLITION NOTES (SEE PLATE M2.1 FOR EXISITN LAYOUT PLANT AND DEMOLOTION):

1. THE FOLLOWING ITEMS OF EQUIPMENT ALONG WITH ASSOCIATED INTERCONNECTING PIPING SHALL BE REMOVED FROM THEIR CURRENT LOCATIONS. THE EQUIPMENT SHALL BE STORED ON SITE AT A LOCATION TO BE COORDINATED WITH THE CONTRACTING OFFICER. THE DEMOLISHED PIPING SHALL BE REMOVED FROM THE SITE.

   T-101, ROUGHING TANK
   SEP-102, OIL WATER SEPARATOR
   DEP-104, DEPURATOR

2. EXISTING PIPING INTERCONNECTING T-402 (BIOLOGICAL EQUALIZATION TANK) AND T-203 (AERATION BASIN) IS DETERIORATING AND SHALL BE DEMOLISHED IN PREPARATION FOR REPLACEMENT. APPROXIMATELY 85 FEET OF HDPE PIPING TO BE REPLACED

NEW CONSTRUCTION NOTES:

1. NEW EQUIPMENT TO BE INSTALLED INCLUDES THE FOLLOWING:

   DAF-104, DISSOLVED AIR FLOTATION
   CAUSTIC STORAGE TANK
   CAUSTIC METERING PUMP
   3" STATIC MIXER FOR CAUSTIC
   ACID STORAGE TANK
   ACID METERING PUMP
   3" STATIC MIXER FOR ACID

2. ALL NEW EQUIPMENT SHALL BE PIPED TO NEW AND EXISTING EQUIPMENT AS INDICATED ON PLATE M2.3 AND IN ACCORDANCE WITH THE SPECIFICATIONS AND THE MANUFACTURER'S INSTALLATION INSTRUCTIONS.

3. INSTALL APPROXIMATELY 85 FEET OF NEW 3" DIAMETER HDPE PIPING. PIPING SHALL BE PROVIDED BETWEEN T-402 (BIOLOGICAL EQUILIZATION TANK) AND T-203 (AERATION BASIN). THIS PIPING SHALL BE INSTALLED WITH THE FOLLOWING COMPONENTS:

   ONE - ONE INCH CHECK VAVLE
   THREE EACH - 3 INCH ISOLATION VALVES
   ONE - TWO INCH FLOW CONTROL VALVES

4. NEW 2" HDPE PRODUCT PIPE IS BURIED 2 FEET DEEP NEAR TP AND CR2 AREA. REMAINING PIPE TO BOILER BLDG. IS ABOVE GROUND.

FIGURE **4.2-8**

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U.S. ARMY ENGINEER DISTRICT, SEATTL
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SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
THERMAL REMEDIATION PILOT CONSTRUCTION
WATER TREATMENT PLANT
MODIFIED PLANT LAYOUT
AND EQUIPMENT SCHEDULE

BAINBRIDGE ISLAND PN C1911 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-20	16NOV01	
DSGN. DAWAG		CHK.	SHEET 18	

REVISIONS				
SYMBOL	ZONE	DESCRIPTION	DATE	BY
		REVISED AS-BUILT	01DEC03	JJK

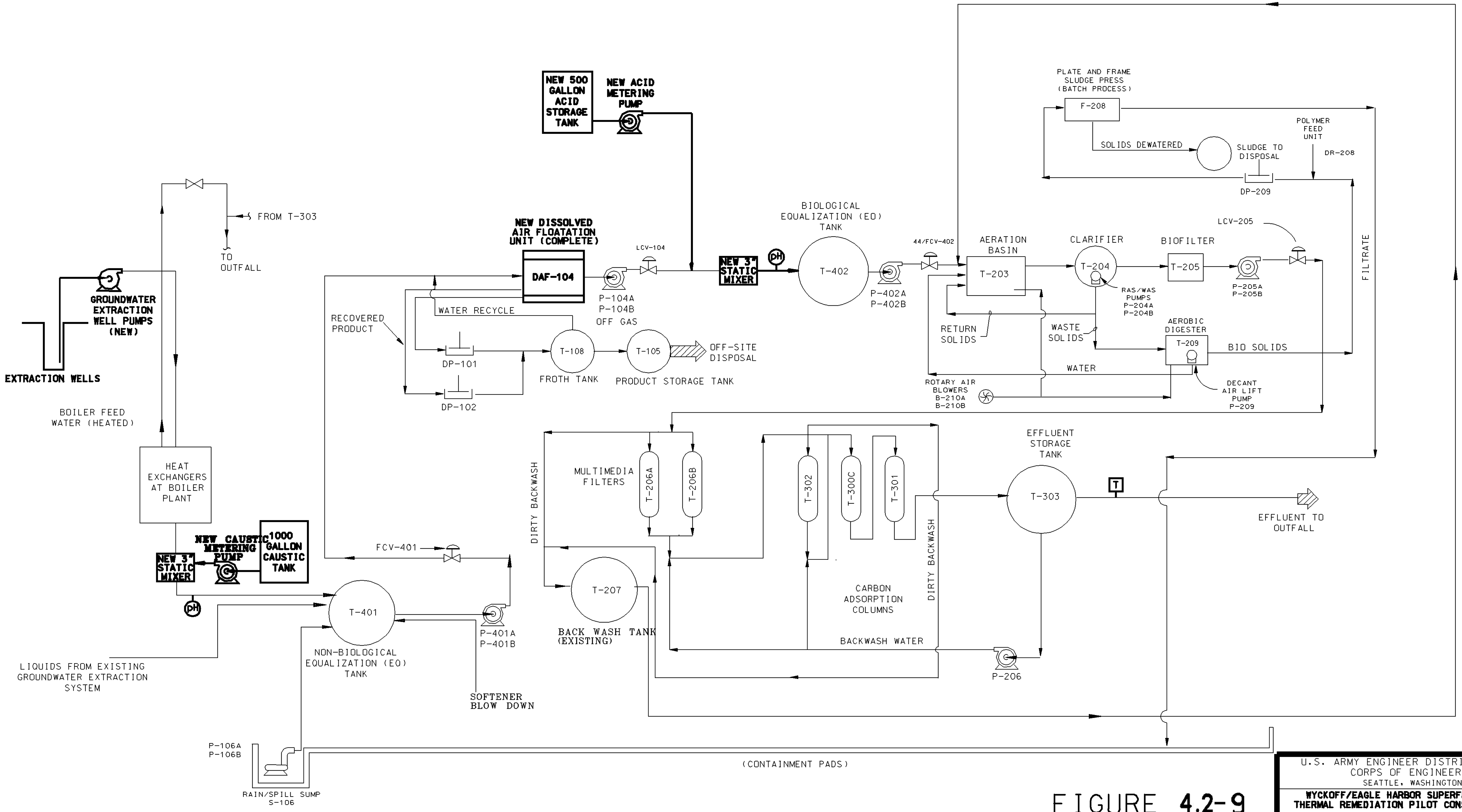


FIGURE 4.2-9

U.S. ARMY ENGINEER DISTRICT, SEATTL
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WYCKOFF/EAGLE HARBOR SUPERFUND SITE
THERMAL REMEDIATION PILOT CONSTRUCTION
WATER TREATMENT PLANT
PROCESS FLOW DIAGRAM

BAINBRIDGE ISLAND PN C1911 WASHINGTON

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
D		E-54-1-20	16NOV01	
DSGN. DAWAG		CHK.	SHEET 19	

Figure 5.1-1 Operations Timeline

		Phase I																					
Systems		1-Oct-02	2-Oct-02	3-Oct-02	4-Oct-02	5-Oct-02	6-Oct-02	7-Oct-02	8-Oct-02	9-Oct-02	10-Oct-02	11-Oct-02	12-Oct-02	13-Oct-02	14-Oct-02	15-Oct-02	16-Oct-02	17-Oct-02	18-Oct-02	19-Oct-02	20-Oct-02	21-Oct-02	22-Oct-02
Extraction	Liquid (gpm)				5			0	1	6	5	5				5	5	5	5				
	Vapor																						
Steam	Boiler							**Records incomplete; sporadic operations**															
	Injection (lbs/hr)																						
Treatment Plant																	On						
Monitoring	DTS		On	On	On	Off	Off	On	On	On	On	On	On	On	On	On	Off	Off	On	On	On	Off	On
	Thermocouples		On	On	On	Off	Off	On	On	On	On	On	On	On	On	On	Off	Off	On	On	On	On	On
	TOC																						
	Pressure	Off	On	On	On	Off	Off	On	Off	On	On	On	On	On	On	On	Off	Off	On	On	On	On	On
Extraction	Liquid																						
	Vapor																						
Steam	Boiler																						
	Injection																						
Treatment Plant													402 pump seized	402 pump seized									
Monitoring	DTS																						
	Thermocouples																						
	TOC																						
	Pressure																						

Figure 5.1-1 Operations Timeline

Systems		**Phase I**							**Phase II**																
		23-Oct-02	24-Oct-02	25-Oct-02	26-Oct-02	27-Oct-02	28-Oct-02	29-Oct-02	30-Oct-02	31-Oct-02	1-Nov-02	2-Nov-02	3-Nov-02	4-Nov-02	5-Nov-02	6-Nov-02	7-Nov-02	8-Nov-02	9-Nov-02	10-Nov-02	11-Nov-02	12-Nov-02	13-Nov-02	14-Nov-02	15-Nov-02
Extraction	Liquid (gpm)	4	3	4			2	4	9	8	8			4	5	6	13	16	19		7	10	14	26	24
	Vapor							Training	Training	Training	Training			Training	Training	Training	On	On	On	Off-On	Off	Off-On	On	On	Off-On
Steam	Boiler							Training	Training	Training	Training			Training	Training	Training	On	On	On	Off-On	Off	Off-On	On	On	On
	Injection (lbs/hr)							778	5893	7649	1195			4955	958	7134	6264	8100	11935		0	2574	5266	5287	4323
Treatment Plant								On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	Off	On	On	On	On	On	Off	On	On	On	On	On	On	Off	On	On	On	On	Off	Off	On	On	On	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On
	TOC																		On	On	On	On	On	On	Off
	Pressure	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On
Extraction	Liquid																								
	Vapor																			Liquid in vacuum pumps			Condensate receiver failed	Condensate receiver failed	
Steam	Boiler									Feed water pump trip	Feed water pump trip			Feed water pump trip; boiler chem feed system											
	Injection																								
Treatment Plant																									
Monitoring	DTS							Software problems																	
	Thermocouples																								
	TOC																								Programming issue
	Pressure																			E-3 temp sensor inop	E-3 temp sensor inop	E-3 temp sensor inop	E-3 temp sensor inop		

Figure 5.1-1 Operations Timeline

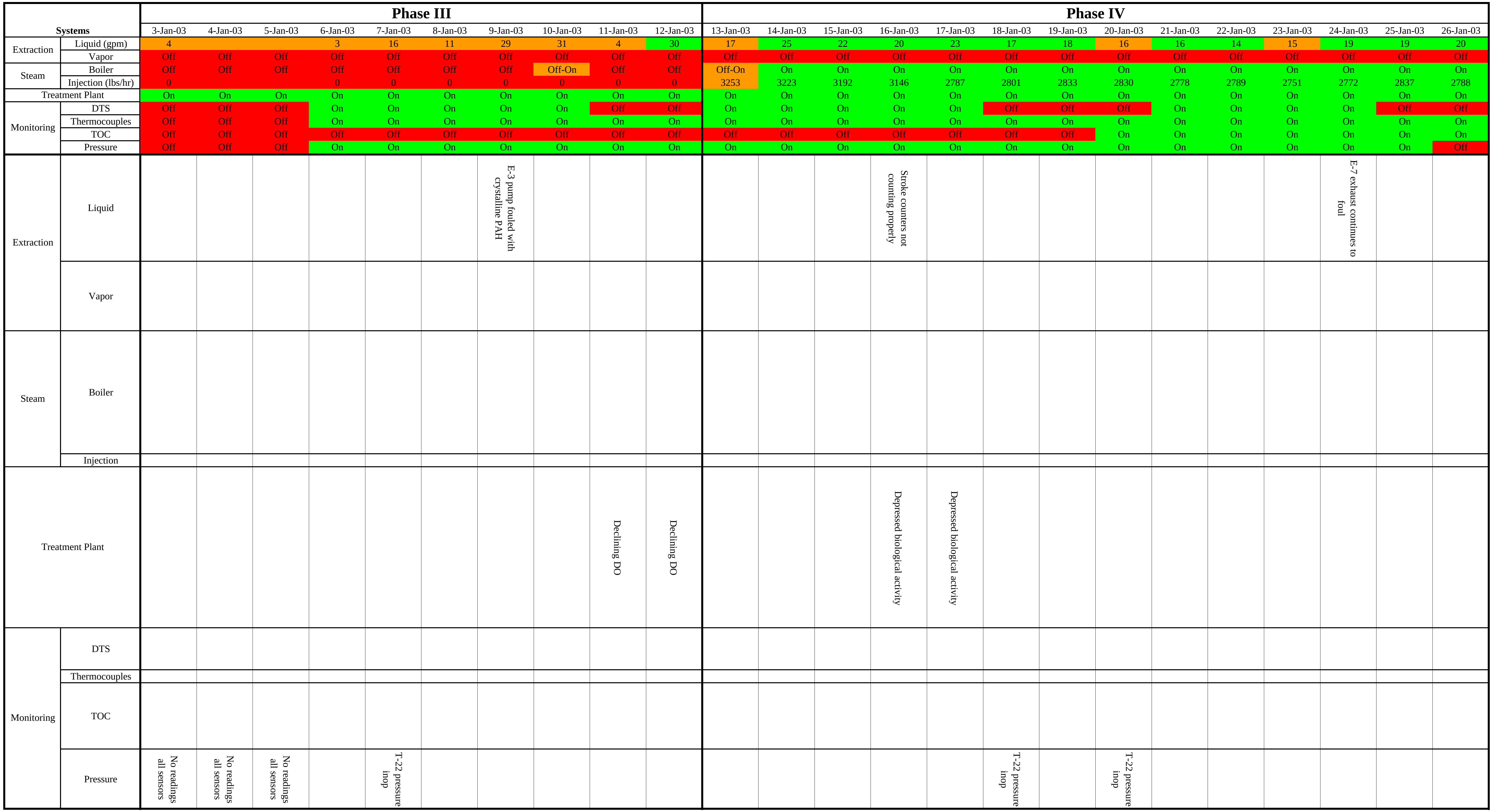
		Phase II																							
Systems		16-Nov-02	17-Nov-02	18-Nov-02	19-Nov-02	20-Nov-02	21-Nov-02	22-Nov-02	23-Nov-02	24-Nov-02	25-Nov-02	26-Nov-02	27-Nov-02	28-Nov-02	29-Nov-02	30-Nov-02	1-Dec-02	2-Dec-02	3-Dec-02	4-Dec-02	5-Dec-02	6-Dec-02	7-Dec-02	8-Dec-02	9-Dec-02
Extraction	Liquid (gpm)	19	21	22	21	20	20	16	22	20	21	14	13		14	15	15	20	21	20	17	20	20	20	22
	Vapor	Off-On	Off-On	On	On	Off	On	On	On	Off	Off	Off	Off-On	Off-On	Off-On	On	On	On	Off-On	Off	Off-On	On	On	On	Off-On
Steam	Boiler	Off-On	Off-On	On	On	On	On	On	On	Off	Off	Off	Off-On	Off-On	Off-On	On	On	On	Off-On	Off	Off-On	On	On	On	Off-On
	Injection (lbs/hr)	0	3942	5809	3864	3863	3837	3846	5182	0	0	0	5036	0	0	4988	5189	5264	5261	0	0	5671	7276	7276	7609
Treatment Plant		On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off-On
Monitoring	DTS	On	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On	On
	TOC	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On	On
	Pressure	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off	On	On	On	On	On	On	On	On
Extraction	Liquid	Waxy PAH fouled cone screen in product tank			E-1 and E-7 pump maintenance	Crystal formation in E-1 exhaust port	E-1 fouled with solidified PAH						E-3 and E-5 pumps lowered 2 ft												
	Vapor	Crystal fouling in condenser			Field condensate pump seals failed														Liquid in vapor system						Pressure differential in vacuum system
Steam	Boiler					Condensate pumps failed due to chem incompatibility				Sticking sour gas valve due to chem incomp; fuel imbalance damages gaskets in boiler		Condensate pumps failed due to chem incompatibility		Feed water pump trip					Sticking valve in sour gas						Sticking valve in sour gas
	Injection																								
Treatment Plant																				Some die-off in aeration basin				Mixing chamber between AB and clarifier clogged; solids spilled downstream	
Monitoring	DTS																								
	Thermocouples																								
	TOC																								
	Pressure																								

Figure 5.1-1 Operations Timeline

Systems		Phase II						Phase III															
		10-Dec-02	11-Dec-02	12-Dec-02	13-Dec-02	14-Dec-02	15-Dec-02	16-Dec-02	17-Dec-02	18-Dec-02	19-Dec-02	20-Dec-02	21-Dec-02	22-Dec-02	23-Dec-02	24-Dec-02	25-Dec-02	26-Dec-02	27-Dec-02	28-Dec-02	29-Dec-02	30-Dec-02	31-Dec-02	1-Jan-03	2-Jan-03
Extraction	Liquid (gpm)	4	4	11	18	23	22	7	0	0	0	0			0	0		0	0			0			0
	Vapor	Off	Off-On	Off-On	On	On	Off-On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Steam	Boiler	Off	Off-On	Off-On	On	On	Off-On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off-On	Off	Off	Off	Off	Off	Off-On
	Injection (lbs/hr)	0	0	7847	7795	8364	0	0	0	0	0	0			0	0		0	0			0			0
Treatment Plant		Off	Off-On	On	On	On	On	Recycle	Recycle	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	On	On	On	On	On	Off	On	On	On	On	On	On	On	On	On	Off	On	On	Off	Off	On	On	Off	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	TOC	On	On	On	On	On	On	On	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
	Pressure	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On

		10-Dec-02	11-Dec-02	12-Dec-02	13-Dec-02	14-Dec-02	15-Dec-02	16-Dec-02	17-Dec-02	18-Dec-02	19-Dec-02	20-Dec-02	21-Dec-02	22-Dec-02	23-Dec-02	24-Dec-02	25-Dec-02	26-Dec-02	27-Dec-02	28-Dec-02	29-Dec-02	30-Dec-02	31-Dec-02	1-Jan-03	2-Jan-03
Extraction	Liquid																								
	Vapor			Field condensate pump air-locked			Gaskets in heat exchanger (HX-3) failed	Seals in vacuum pumps failed; LRVP seal torn																	
Steam	Boiler			Condensate receiver pump failed				Condensate receiver pump failed																	
	Injection																								
Treatment Plant							Nearly complete die-off in AB	Low DO in AB; recycle mode with no discharge to outfall	Recycle mode with no discharge to outfall																
Monitoring	DTS			Sporadic software problems			Loop 2 down																		
	Thermocouples																								
	TOC																								
	Pressure															T-22 pressure inop			T-22 pressure inop			T-22 pressure inop			No readings all sensors

Figure 5.1-1 Operations Timeline



Systems		Phase III										Phase IV													
		3-Jan-03	4-Jan-03	5-Jan-03	6-Jan-03	7-Jan-03	8-Jan-03	9-Jan-03	10-Jan-03	11-Jan-03	12-Jan-03	13-Jan-03	14-Jan-03	15-Jan-03	16-Jan-03	17-Jan-03	18-Jan-03	19-Jan-03	20-Jan-03	21-Jan-03	22-Jan-03	23-Jan-03	24-Jan-03	25-Jan-03	26-Jan-03
Extraction	Liquid (gpm)	4			3	16	11	29	31	4	30	17	25	22	20	23	17	18	16	16	14	15	19	19	20
	Vapor	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Steam	Boiler	Off	Off	Off	Off	Off	Off	Off	Off-On	Off	Off	Off-On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Injection (lbs/hr)	0			0	0	0	0	0	0	0	3253	3223	3192	3146	2787	2801	2833	2830	2778	2789	2751	2772	2837	2788
Treatment Plant		On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	Off	Off	Off	On	On	On	On	On	Off	Off	On	On	On	On	On	Off	Off	Off	On	On	On	On	Off	Off
	Thermocouples	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	TOC	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	On	On	On	On	On	On	On
	Pressure	Off	Off	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off
Extraction	Liquid							E-3 pump fouled with crystalline PAH							Stroke counters not counting properly								E-7 exhaust continues to foul		
	Vapor																								
Steam	Boiler																								
	Injection																								
Treatment Plant										Declining DO	Declining DO				Depressed biological activity	Depressed biological activity									
Monitoring	DTS																								
	Thermocouples																								
	TOC																								
	Pressure	No readings all sensors	No readings all sensors	No readings all sensors		T-22 pressure inop											T-22 pressure inop		T-22 pressure inop						

Figure 5.1-1 Operations Timeline

		Phase IV																							
Systems		27-Jan-03	28-Jan-03	29-Jan-03	30-Jan-03	31-Jan-03	1-Feb-03	2-Feb-03	3-Feb-03	4-Feb-03	5-Feb-03	6-Feb-03	7-Feb-03	8-Feb-03	9-Feb-03	10-Feb-03	11-Feb-03	12-Feb-03	13-Feb-03	14-Feb-03	15-Feb-03	16-Feb-03	17-Feb-03	18-Feb-03	19-Feb-03
Extraction	Liquid (gpm)	18	23	28	26	25	25	24	26	23	23	20	20	19	19	19	18	14	13	15	12	13	12	17	20
	Vapor	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Steam	Boiler	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Injection (lbs/hr)	2824	2726	2726	2785	2750	2672	2699	2764	2796	2498	2545	2548	2359	2359	2570	2294	2271	2266	2261	2143	2137	2248	2265	2374
Treatment Plant		On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	On	On	On	On	On	Off	Off	On	On	On	On	On	Off	Off	On	On	On	On	On	Off	Off	Off	On	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	TOC	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Pressure	Off	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Extraction	Liquid	E-7 exhaust continues to foul													Heat exchanger plugged with PAH				Product tank and liq heat exchangers clogged					E-3 exhaust plugged with PAH? Suspected E-5 discharge tube rupture	E-3 exhaust air/vapor lock
	Vapor																								
Steam	Boiler											Feed water pump trip	Feed water pump trip		Feed water flow control valve failed; feed water pump trip		Feed water pump trip	Feed water pump trip	Feed water pump trip						
	Injection																								
Treatment Plant					Unstable DO					T401 flow meter not working	T401 flow meter not working	Clarifier pump failed			T401 flow meter plugged with PAH crystals; clarifier pump not working		Clarifier pump not working	T401 flow valve not working; clarifier pump not working	T401 flow valve not working					T401 flow valve not working	T401 flow valve not working
Monitoring	DTS																								
	Thermocouples																								
	TOC									Crystals forming in TOC well									TOC clogged w/ PAH crystals			TOC pump clogged w/ PAH			TOC failed due to chemical incompatibility
	Pressure						T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop

Figure 5.1-1 Operations Timeline

		Phase IV																							
Systems		20-Feb-03	21-Feb-03	22-Feb-03	23-Feb-03	24-Feb-03	25-Feb-03	26-Feb-03	27-Feb-03	28-Feb-03	1-Mar-03	2-Mar-03	3-Mar-03	4-Mar-03	5-Mar-03	6-Mar-03	7-Mar-03	8-Mar-03	9-Mar-03	10-Mar-03	11-Mar-03	12-Mar-03	13-Mar-03	14-Mar-03	15-Mar-03
Extraction	Liquid (gpm)	21	20	20	20	20	20	20	20	20	20	20	18	19	20	8	19	21	20	21	21	21	21	21	22
	Vapor	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Steam	Boiler	On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off-On	On	On	On	On	On	On	On	On	On
	Injection (lbs/hr)	2270	2266	2187	2187	2266	2267	2264	2271	2298	2328	2311	2303	2299	2291	0	2255	2156	2156	2247	2278	2267	2263	2257	2295
Treatment Plant		On	On	On	On	On	On	On	On	On	On	On	On	On	On	Off-On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	On	On	Off	Off	On	On	On	On	On	Off	Off	On	On	On	On	On	Off	Off	On	On	On	On	On	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	TOC	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Pressure	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Extraction	Liquid								Seals failed on heat exchanger (HX-2)					Liquid line to TP plugged				E-3 exhaust air/vapor lock							
	Vapor																								
Steam	Boiler					Feed water pump trip	Feed water pump trip	Feed water pump trip									Corrosion noted in DA tank								
	Injection																								
Treatment Plant		Backwash pump P206 motor failed; T401 flow valve inop; DAF pumps/valves fouling with PAH	T401 flow valve not working			Waxy buildup decreasing efficiency of DAF pump; T401 flow valve cleaned but still inop	T401 flow valve clogged with waxy substance	Skimmers in clarifier not keeping up with solids production					T401 pumping efficiency decrease	T401 pumping efficiency decrease	DAF pump system clogged								DAF recycle pump clogging		
Monitoring	DTS																								
	Thermocouples																								
	TOC						TOC sampling arm clogged	TOC drain part disintegrated				TOC sampler clogged		TOC clogged											
	Pressure	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop

Figure 5.1-1 Operations Timeline

Systems		Phase IV							Phase V																
		16-Mar-03	17-Mar-03	18-Mar-03	19-Mar-03	20-Mar-03	21-Mar-03	22-Mar-03	23-Mar-03	24-Mar-03	25-Mar-03	26-Mar-03	27-Mar-03	28-Mar-03	29-Mar-03	30-Mar-03	31-Mar-03	1-Apr-03	2-Apr-03	3-Apr-03	4-Apr-03	5-Apr-03	6-Apr-03	7-Apr-03	8-Apr-03
Extraction	Liquid (gpm)	22	23	22	24	24	21	20	20	18	20	19	18	18	18	18	17	10	10	8	12	11	10	11	10
	Vapor	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off	Off
Steam	Boiler	On	Off-On	Off-On	Off-On	On	On	On	Off-On	Off-On	Off-On	Off-On	Off	Off	Off	Off	Off	Off	Off-On	Off-On	Off	Off	Off	Off	Off
	Injection (lbs/hr)	2252	0	2240	2246	2206	2222	2169	0	0	0	2222	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment Plant		On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Monitoring	DTS	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Thermocouples	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	TOC	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
	Pressure	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On	On
Extraction	Liquid		No discharge at E-5			2" slit in E-5 discharge tube																			
	Vapor																								
Steam	Boiler			Compressor oil leak		Compressor line air leak			Low water alarm trip; air/fuel ratio problem causing boiler panting												Boiler fuel igniter inop				
	Injection																								
Treatment Plant			DAF recycle pump completely clogged with NAPL wax																						
Monitoring	DTS																								
	Thermocouples																								
	TOC					TOC PVC drain part disintegrated																			
	Pressure	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop	T-29 pressure inop		T-22 pressure inop	T-22 pressure inop	T-22 pressure inop		T-22 pressure inop	T-22 pressure inop	T-29 pressure inop	T-29 pressure inop

Figure 5.1-1 Operations Timeline

Systems		Phase V	
		9-Apr-03	10-Apr-03
Extraction	Liquid (gpm)	10	9
	Vapor	Off	Off
Steam	Boiler	Off	Off-On
	Injection (lbs/hr)	0	1804
Treatment Plant		On	On
Monitoring	DTS	On	On
	Thermocouples	On	On
	TOC	On	On
	Pressure	On	On

Extraction	Liquid		E-3 exhaust line fouling
	Vapor		
Steam	Boiler		
	Injection		
Treatment Plant			
Monitoring	DTS		
	Thermocouples		
	TOC		
	Pressure	T-22 pressure inop	

Notes

	Records incomplete
5	Records incomplete (gpm operating condition if known)
Training	Training
9	System operating (gpm or lbs/hr operating condition)
On	System operating
Off	System not operating
0	System not operating (0 gpm or lbs/hr operating condition noted)
Off-On	System turned on or off during day
1647	System turned on or off during day (gpm or lbs/hr operating condition)

Figure 6.1-1. Total steam production rates calculated based on water usage, fuel usage, and well-head measurements

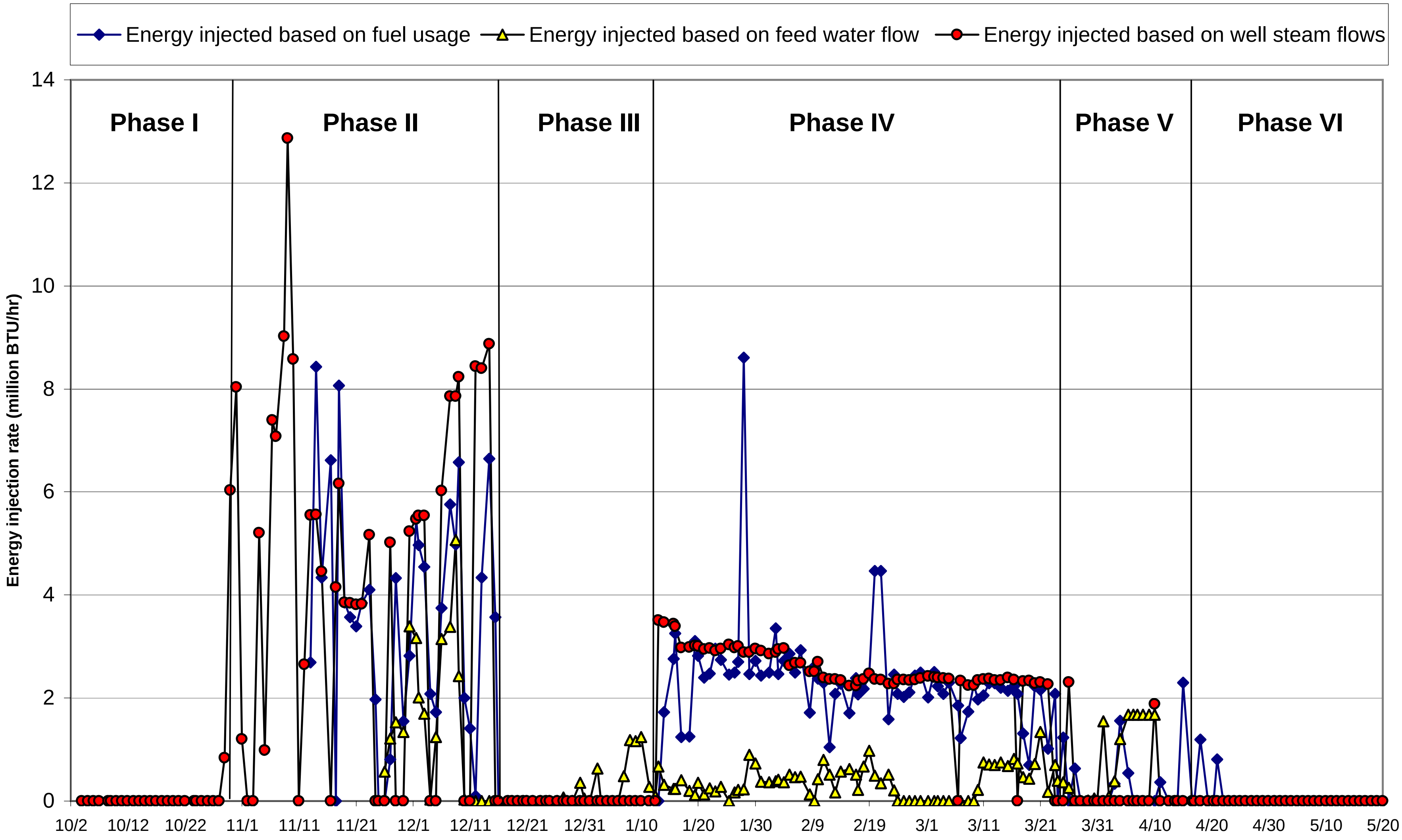


Figure 6.1-2. Steam injection rates for all 16 injection wells combined

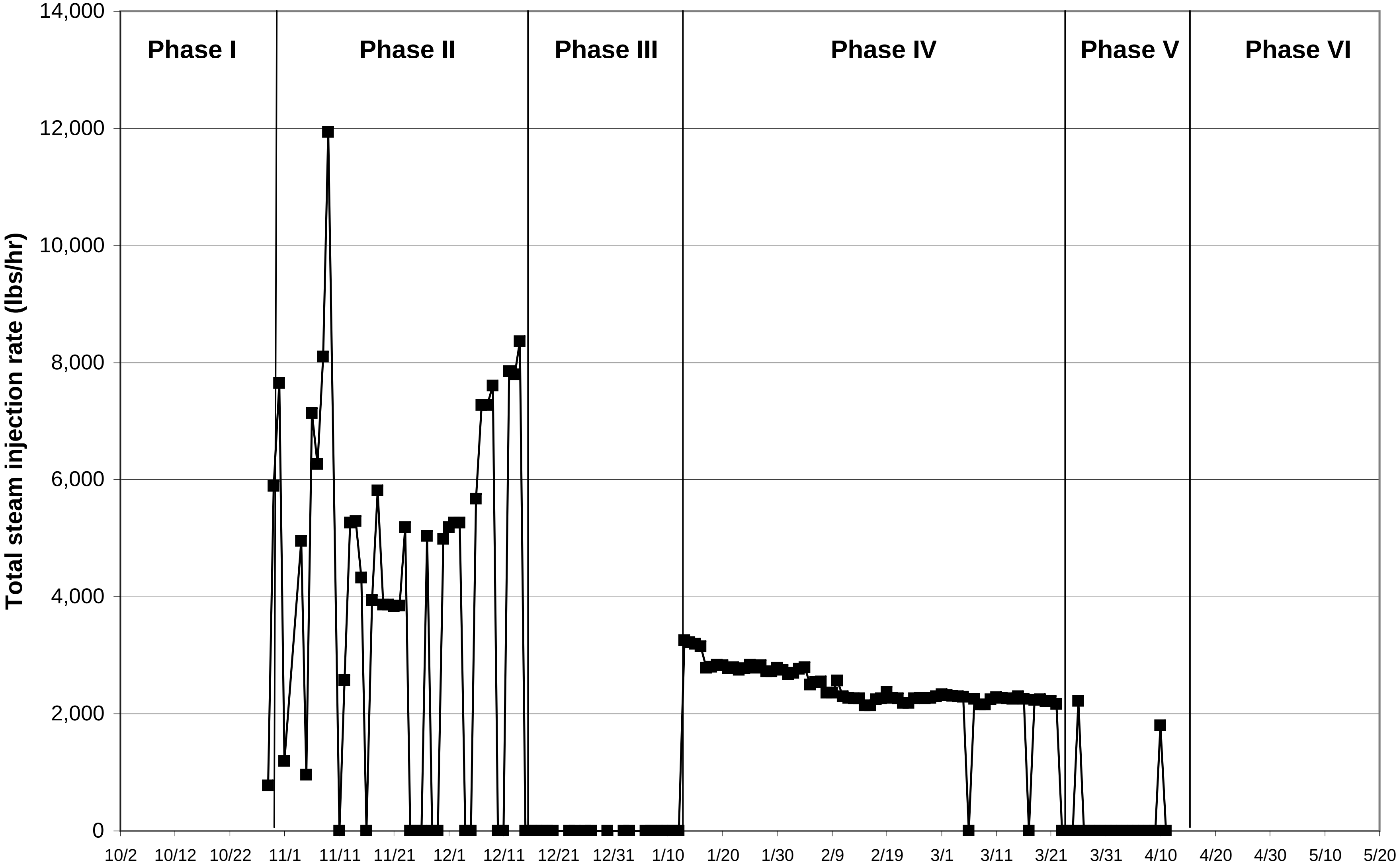


Figure 6.1-3. Steam injection rates for the 16 injection wells during 2002 operations. No steam was injected after 12/16/02 that year

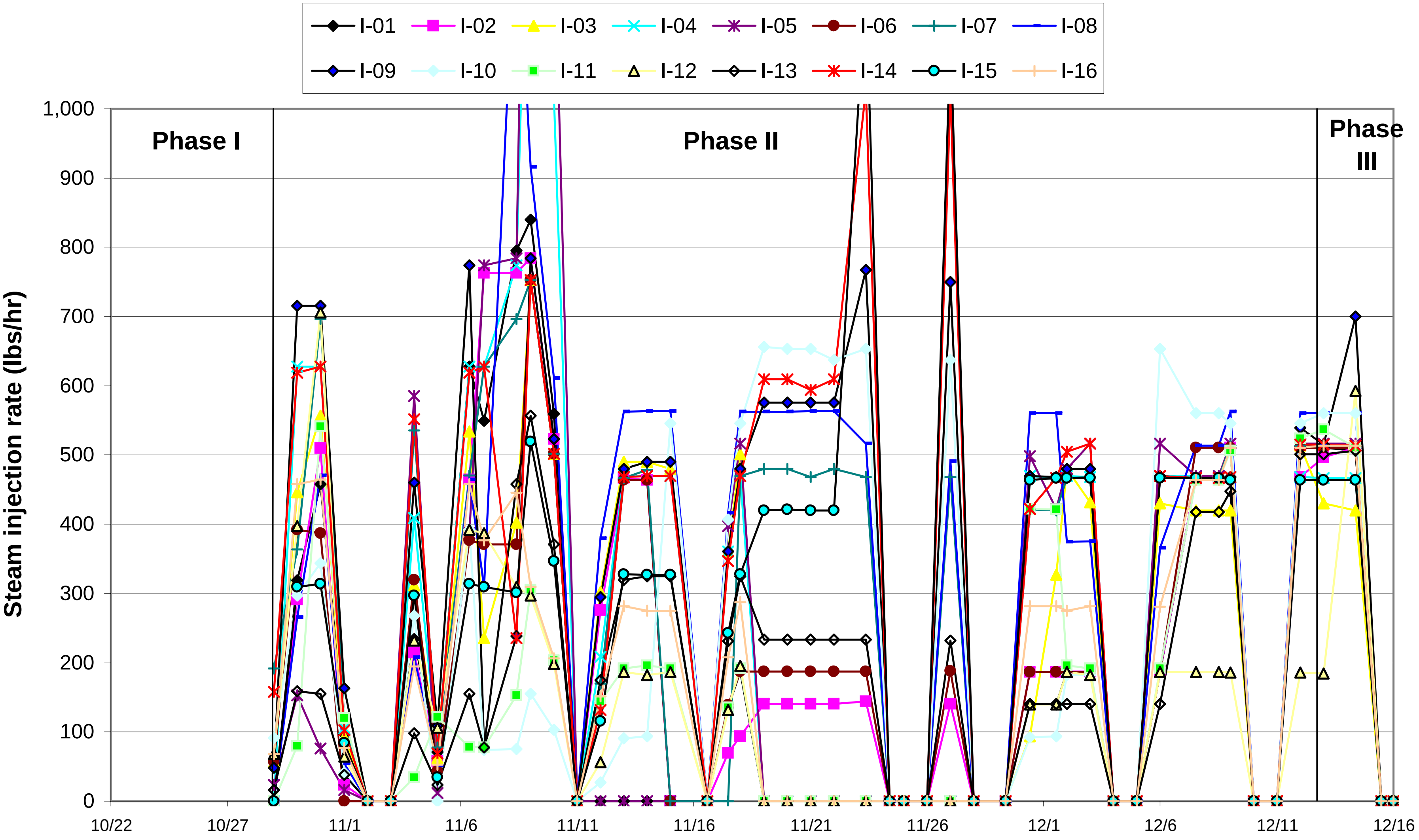


Figure 6.1-4. Steam injection rates for the 16 injection wells during 2003 operations

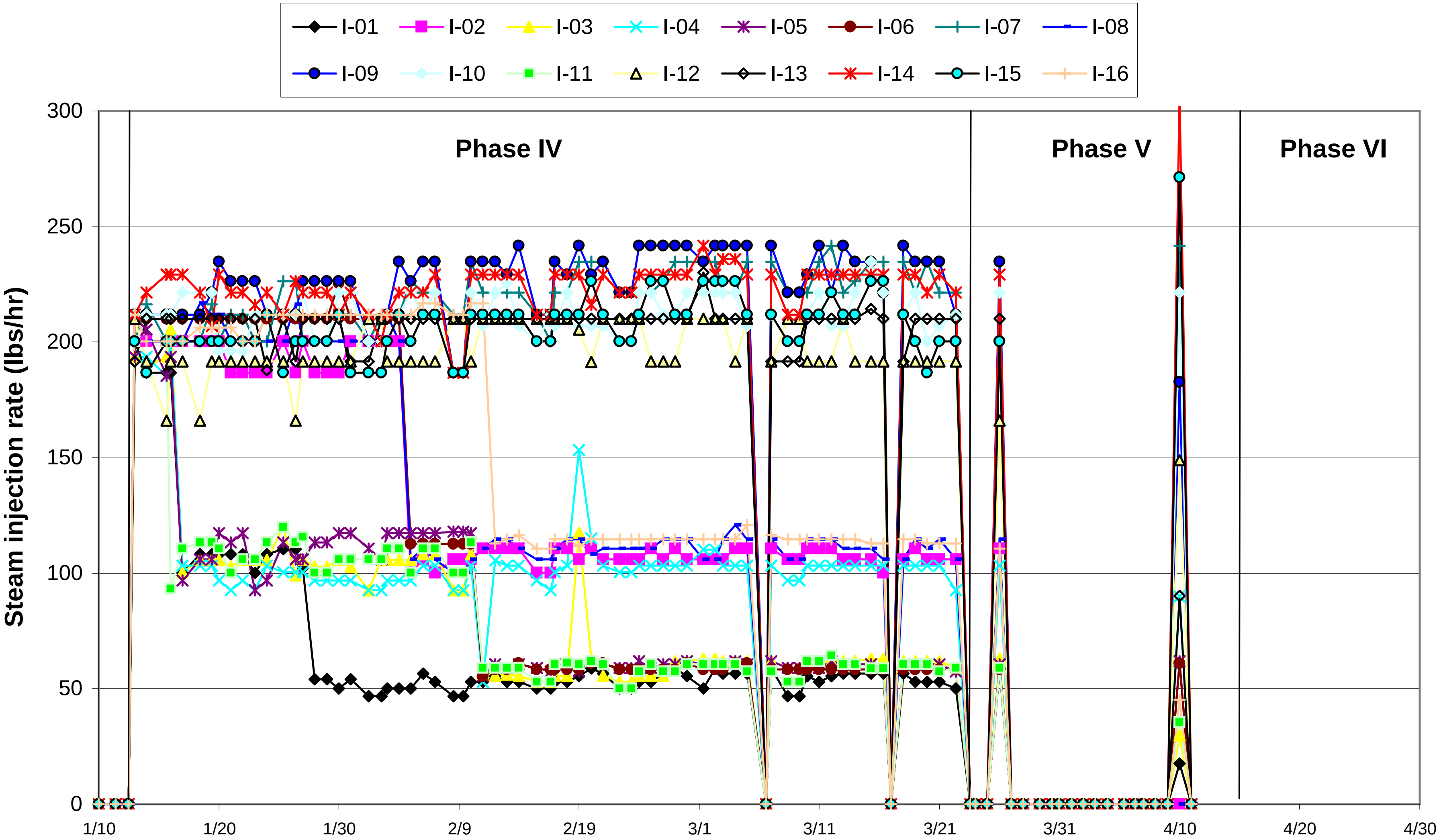


Figure 6.1-5. Cumulative steam injection volumes for each of the 16 injection wells

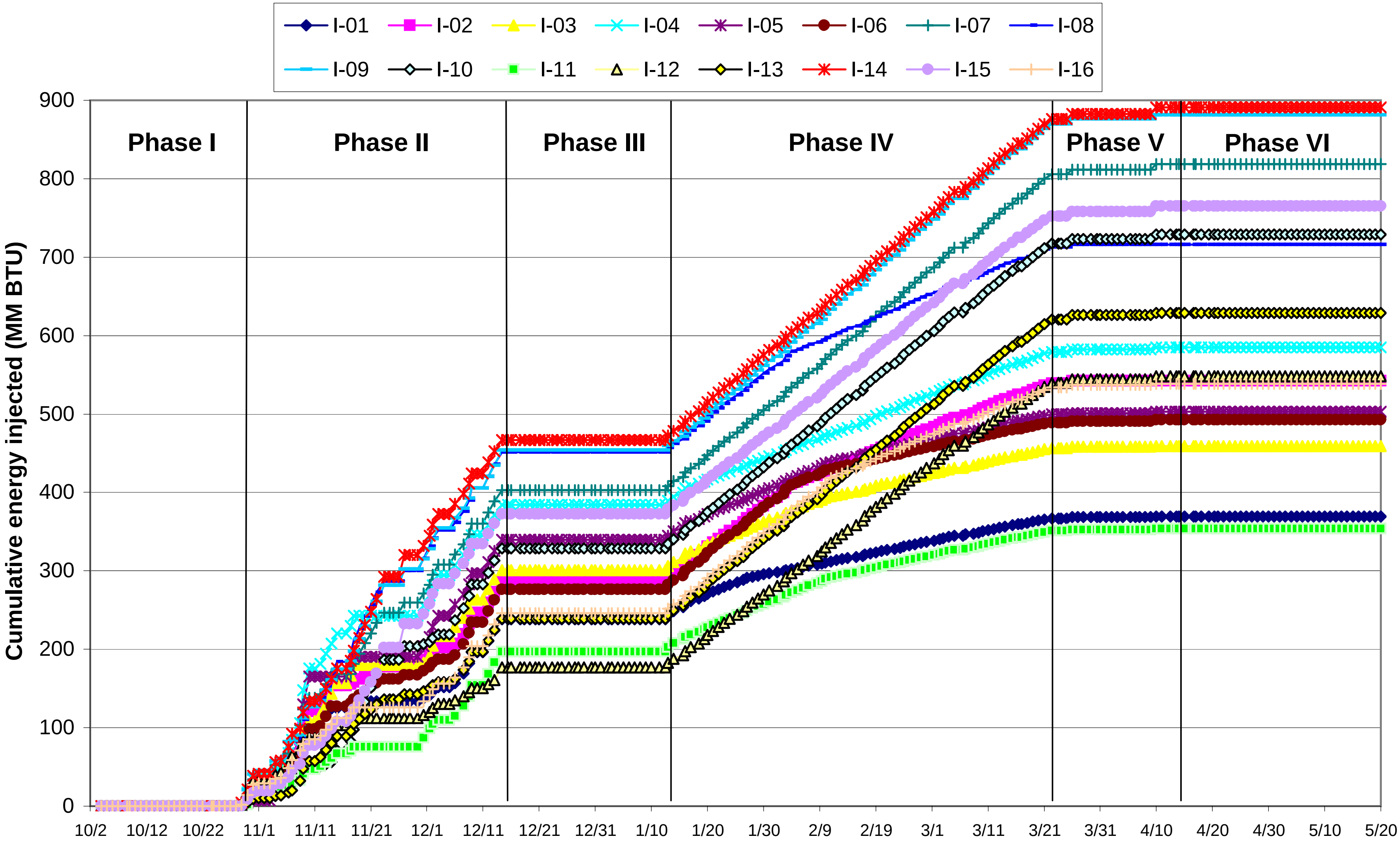


Figure 6.1-6. Liquid extraction rates from each of the seven extraction wells.

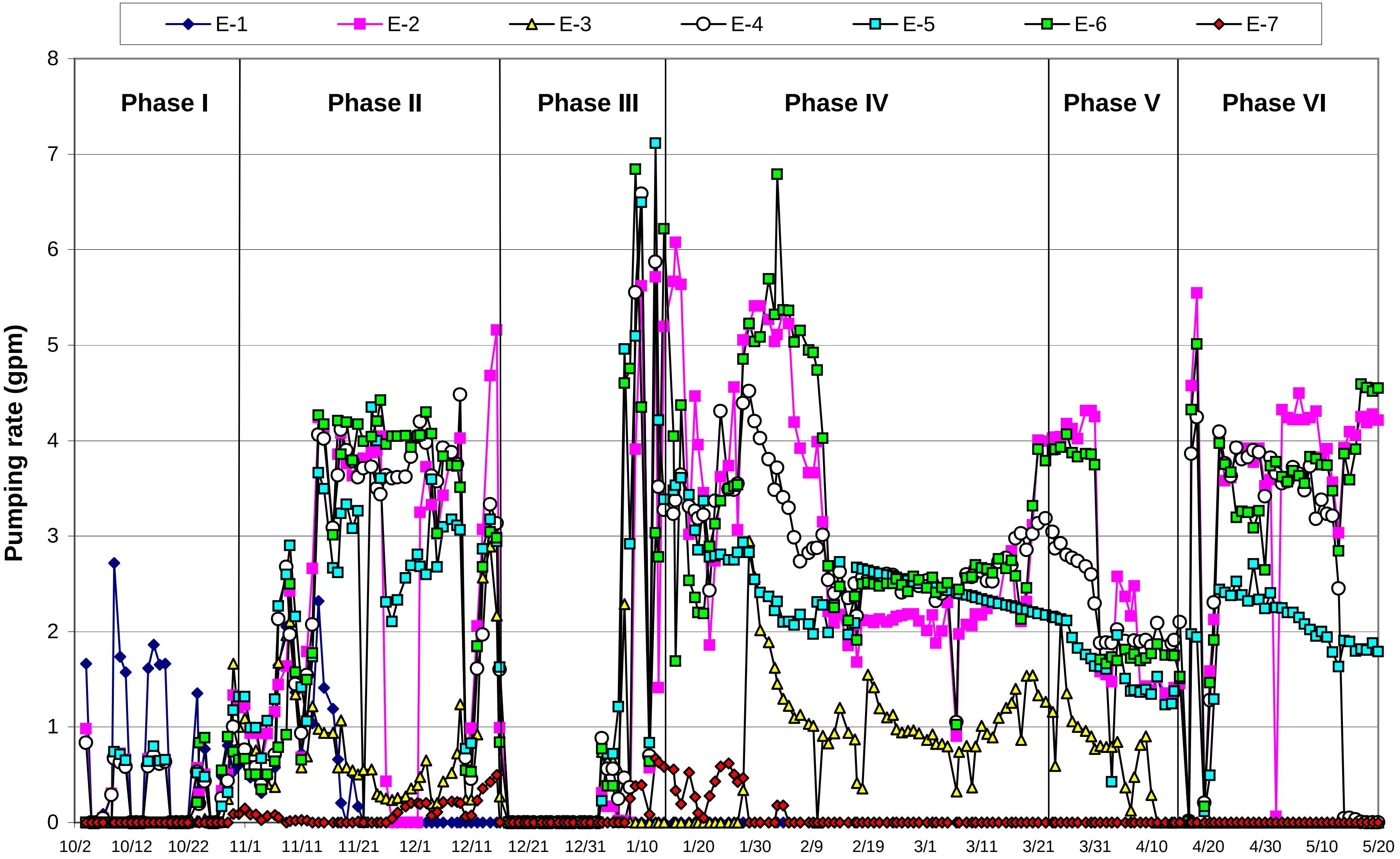


Figure 6.1-7. Cumulative water volumes extracted from each extraction well

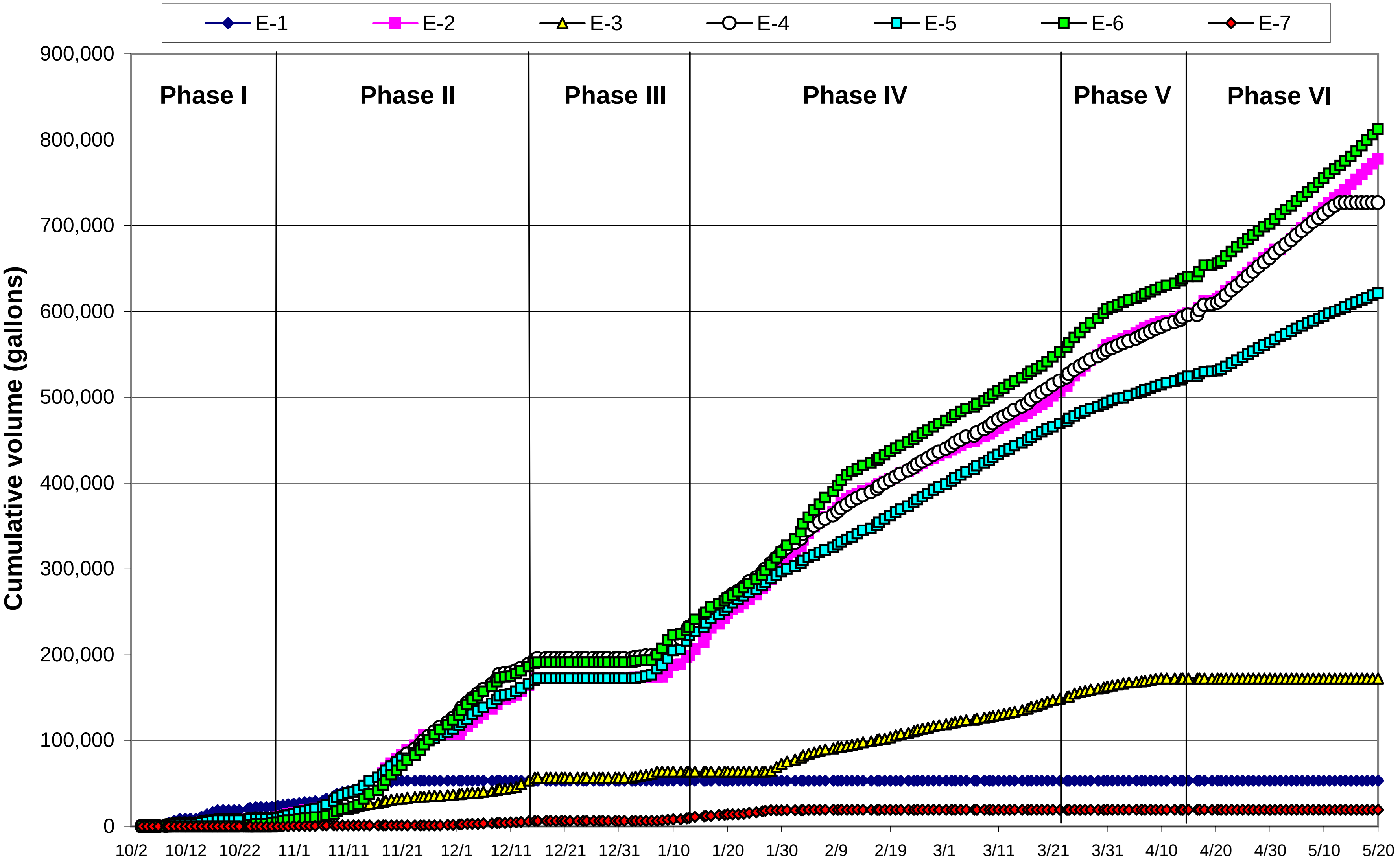


Figure 6.1-8. Total liquid extraction rates from the seven wells

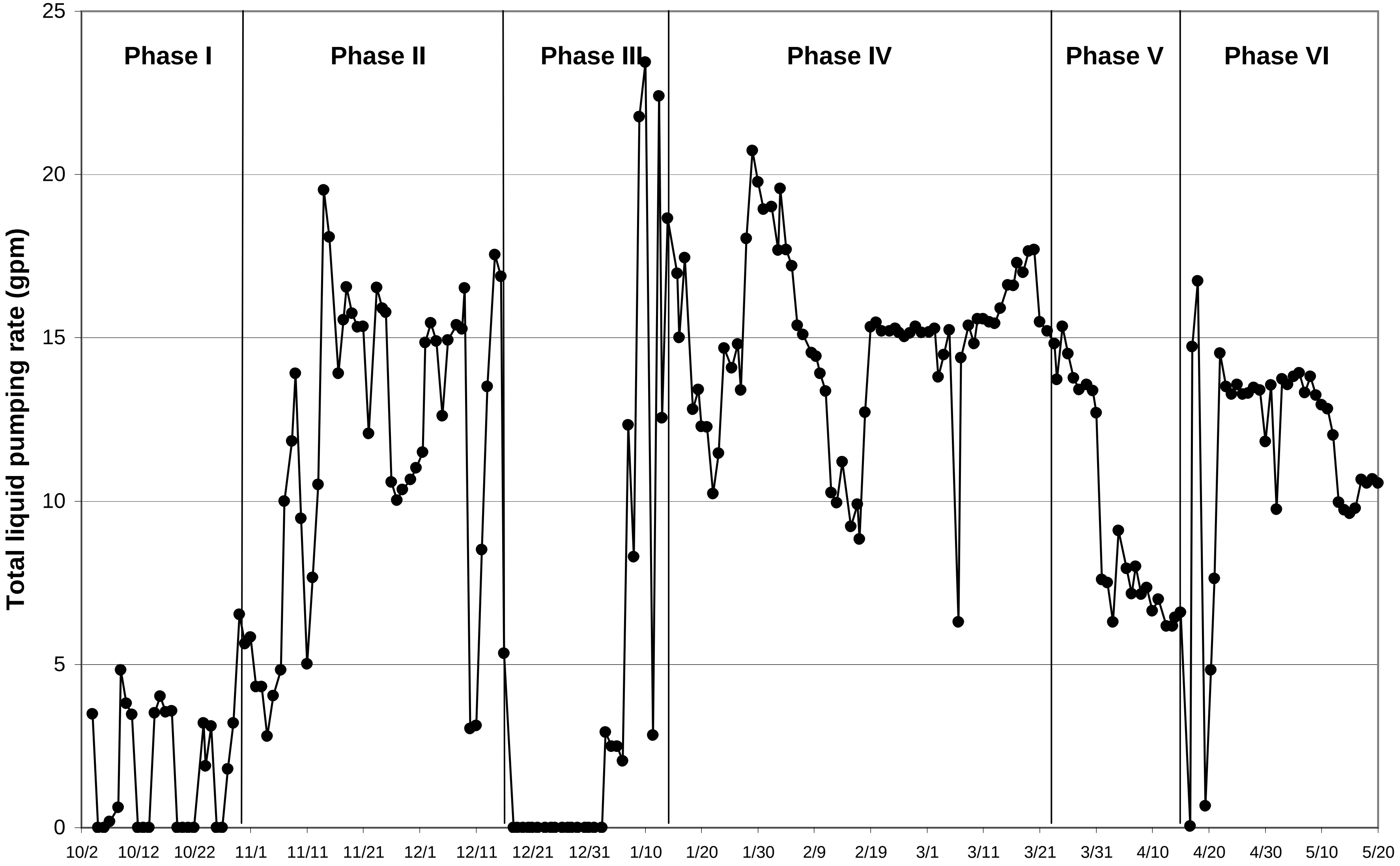


Figure 6.1-9. Water levels observed in extraction wells during operation

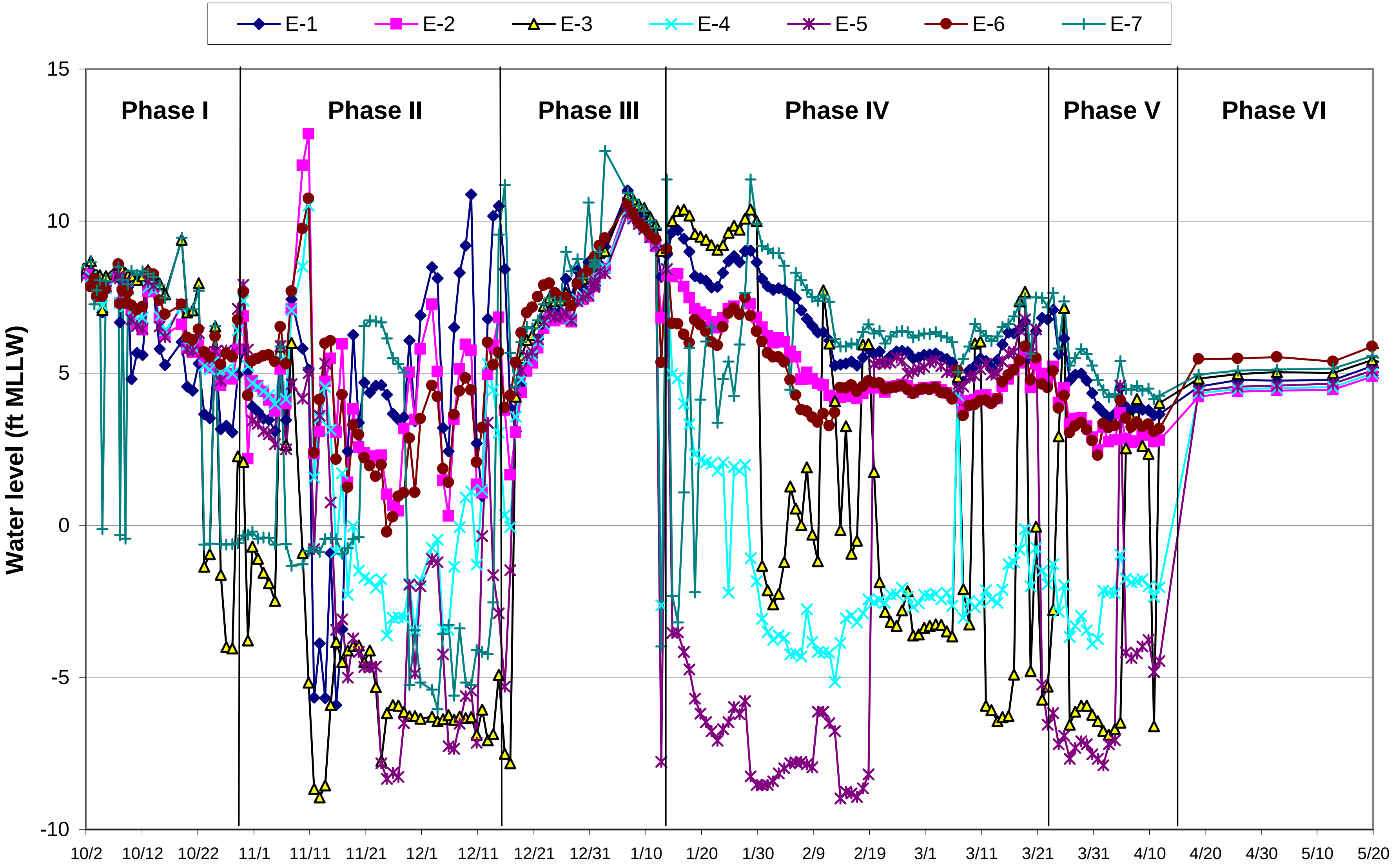


Figure 6.1-10. Water levels observed in monitoring well locations during operation

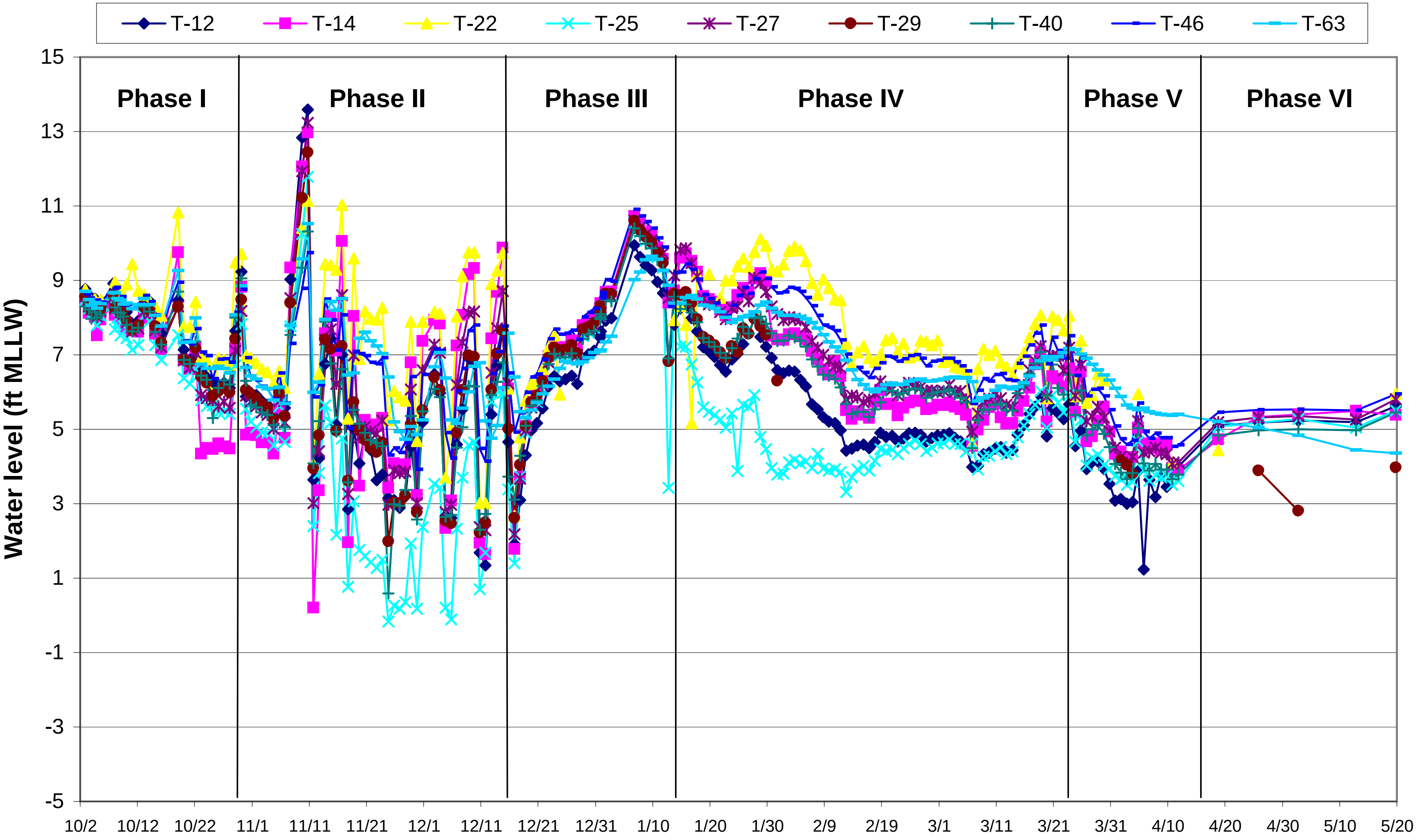


Figure 6.1-11. Water flow rates for the pilot test area

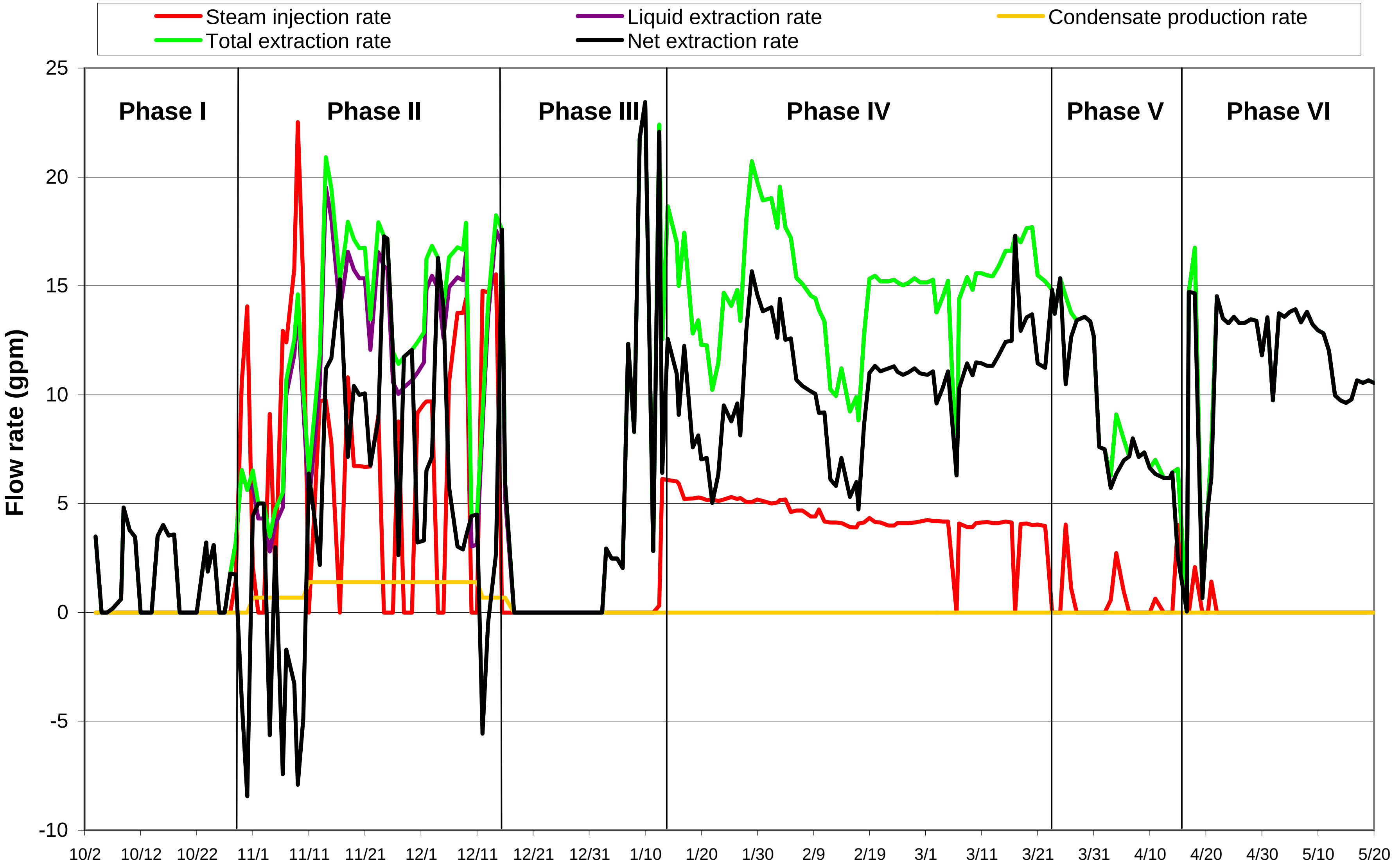


Figure 6.1-12. Cumulative water balance for the pilot test area

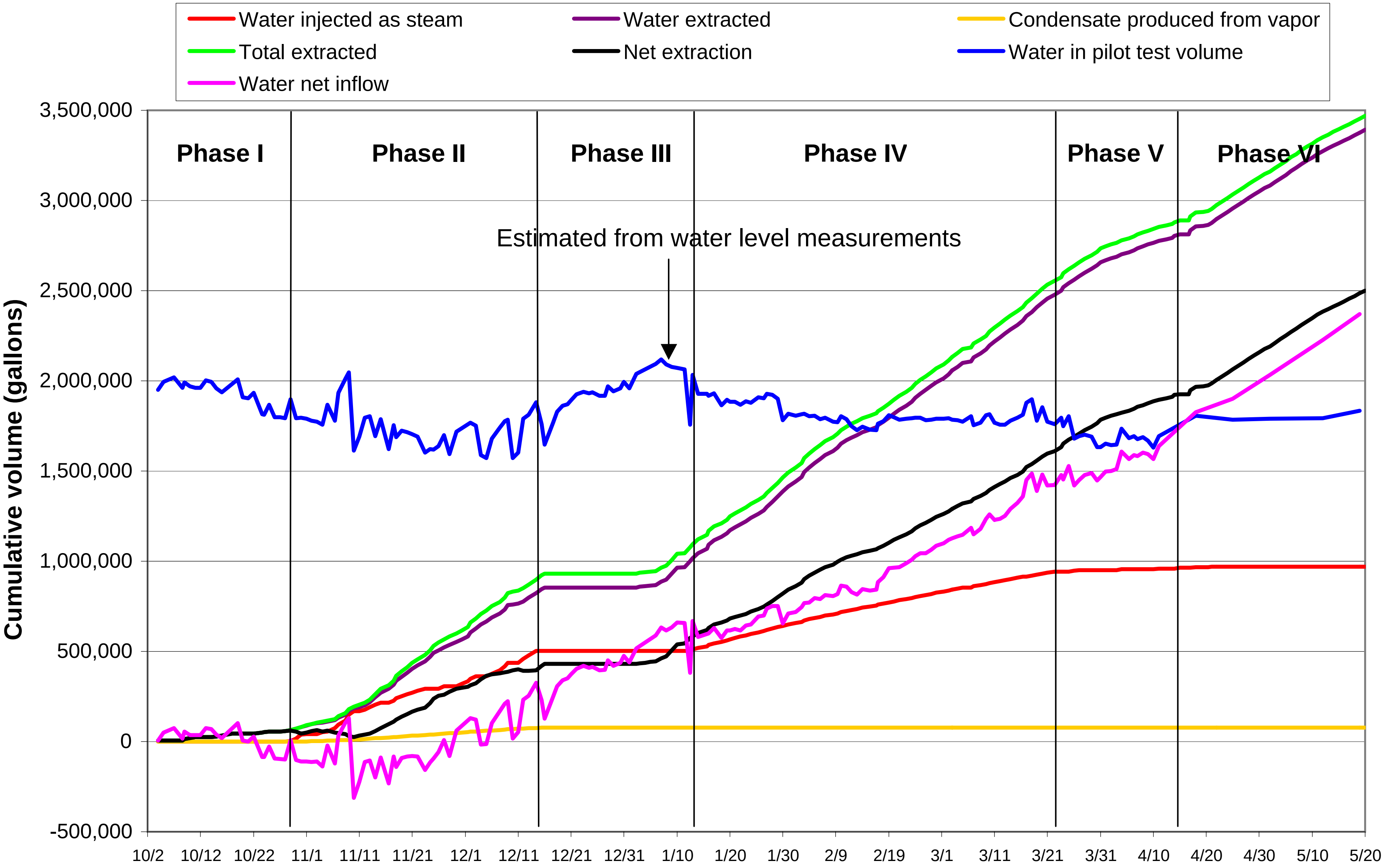


Figure 6.1-13. Enthalpy fluxes for the pilot test area during operation.

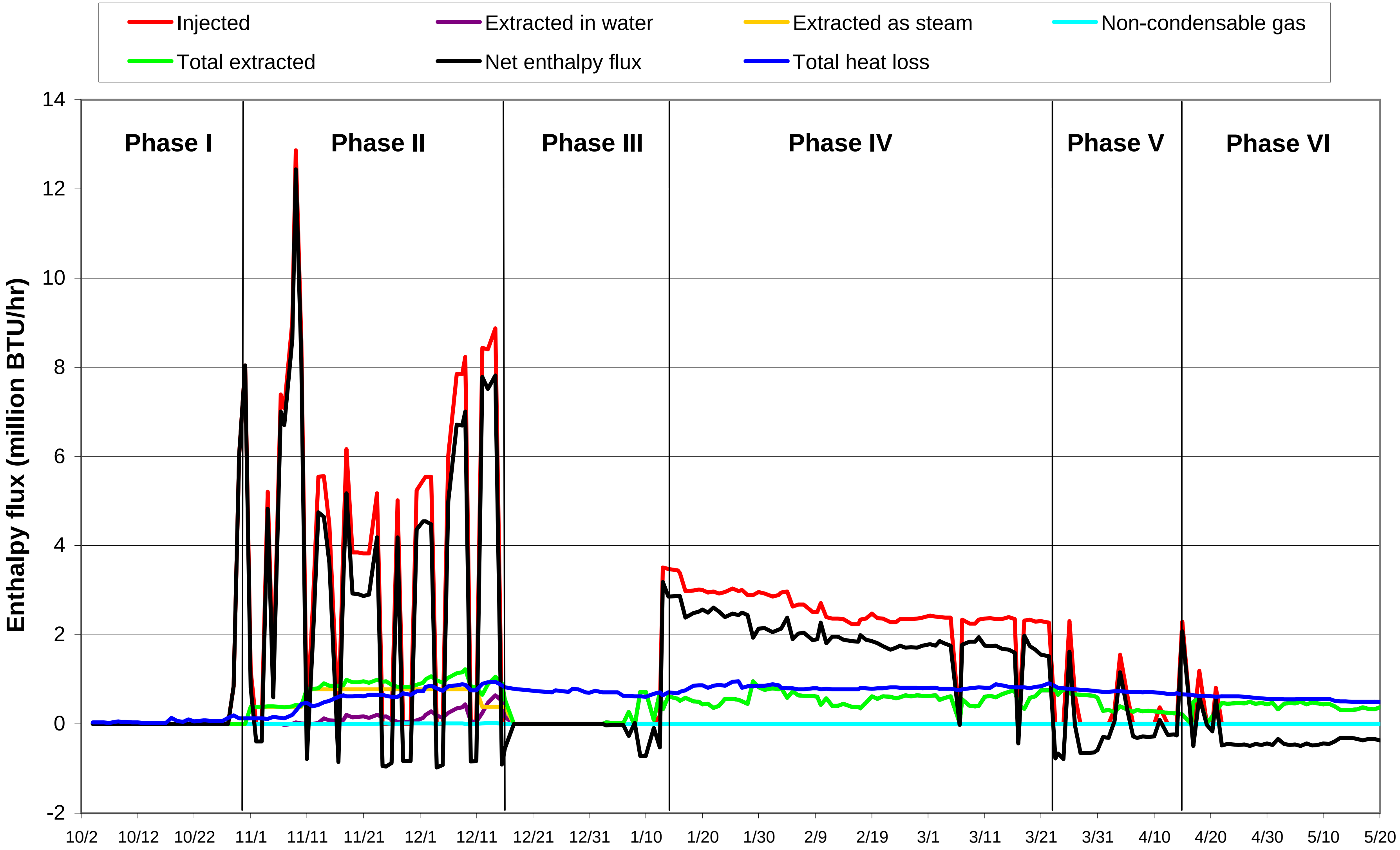


Figure 6.1-14. Energy balance for the pilot test area during operation

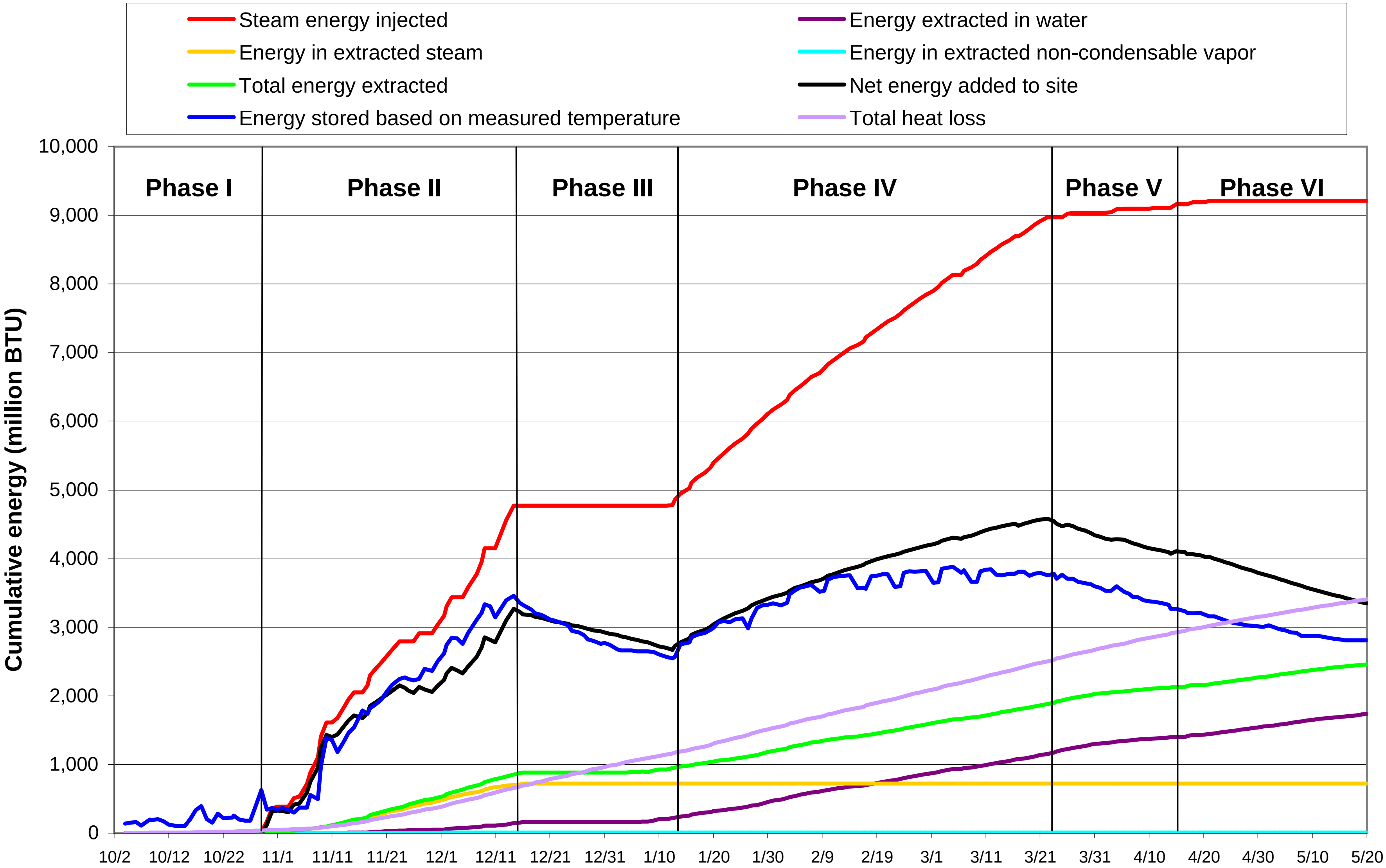


Figure 6.1-15. Cumulative energy losses estimated based on temperature gradients at the boundaries of the pilot test volume

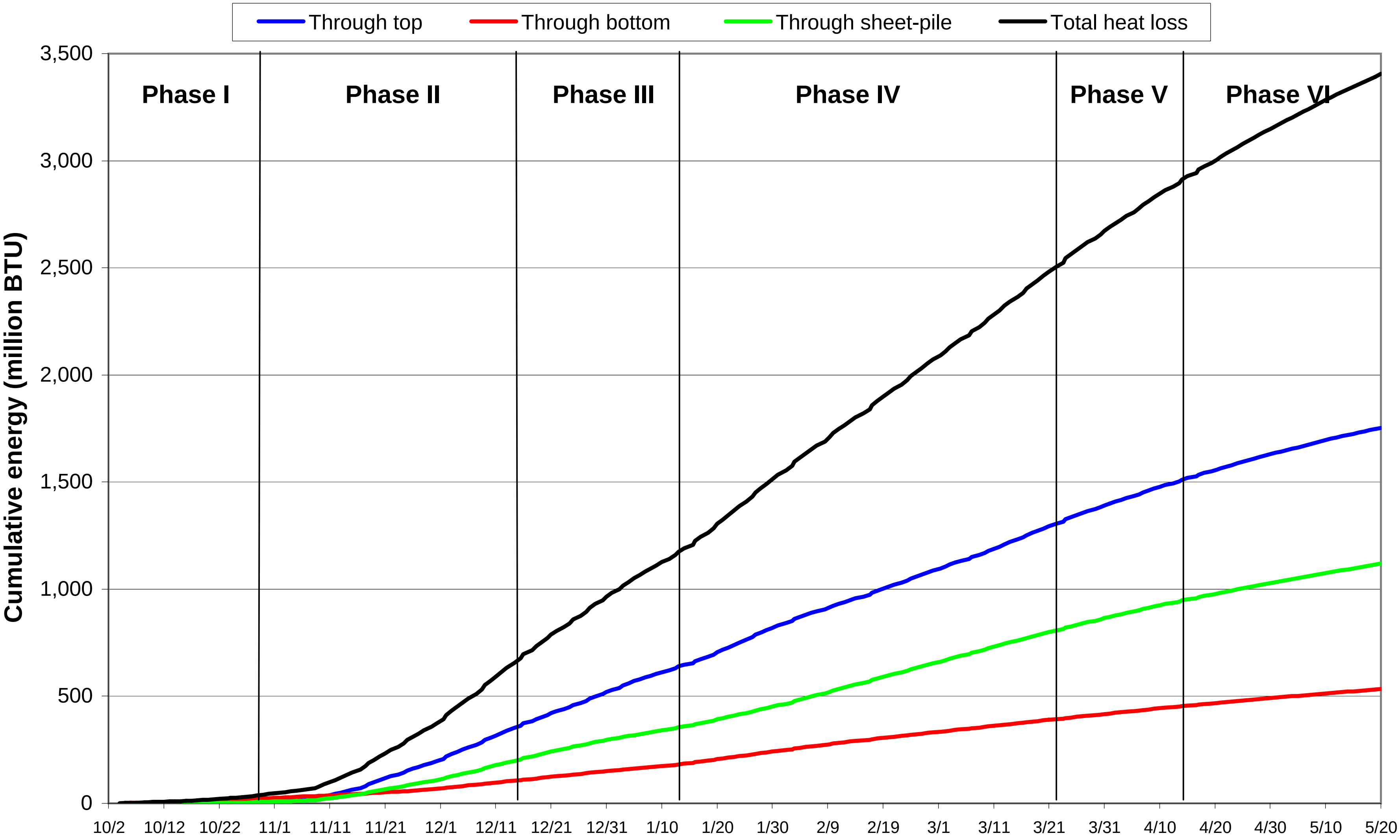
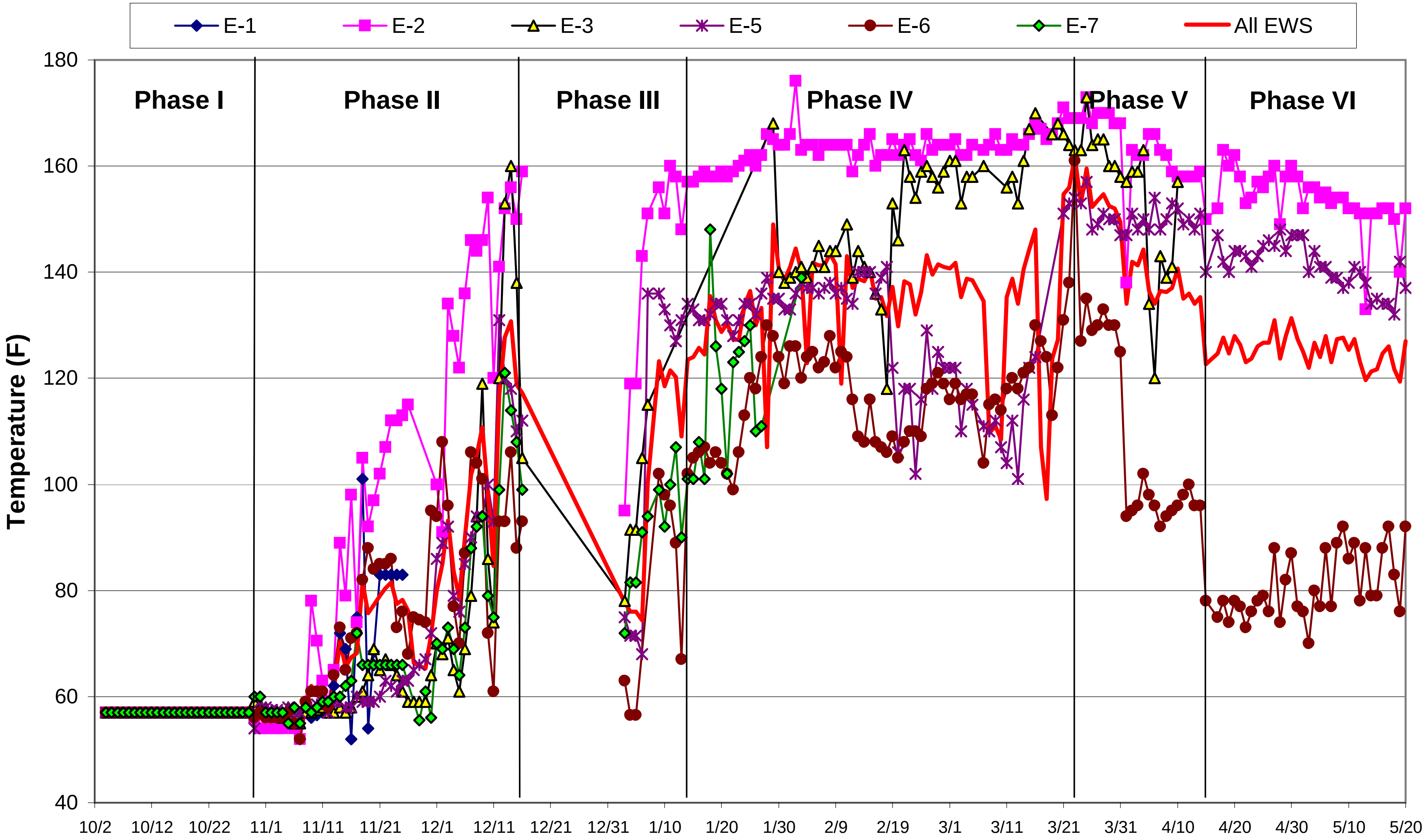
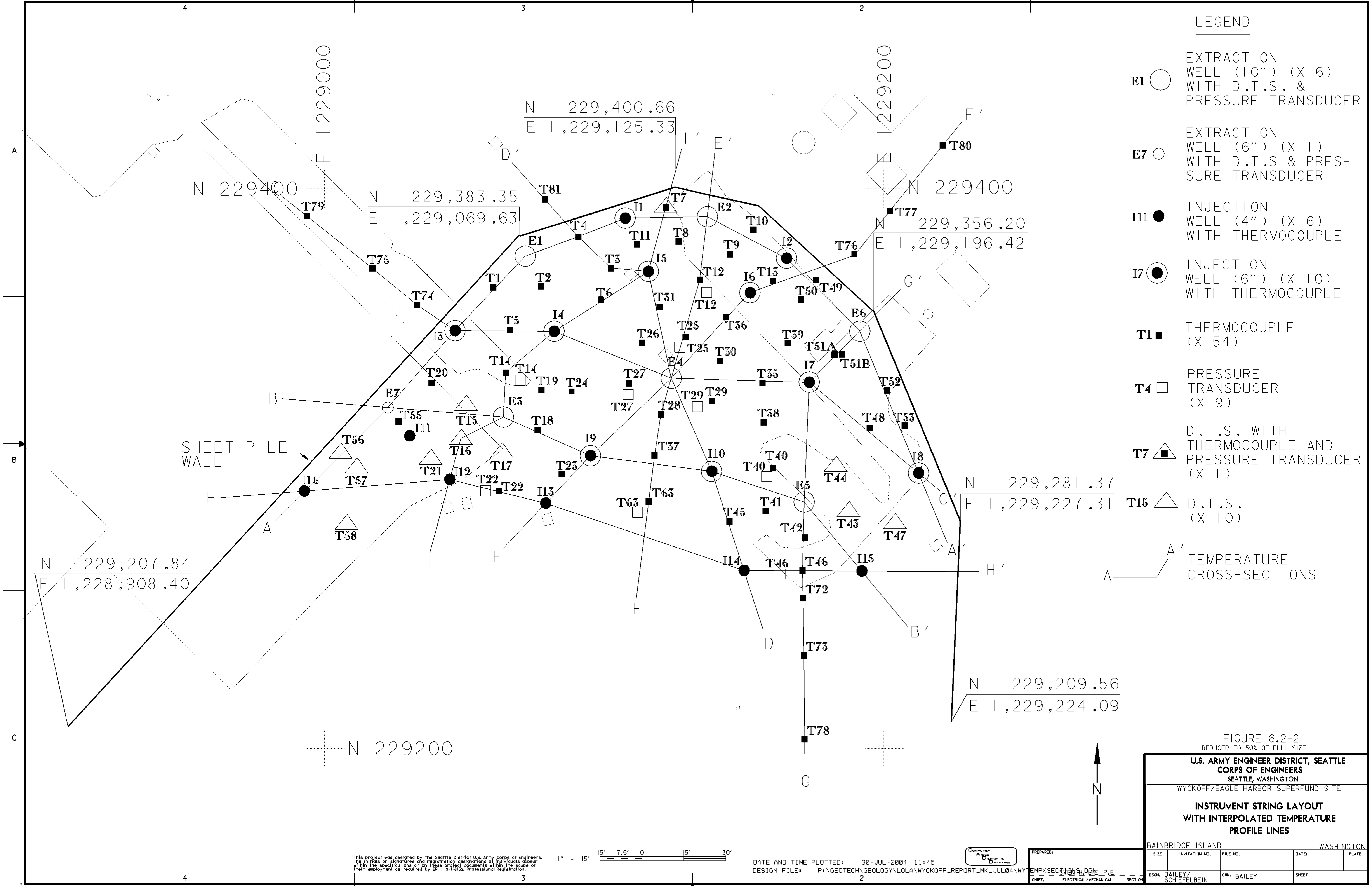


Figure 6.2-1. Temperatures of the liquid extracted from six of the seven extraction wells. No temperature measurements were made for E-4





This project was designed by the Seattle District U.S. Army Corps of Engineers. The initials or signatures and registration designations of individuals appear within the specifications or on these project documents within the scope of their employment as required by ER 1110-1-8152, Professional Registration.

DATE AND TIME PLOTTED: 30-JUL-2004 11:45
DESIGN FILE: P:\GEOTECH\GEOLOGY\LOLA\WYCKOFF_REPORT_MK_JUL04\WYTEMPXSECTIONS.DGN

FIGURE 6.2-2
REDUCED TO 50% OF FULL SIZE

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
WYCKOFF/EAGLE HARBOR SUPERFUND SITE

INSTRUMENT STRING LAYOUT
WITH INTERPOLATED TEMPERATURE
PROFILE LINES

BAINBRIDGE ISLAND WASHINGTON

PREPARED:
SVEN H. LIE, P.E.
CHIEF, ELECTRICAL/MECHANICAL SECTION

SIZE	INVITATION NO.	FILE NO.	DATE:	PLATE
DSGN. BAILEY/ SCHIEFELBEIN		CHK. BAILEY	SHEET	

Figure 6.2-3. Comparison of temperature profiles from DTS and thermocouples for instrument string T-7.

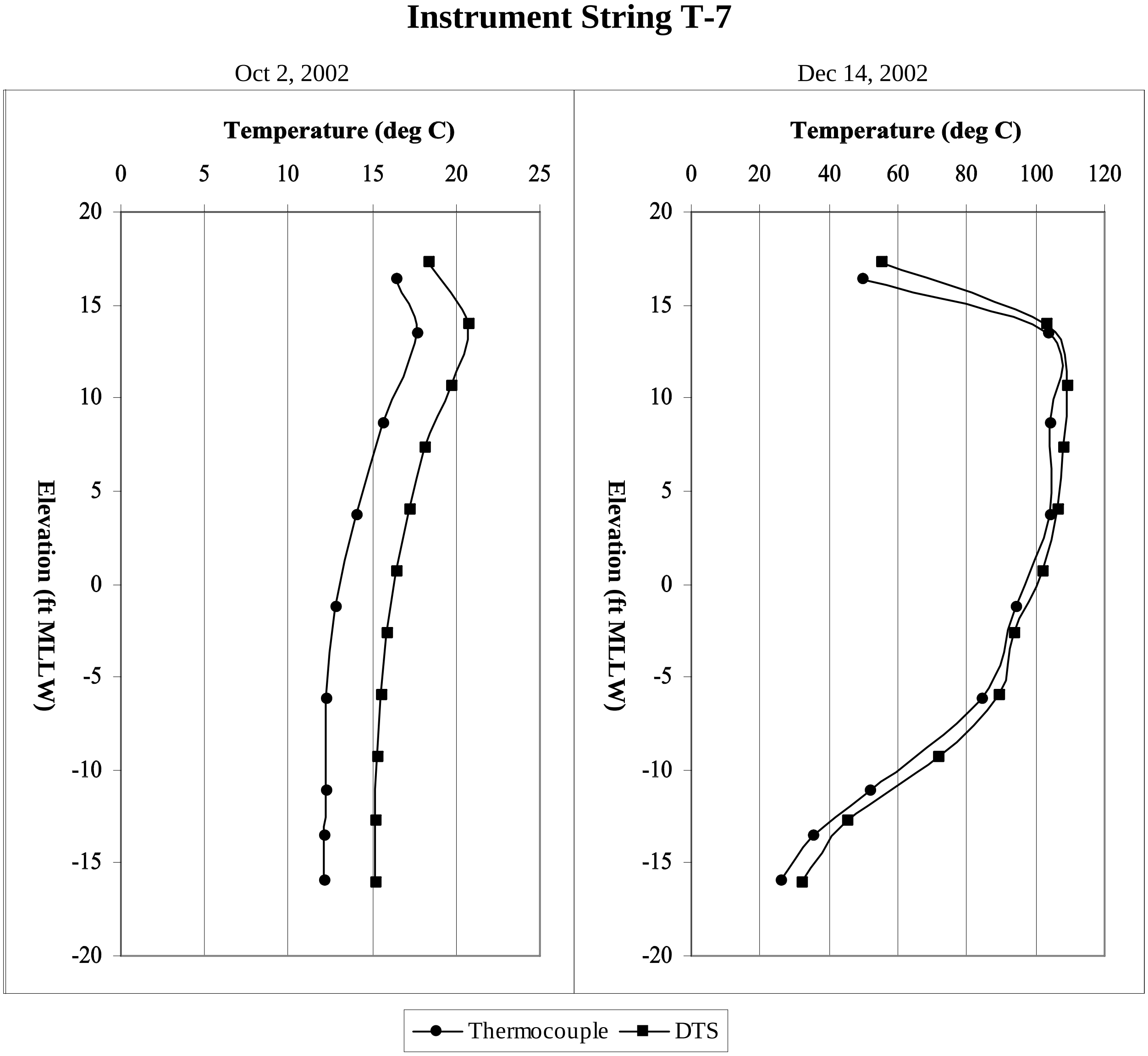


Figure 6.2-4. Interpolated temperature maps for pseudo-horizonal Slices A-D and horizontal Slice E.

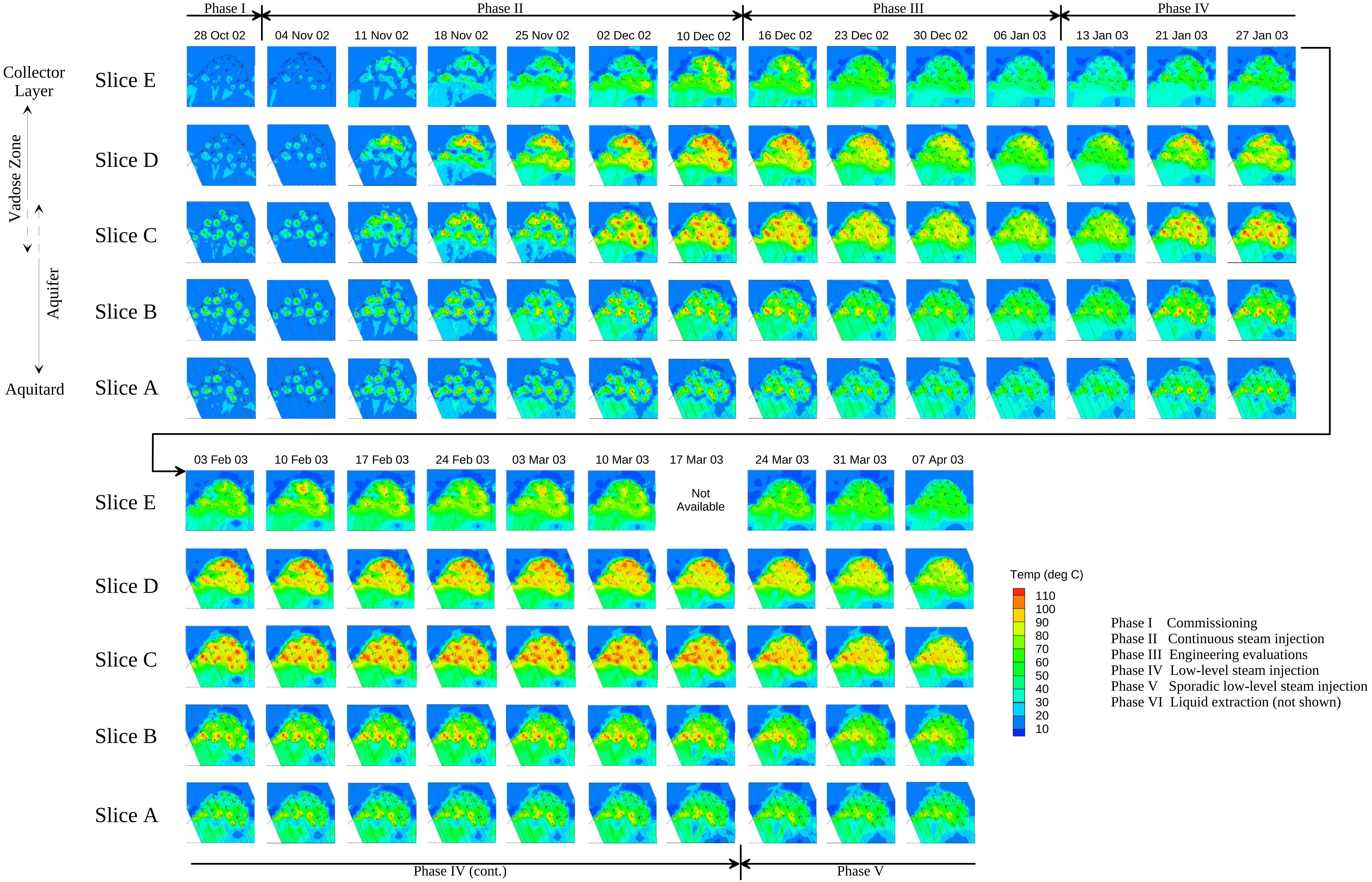
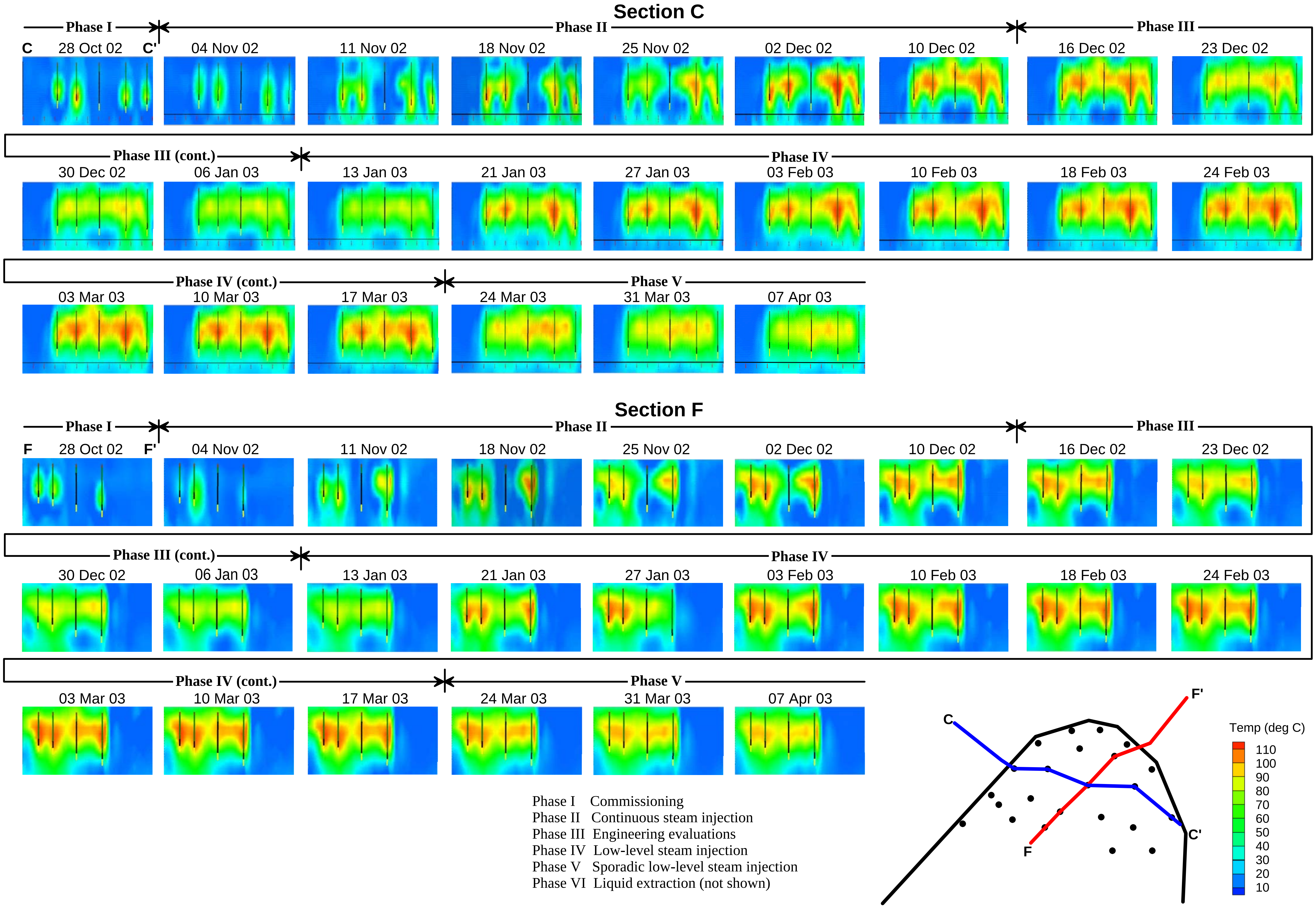


Figure 6.2-5. Interpolated temperature profiles along Sections C and F.



Phase I	Commissioning
Phase II	Continuous steam injection
Phase III	Engineering evaluations
Phase IV	Low-level steam injection
Phase V	Sporadic low-level steam injection
Phase VI	Liquid extraction (not shown)

Figure 6.2-6. Temperature profiles and water levels for extraction wells E-4 and E-6.

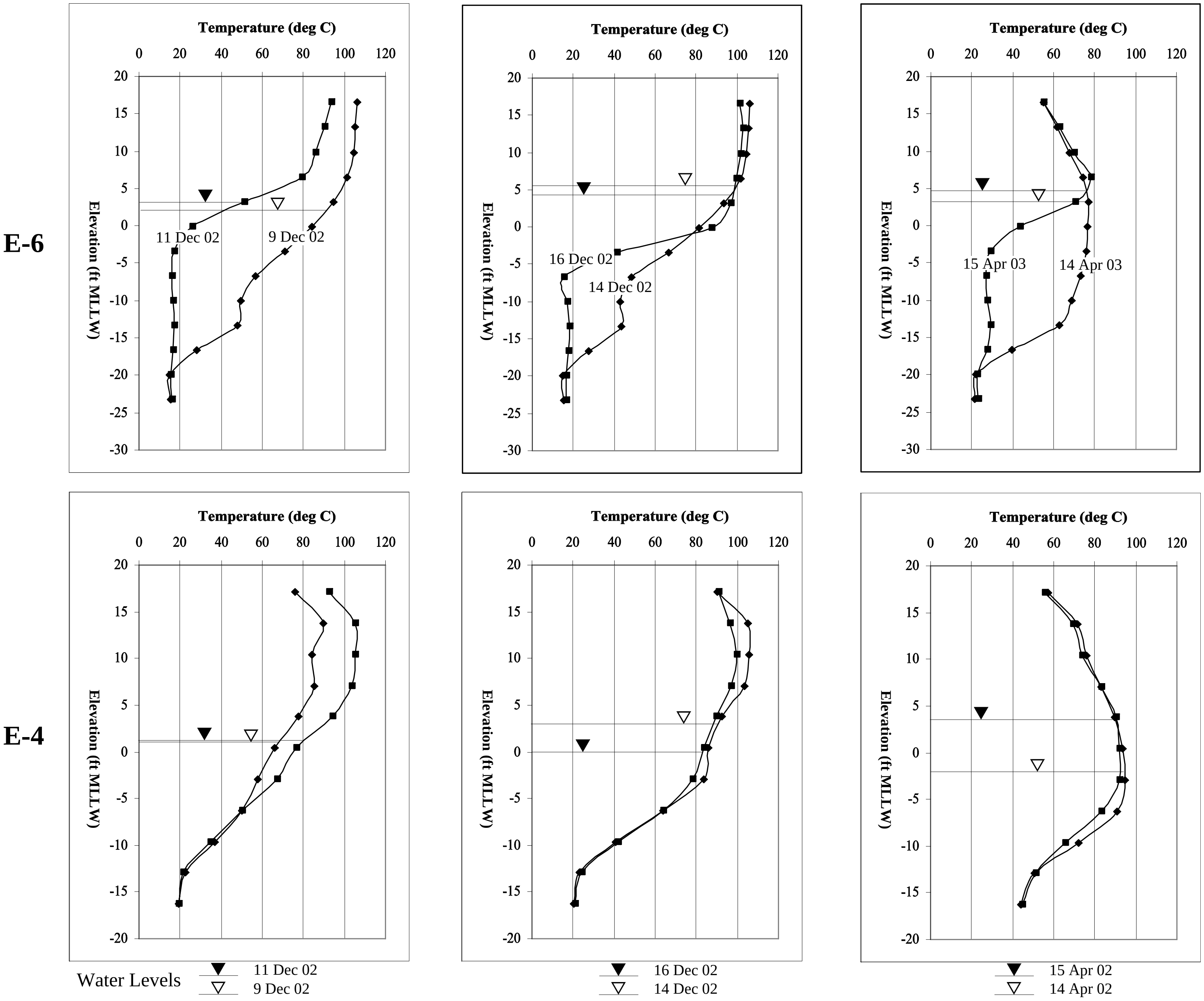
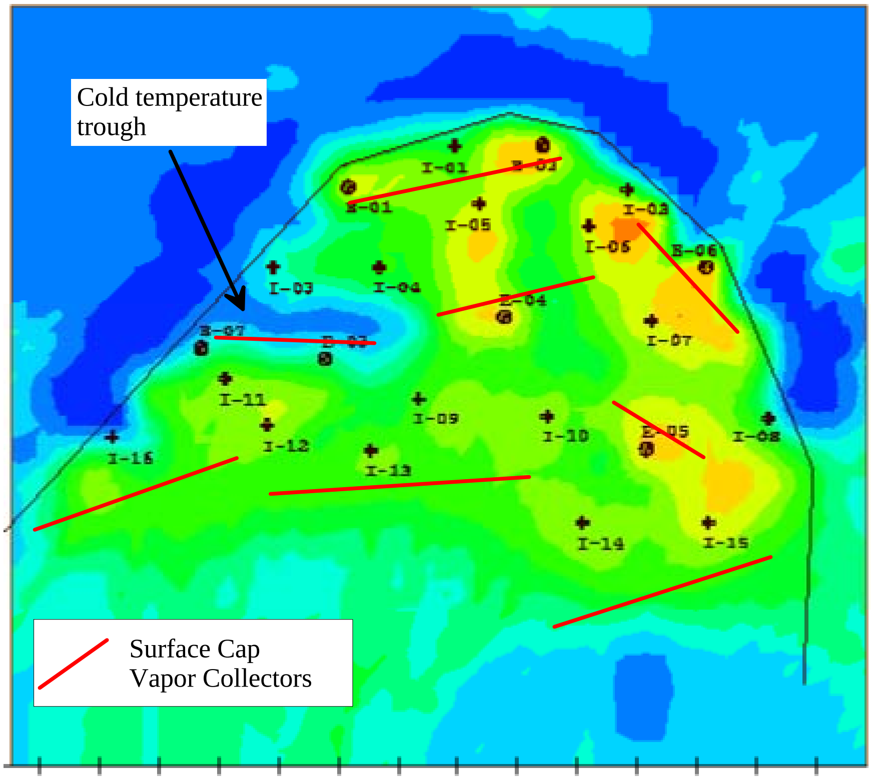


Figure 6.2-7. Collector layer temperatures on December 10 and 12, 2002.

December 10, 2002



December 12, 2002

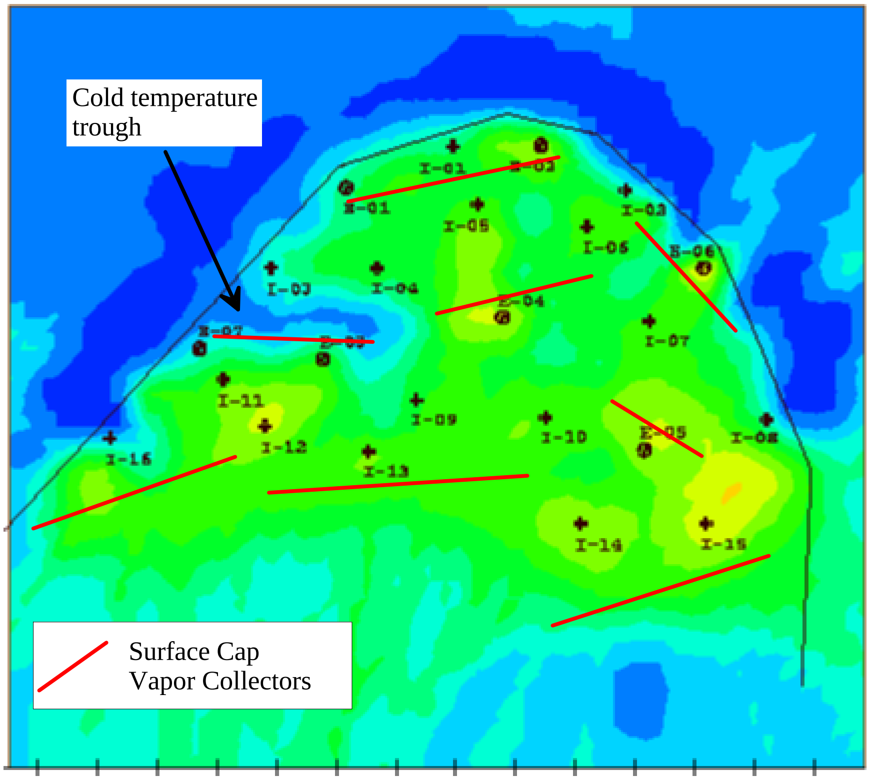
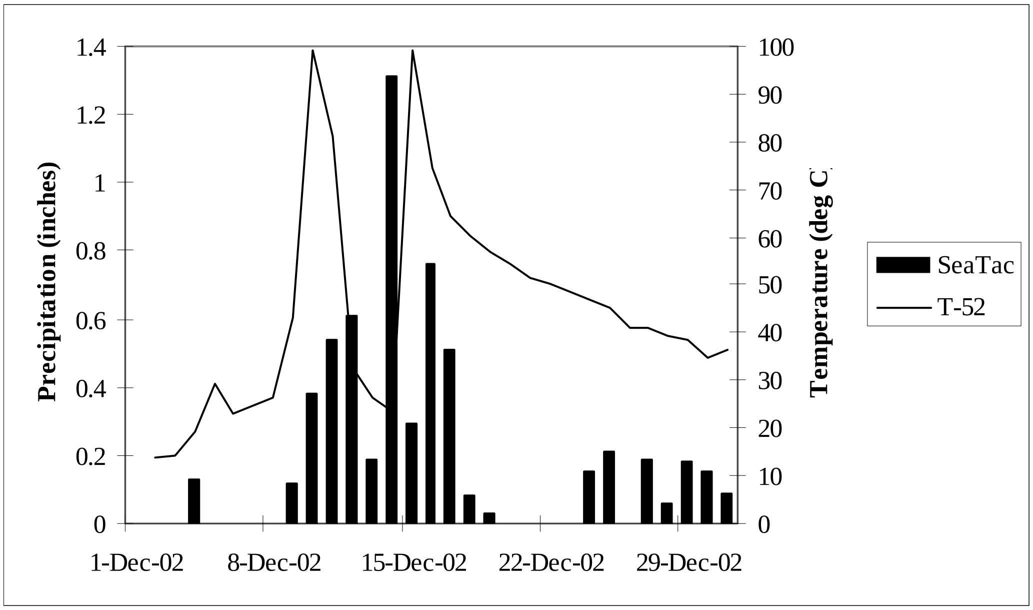
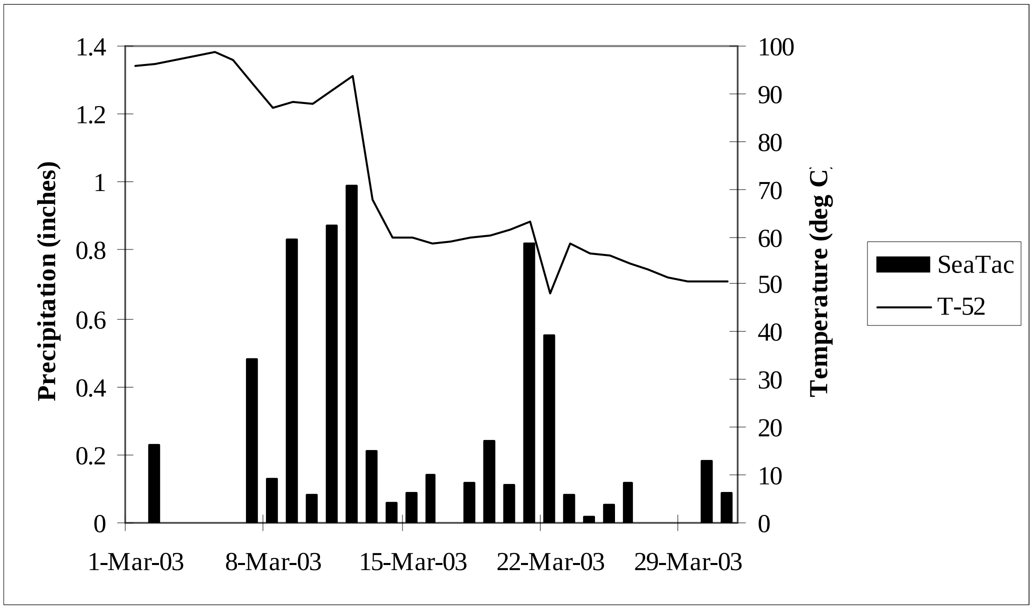


Figure 6.2-8. SeaTac airport precipitation and collector layer temperature at instrument string T-52.



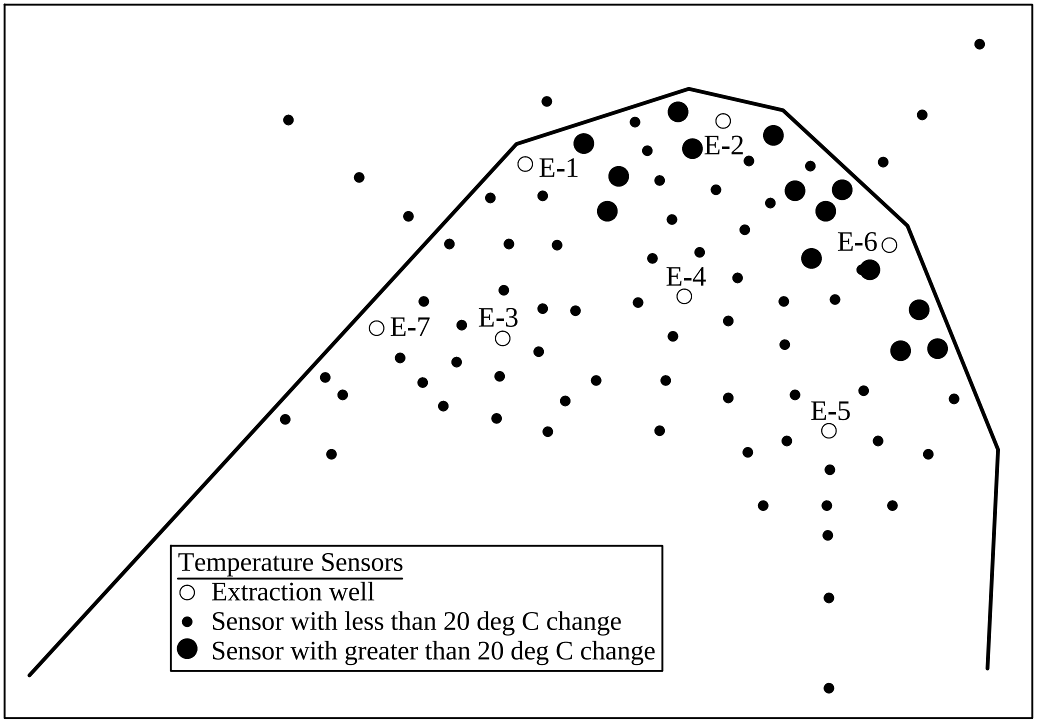
December 2002



March 2003

Figure 6.2-9. Temperature sensor locations in the vapor collector layer exhibiting a temperature drop of greater than 20 degrees C.

December 10-12, 2002



March 12-13, 2003

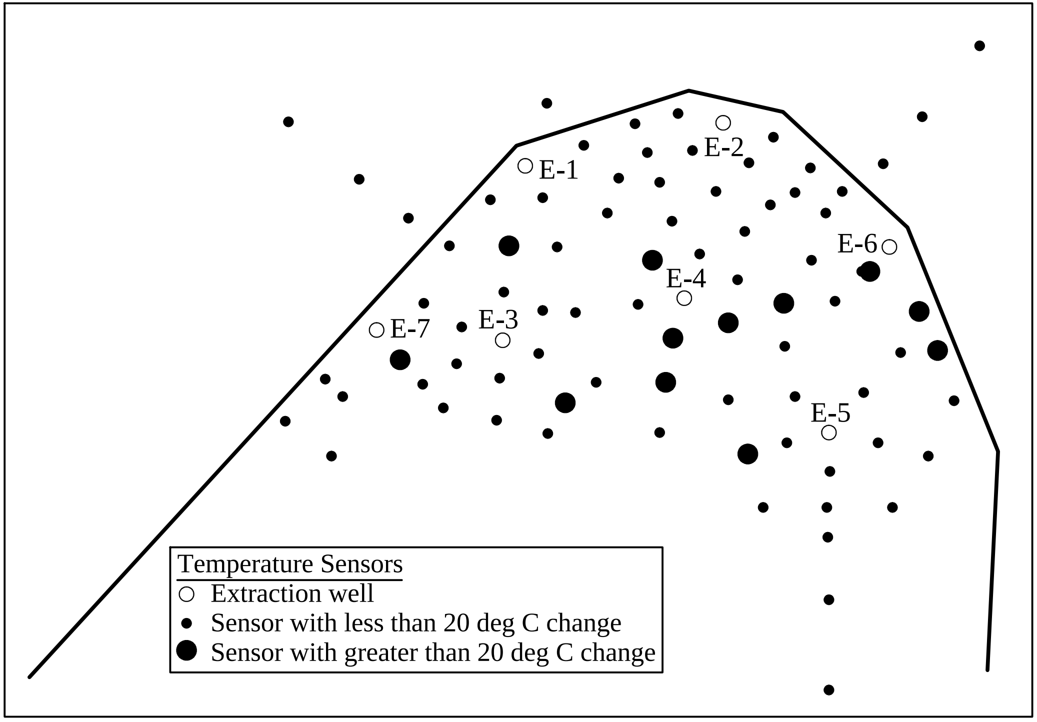


Figure 6.2-10. Instrument string temperature profiles along the inside of the sheet-pile wall for October-December 2002.

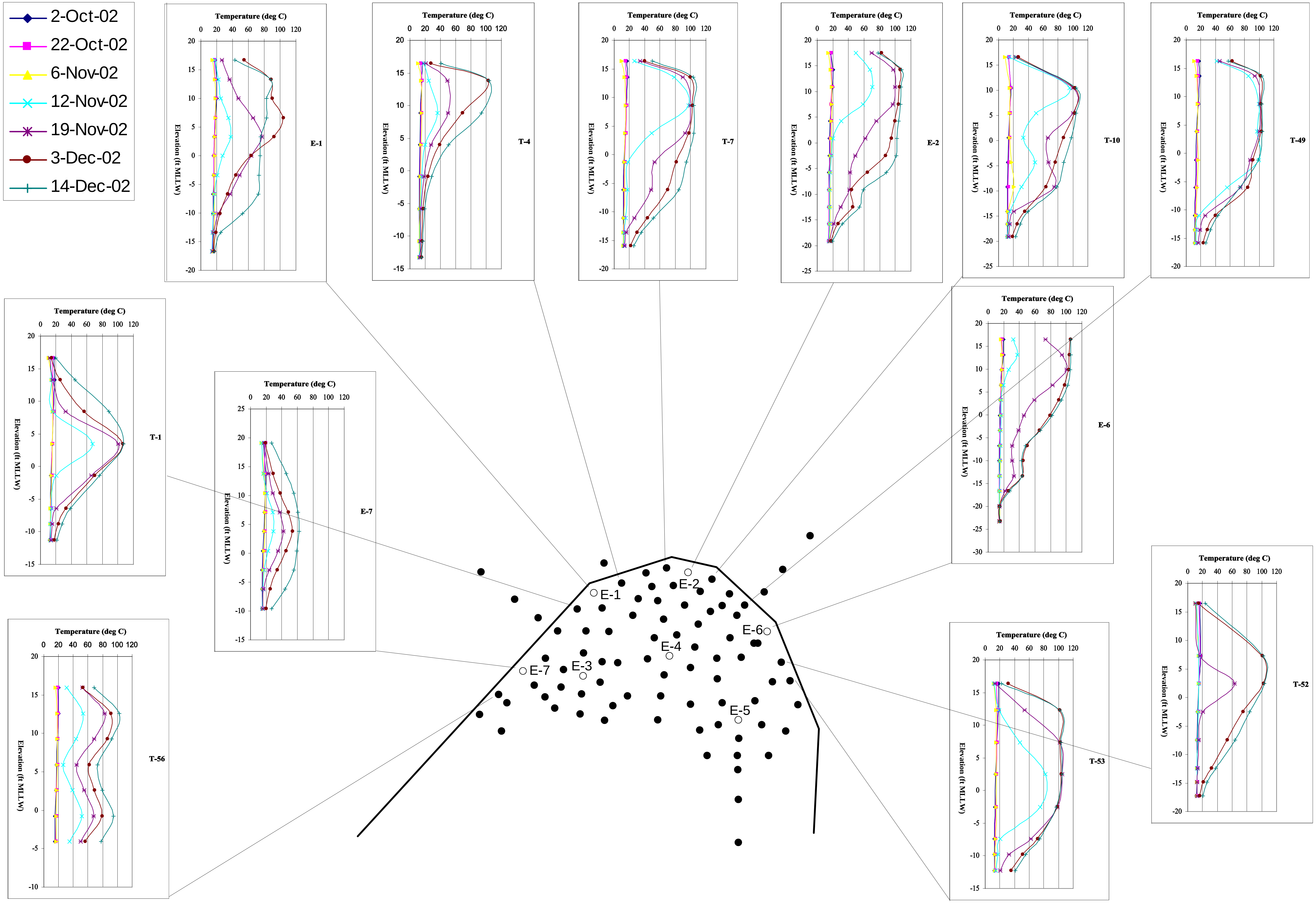


Figure 6.2-11. Instrument string temperature profiles along the inside of the sheet-pile wall for January-May 2003.

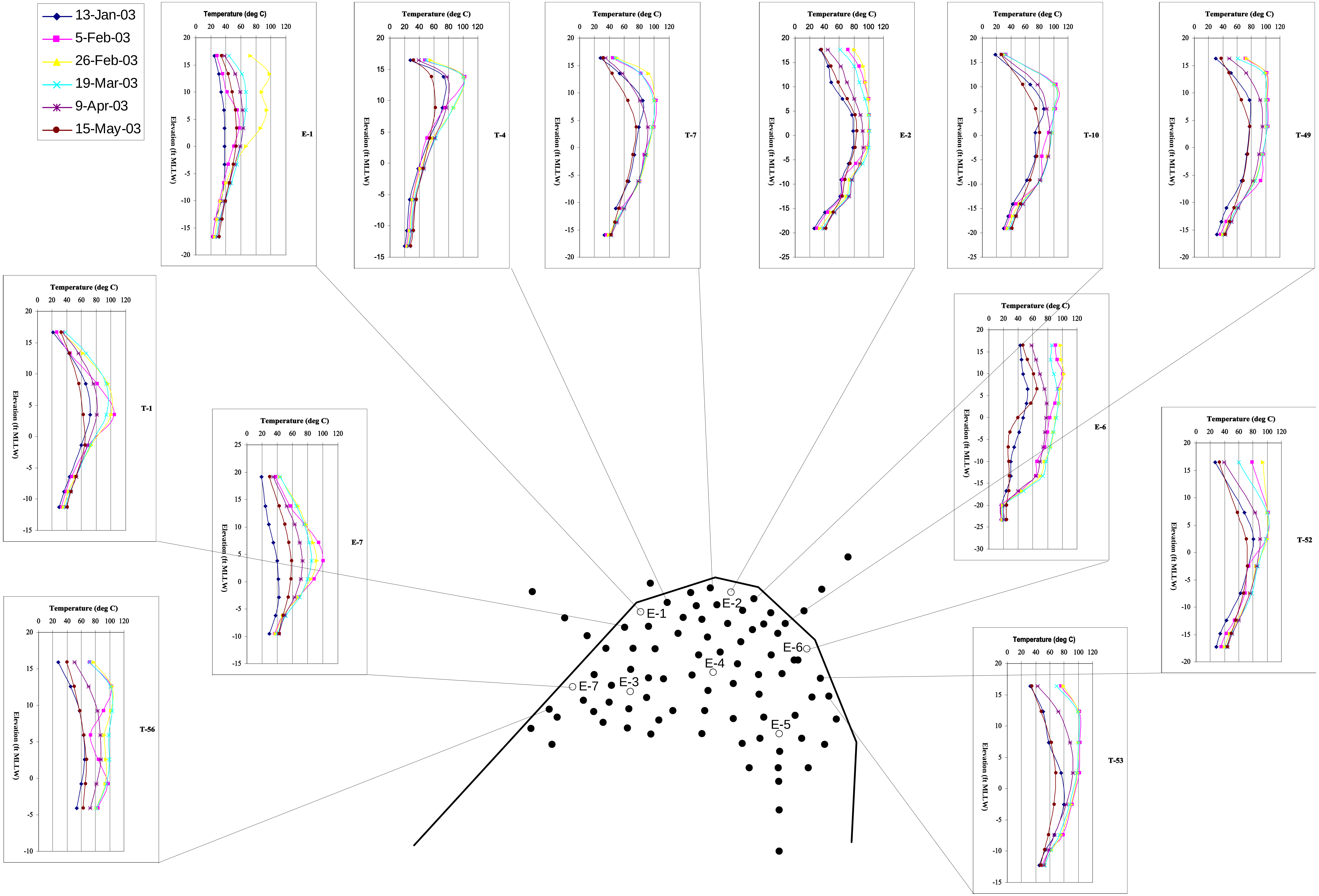


Figure 6.2-12. Instrument string temperature profiles for the E-4 array for October-December 2002.

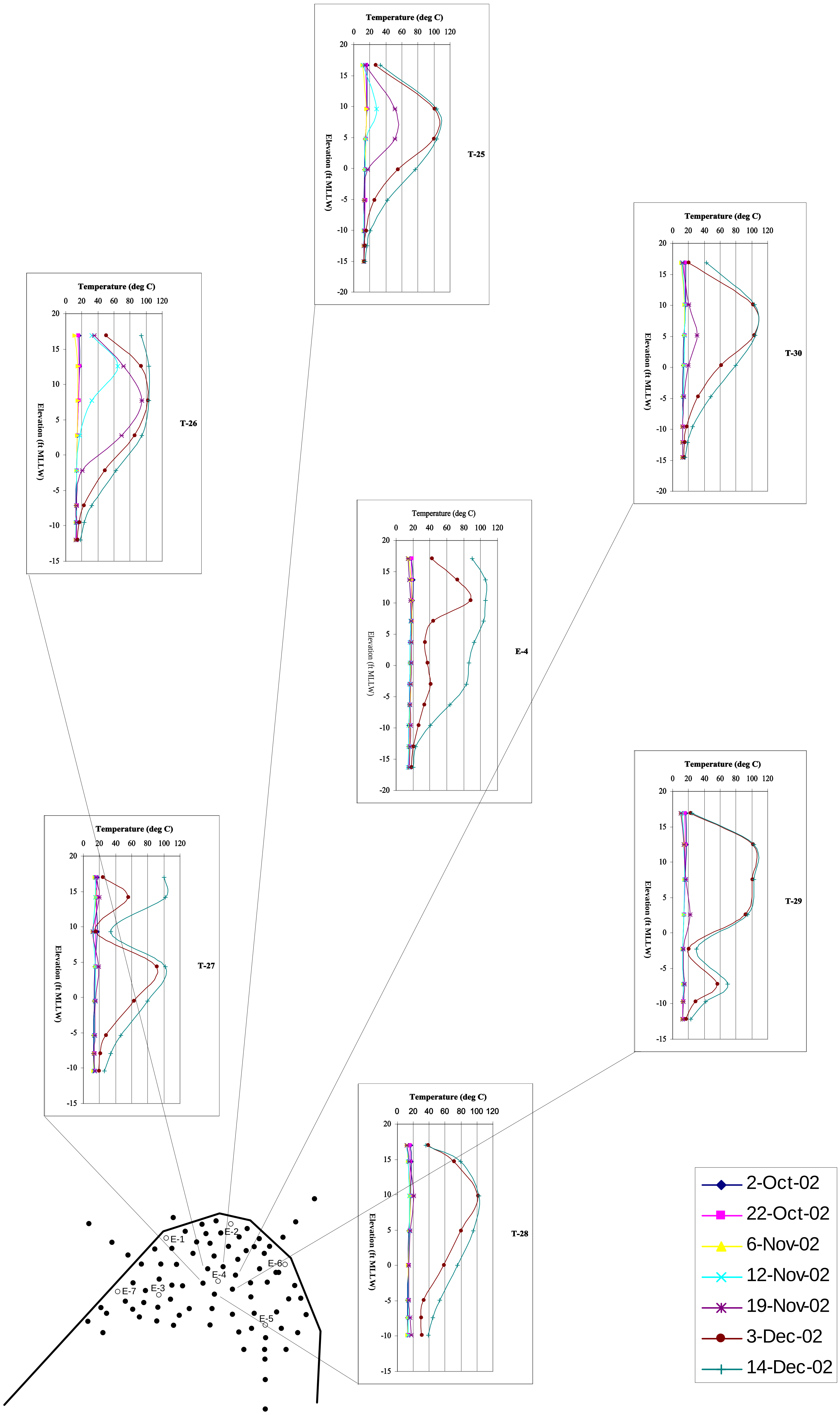


Figure 6.2-13. Instrument string temperature profiles for the E-4 array for January-May 2003.

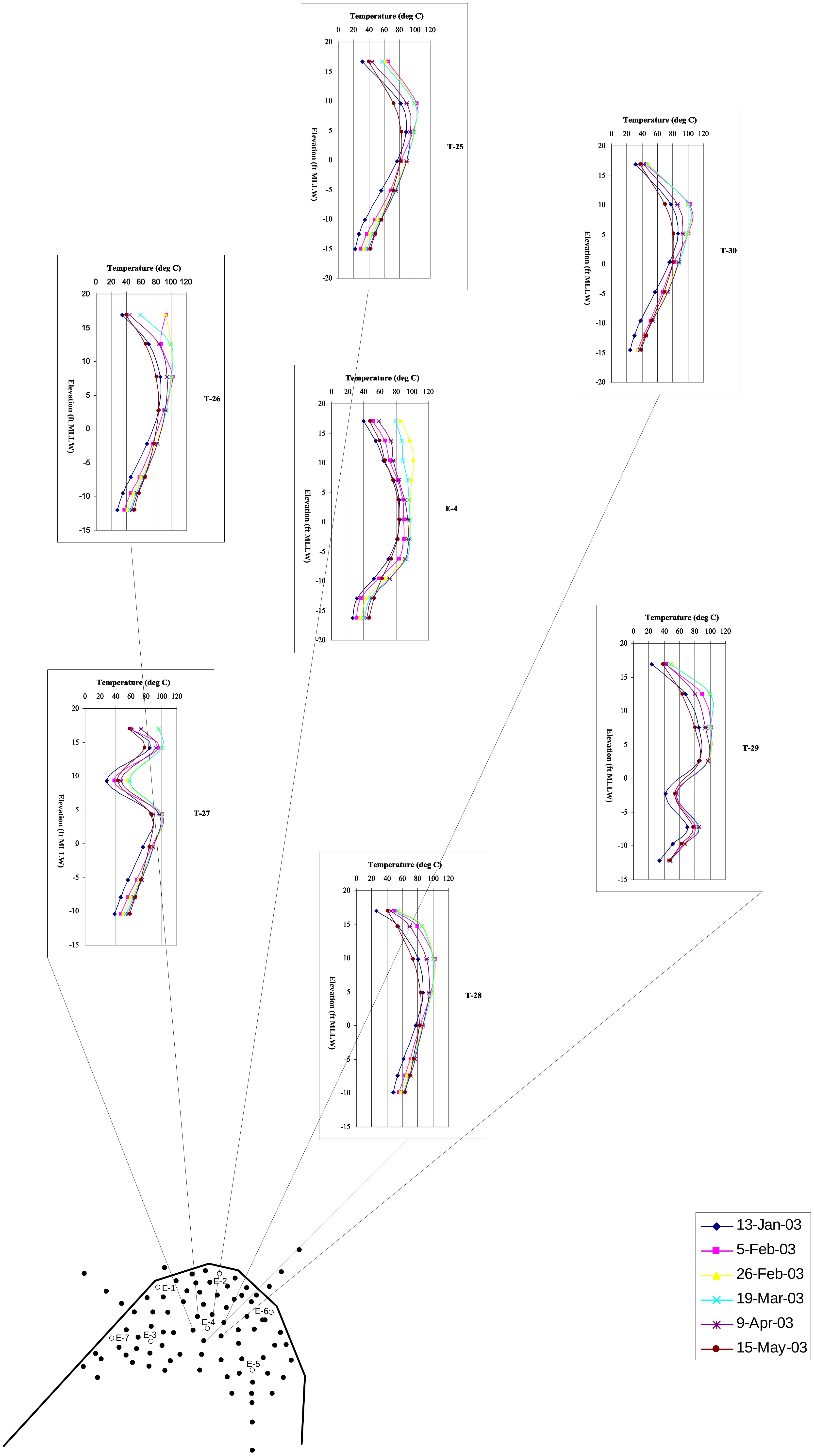


Figure 6.3-1. Calculated average temperatures based on subsurface temperature sensors

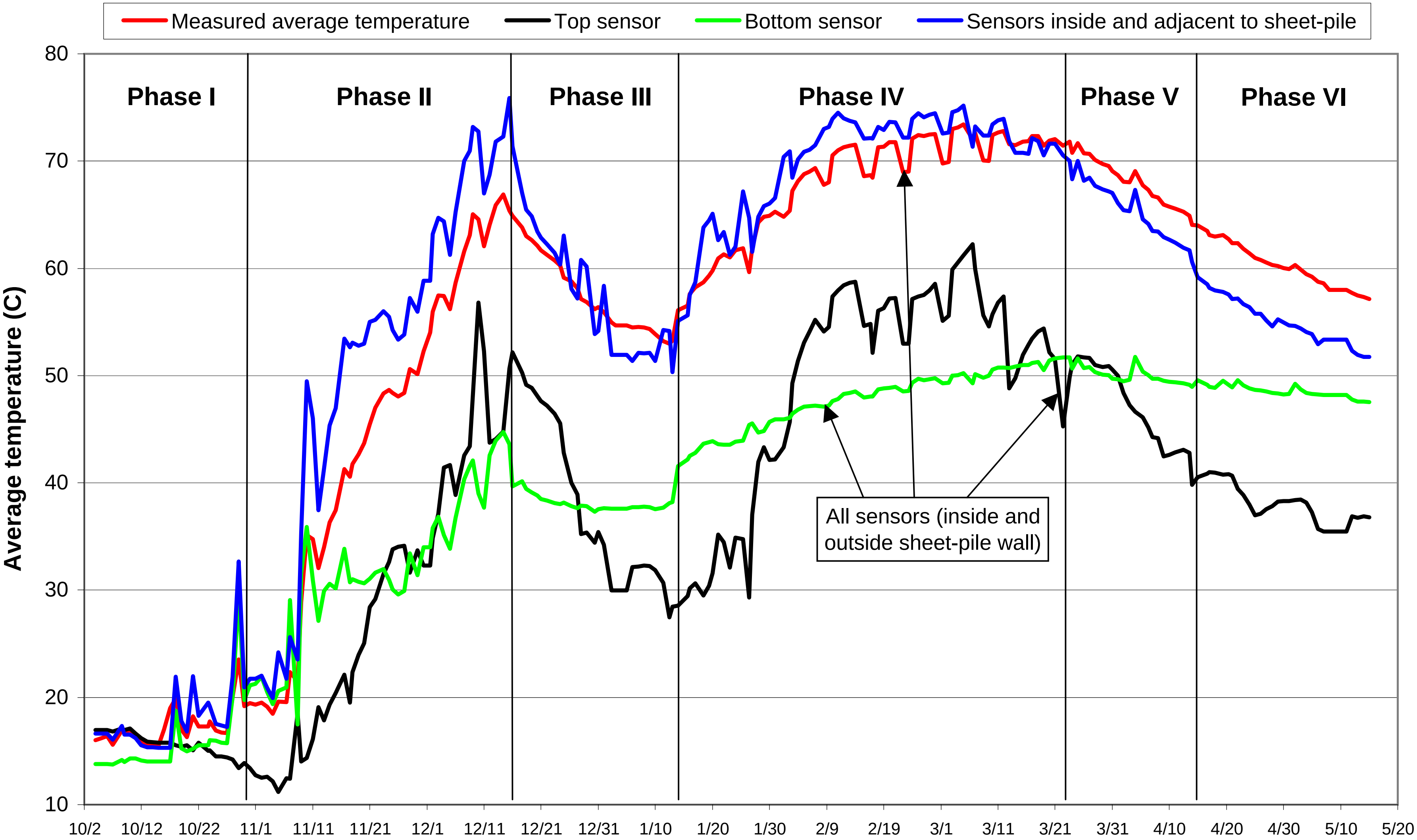


Figure 6.3-2. Comparison of the measured average pilot test area temperature to the average temperature calculated from energy balance data and an assumed volume and heat capacity

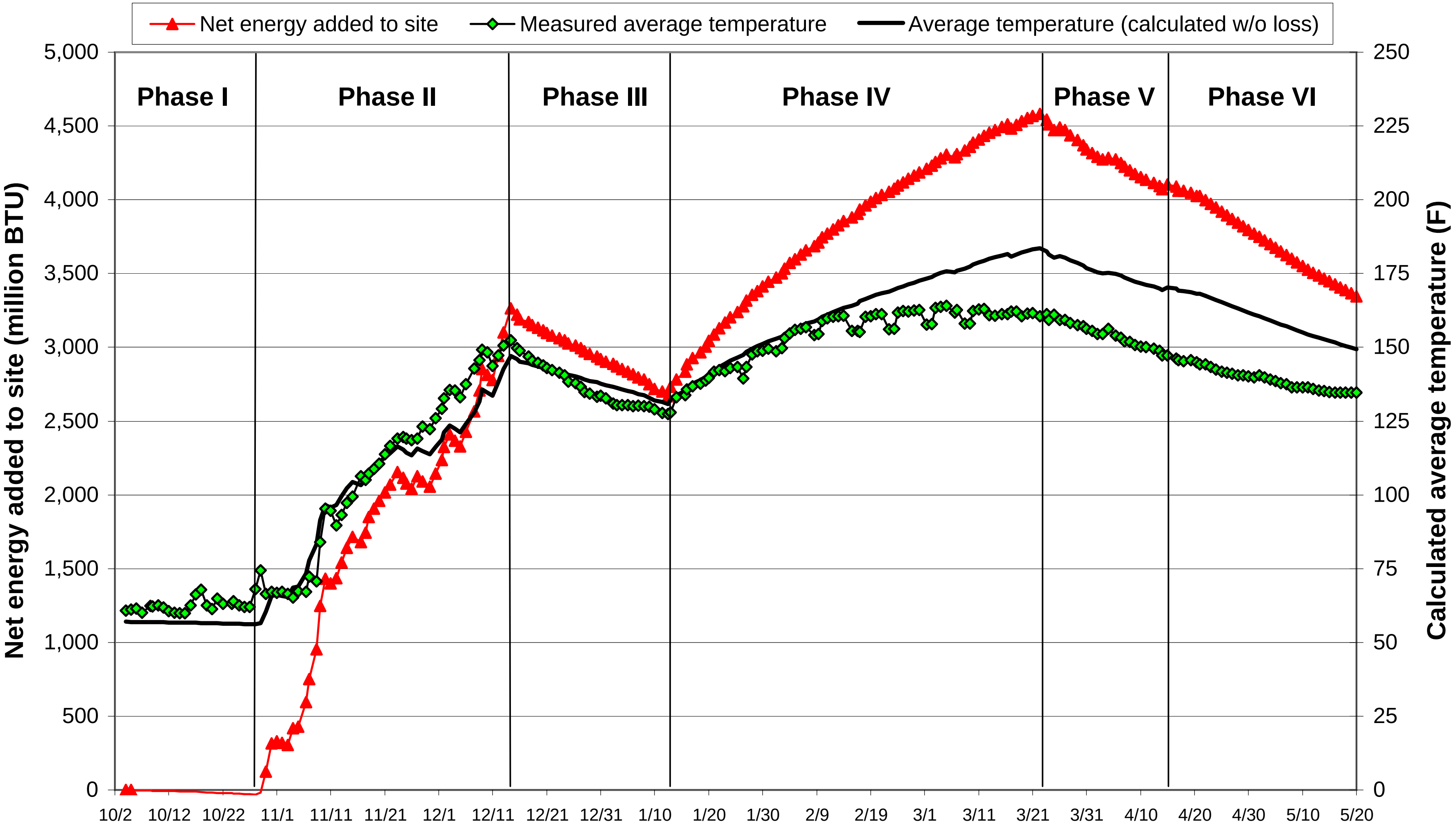


Figure 6.3-3. Cumulative volume of water (in thousand gallons) extracted from each E well during steam pilot

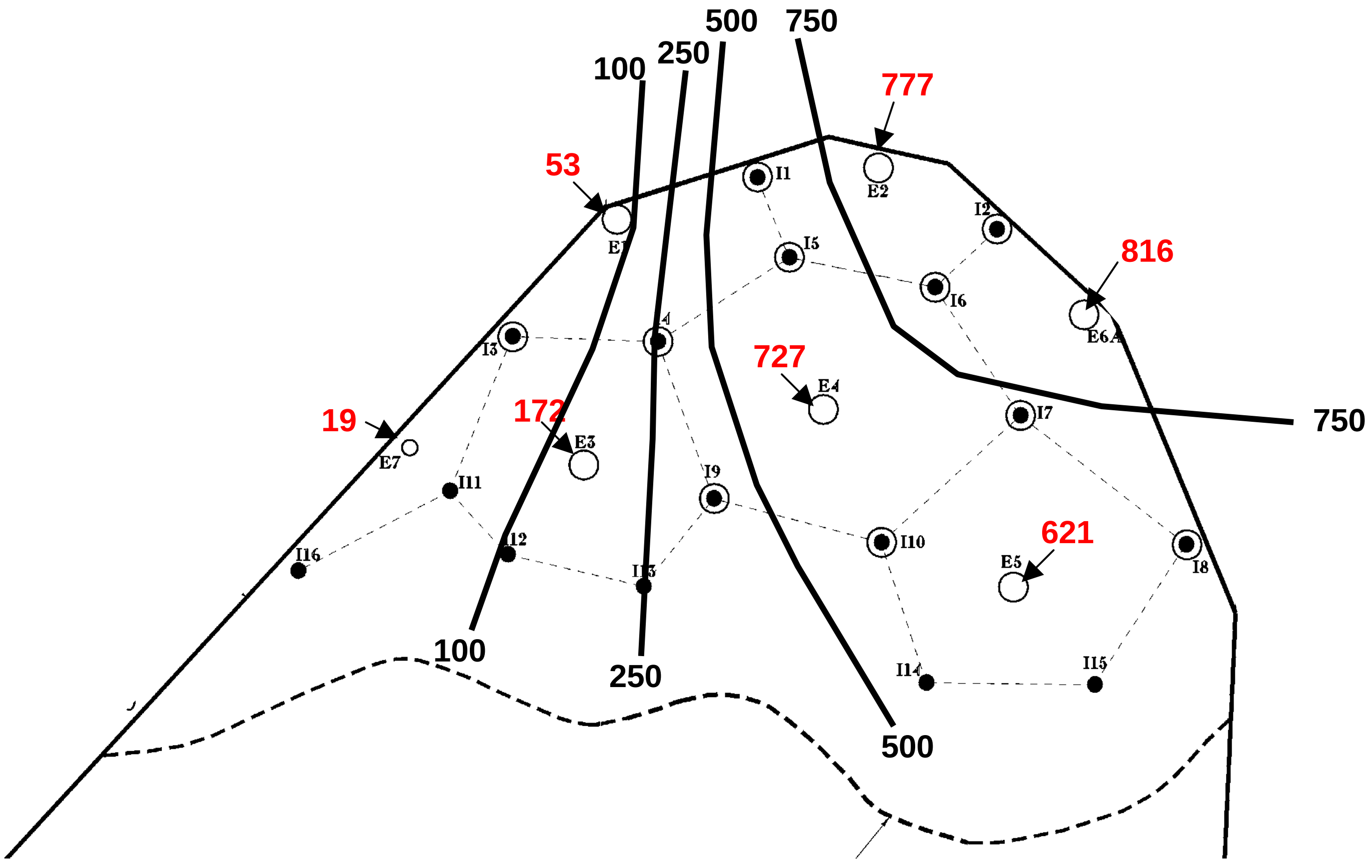


Figure 6.3-4. Average steam injection rate (in lbs/hr) for each of the 16 injection wells in the period between 10/30/02 and 12/14/02

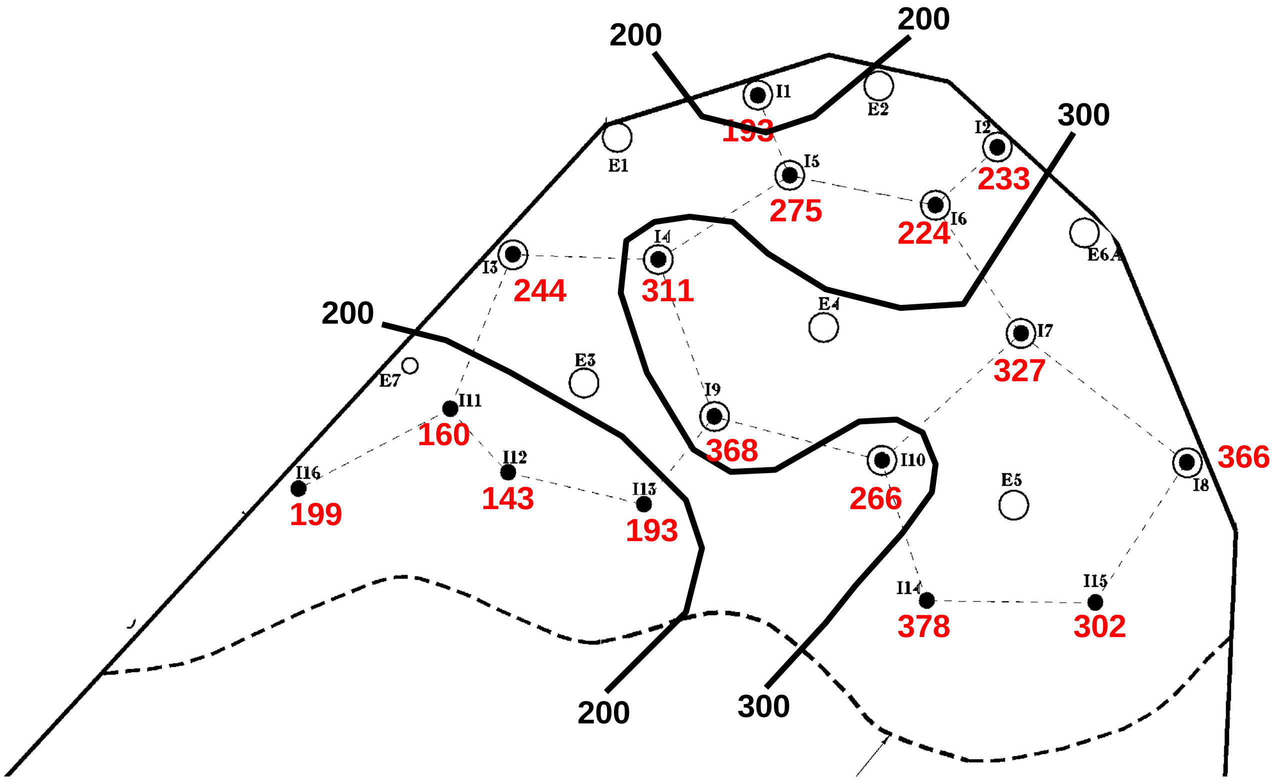


Figure 6.4-1. Extracted Liquid PAH Concentrations
(November 7, 2002 through January 27, 2003)

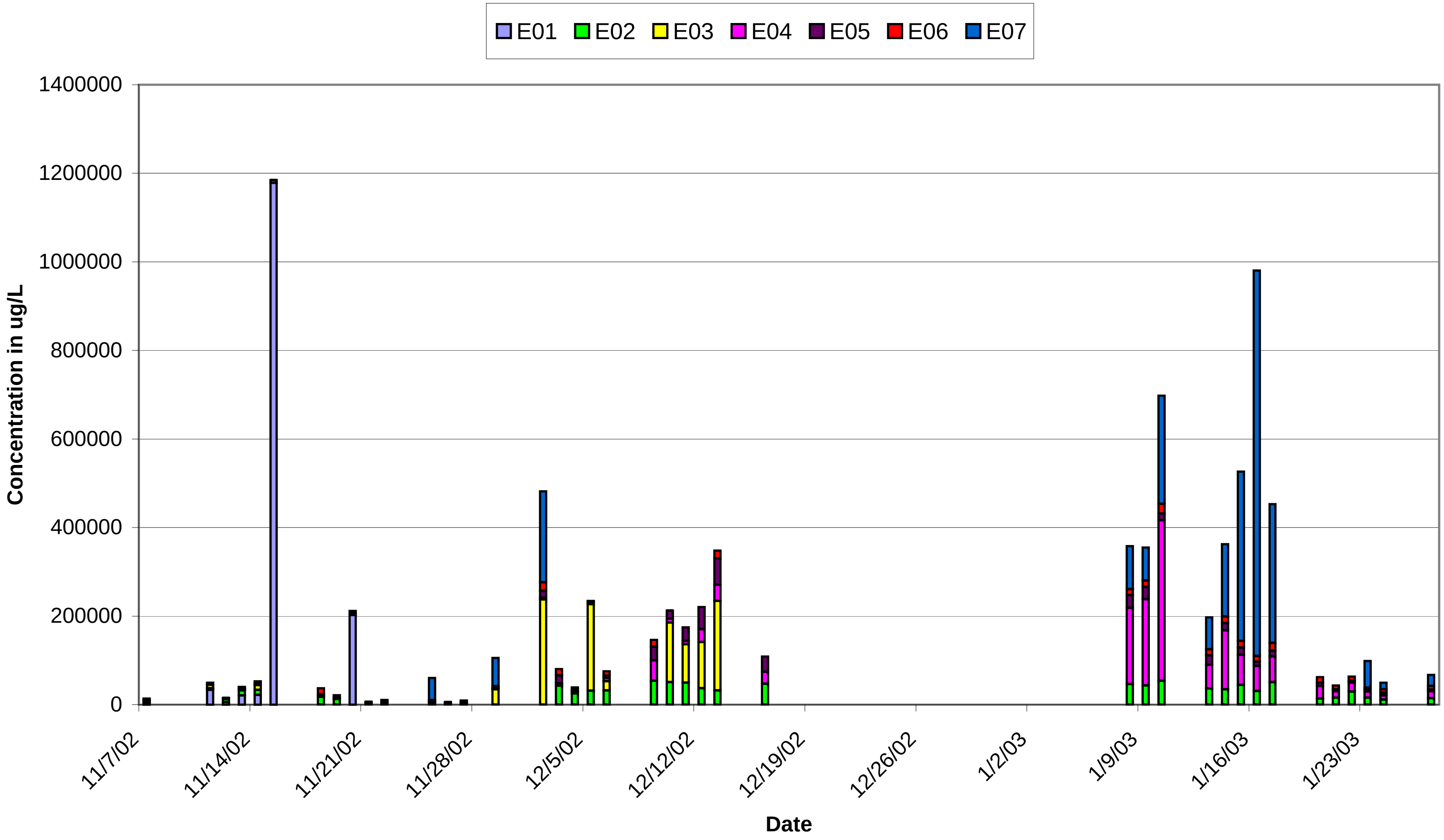


Figure 6.4-2. Extracted Liquid PAH Concentrations
(January 28, 2003 through May 12, 2003)

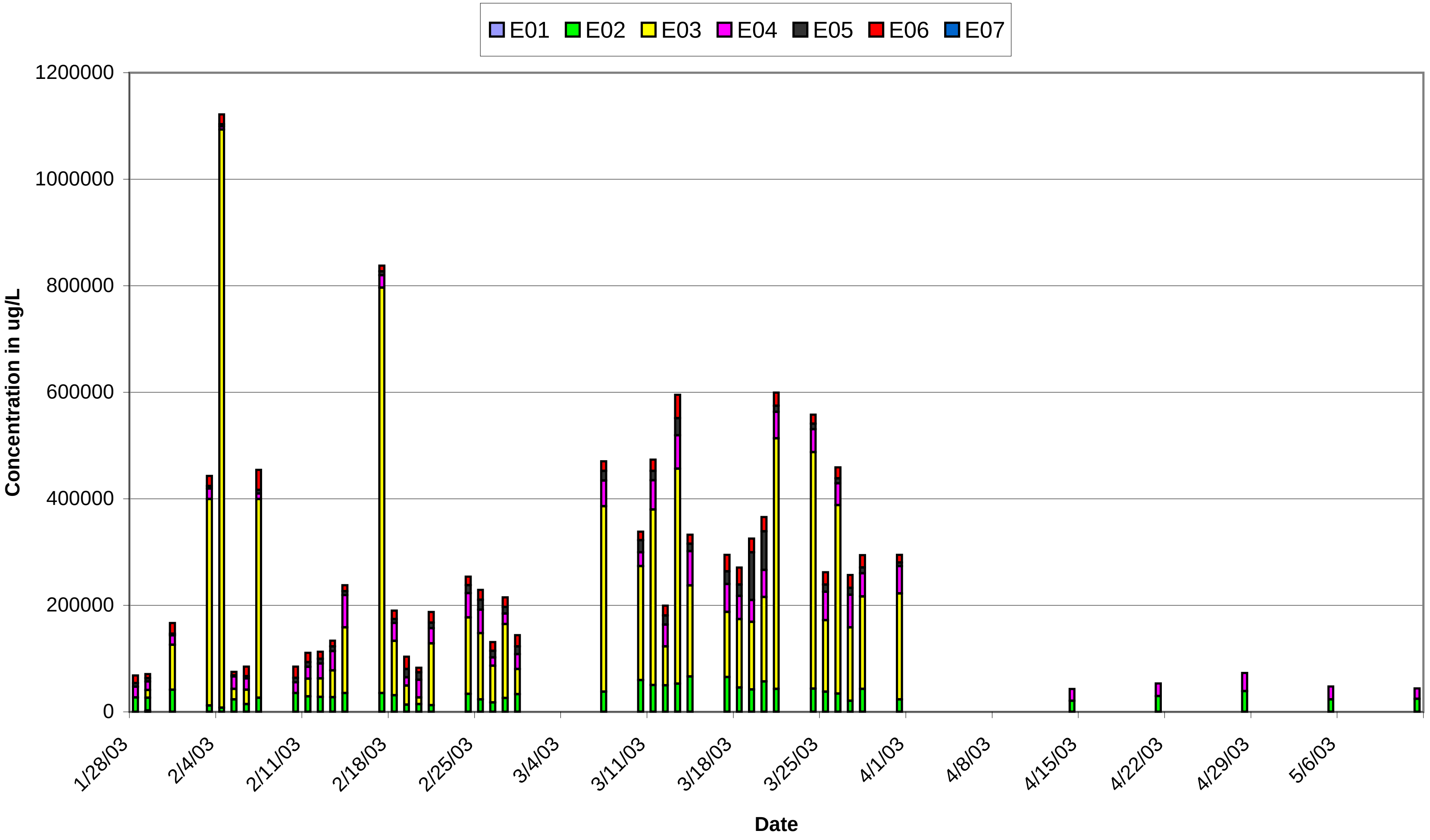


Figure 6.4-3. Extracted Liquid PCP Concentrations
(November 7, 2002 through January 27, 2003)

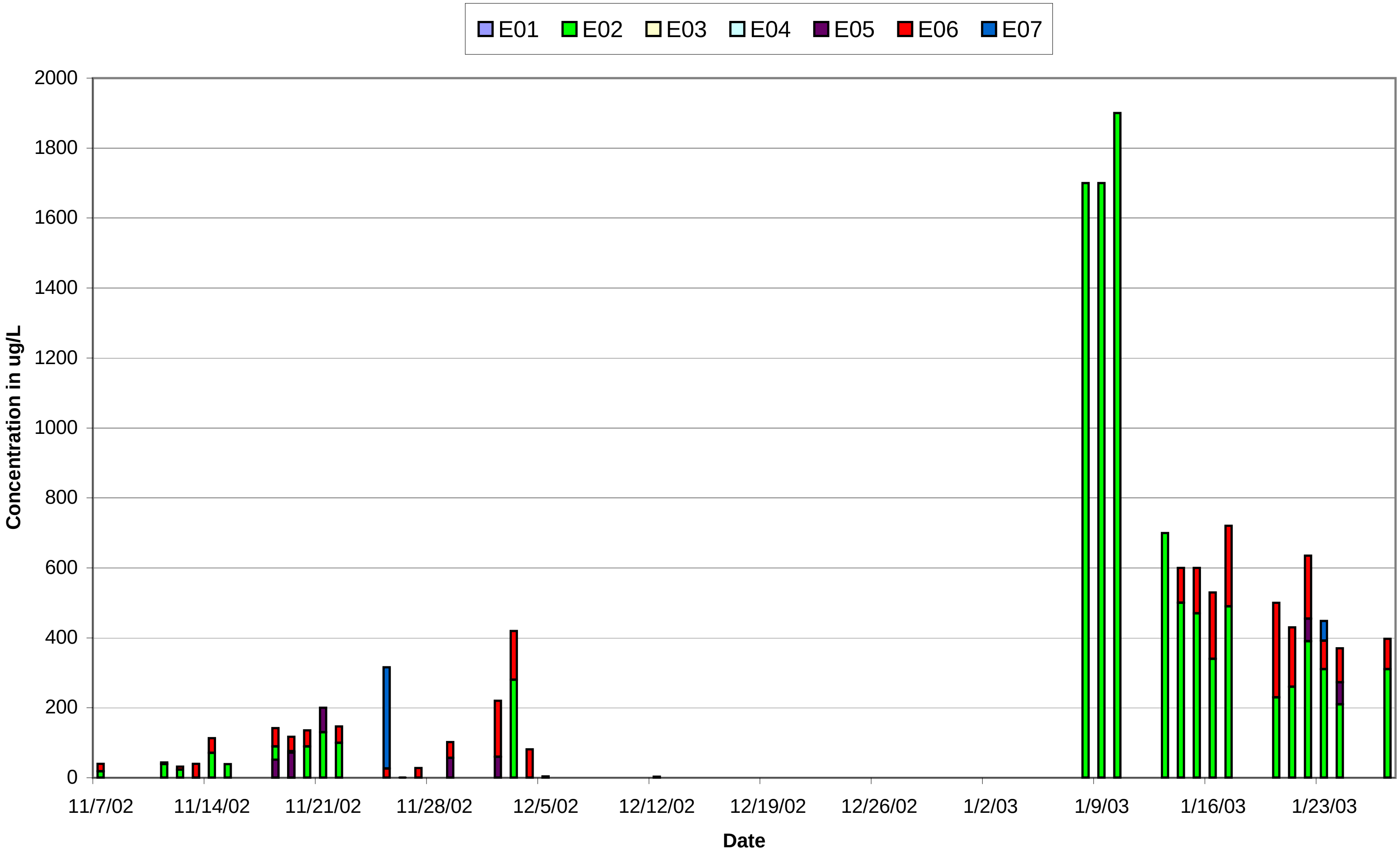


Figure 6.4-4. Extracted Liquid PCP Concentrations
(January 28, 2003 through May 12, 2003)

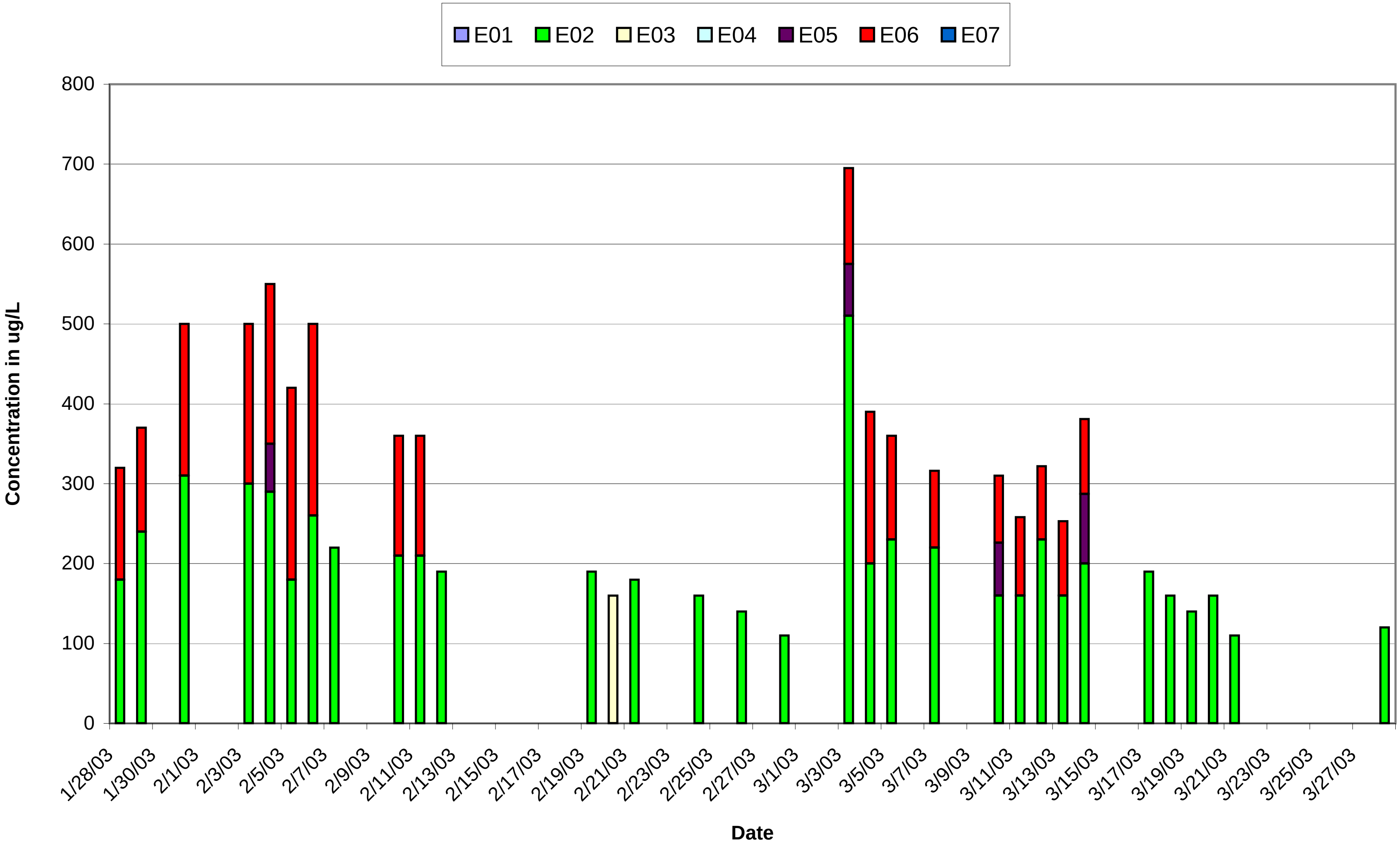


Figure 6.4-5. Average daily TOC and cumulative TOC (estimated where no data). Also shown are maximum average daily TOC, average TOC removal rate per day, and average subsurface temperature and average extraction rate for each operational phase.

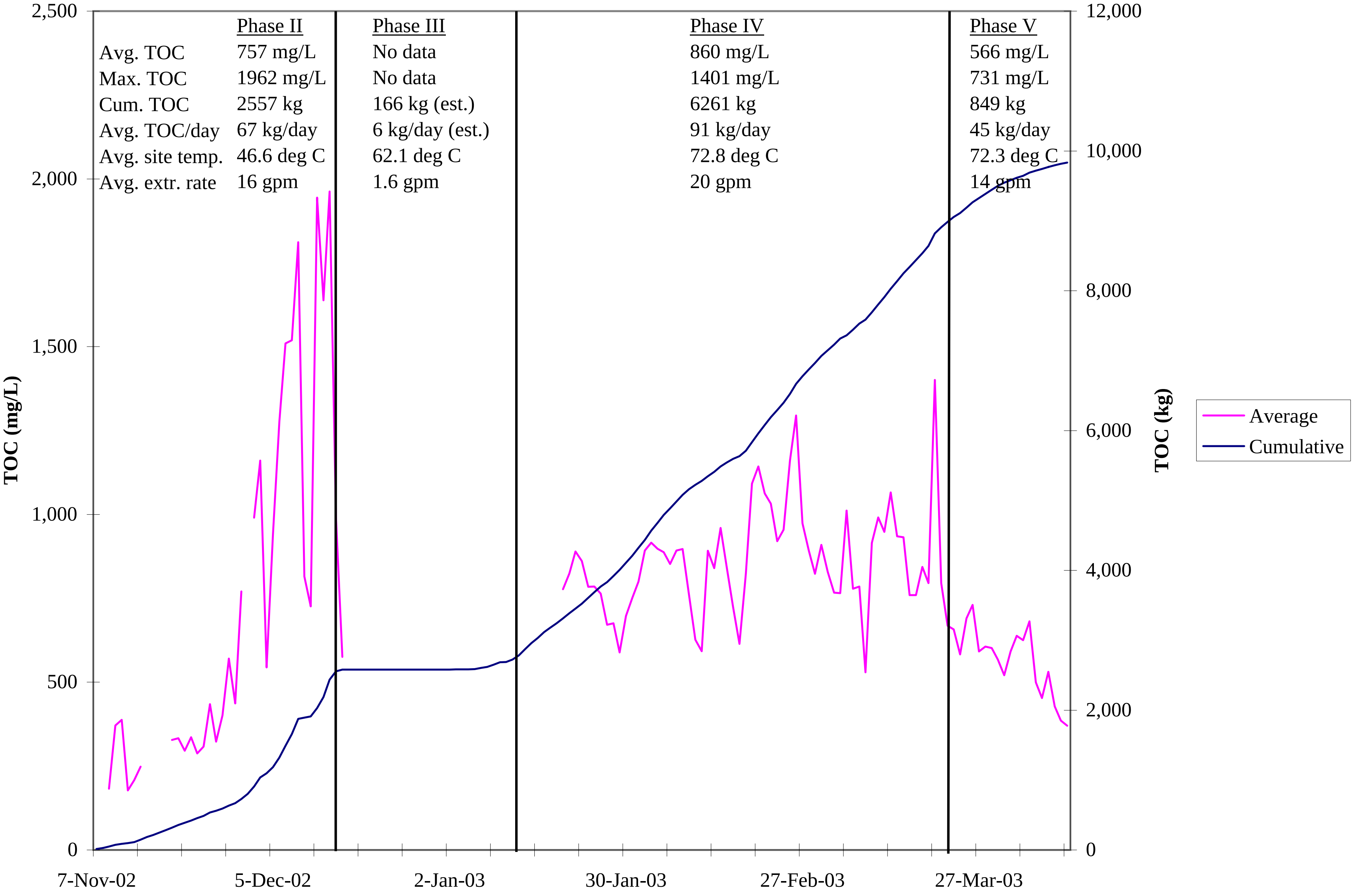


Figure 6.6-1. Total PAH and PCP Concentrations in Treatment Plant Influent Prior to and at Start of Pilot Study

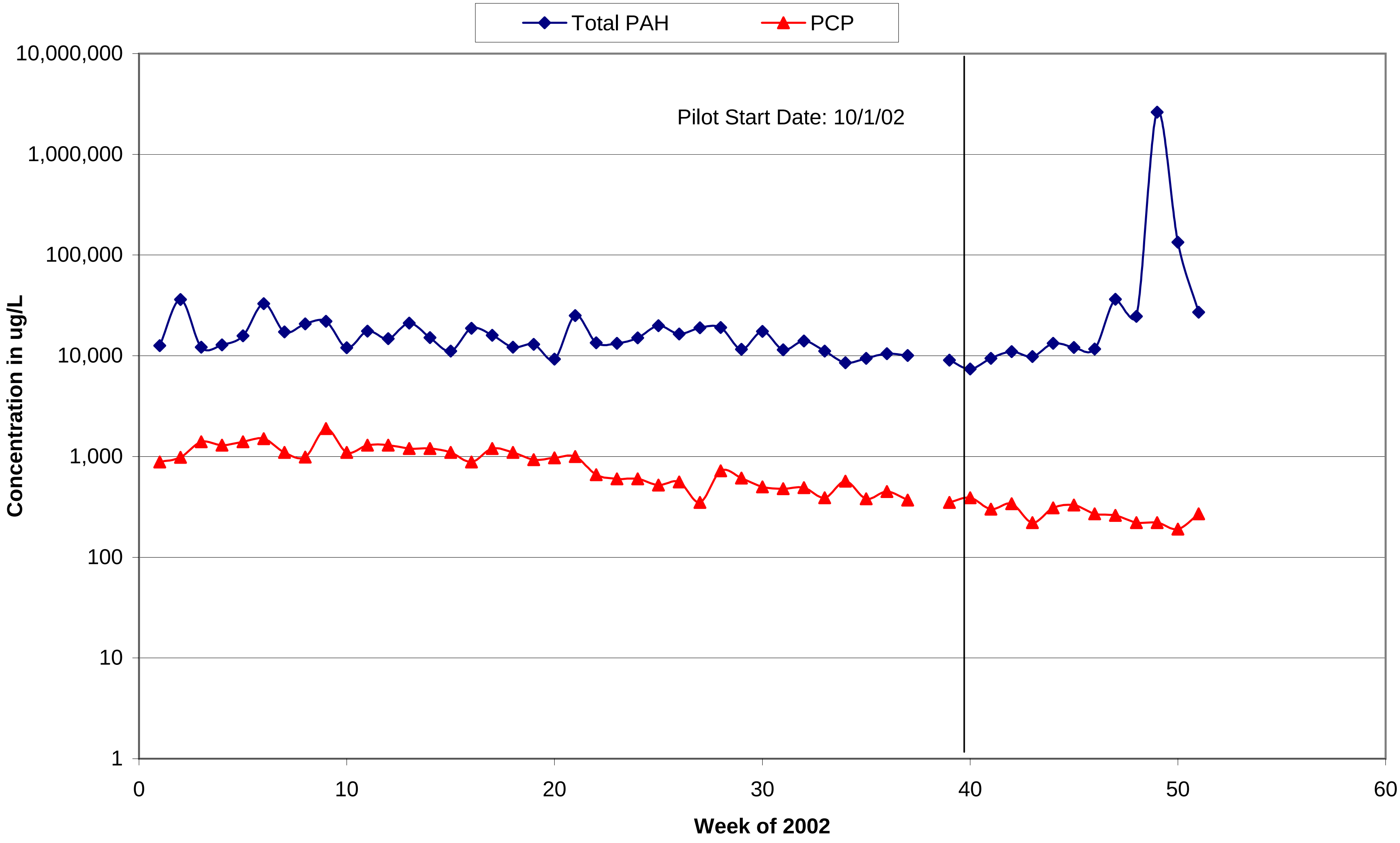


Figure 6.6-2. Total PAH Concentrations Into (SP-0) and Out of (SP-4) DAFT

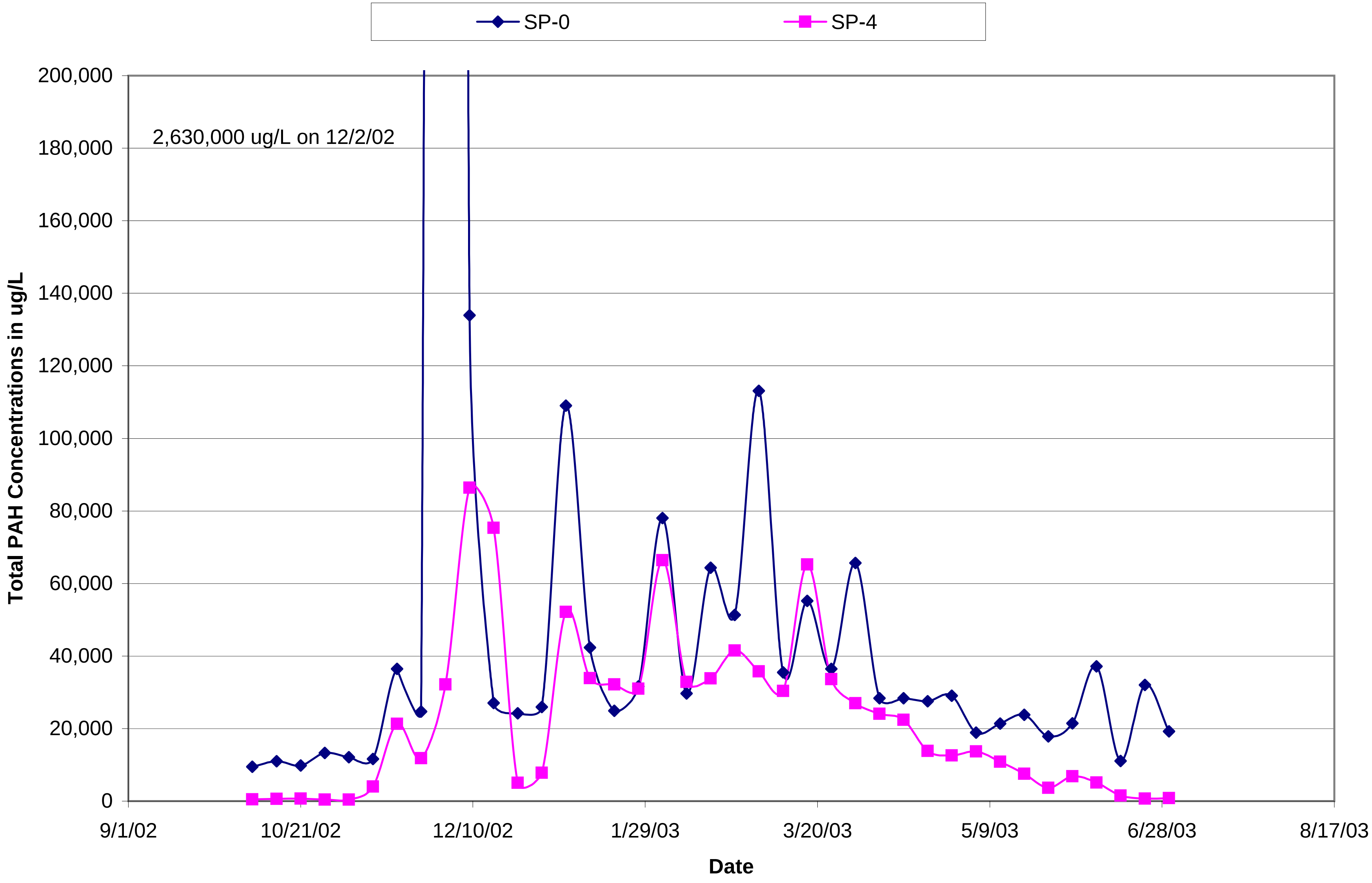


Figure 6.6-3. Naphthalene Concentrations Into (SP-0) and Out of (SP-4) DAFT

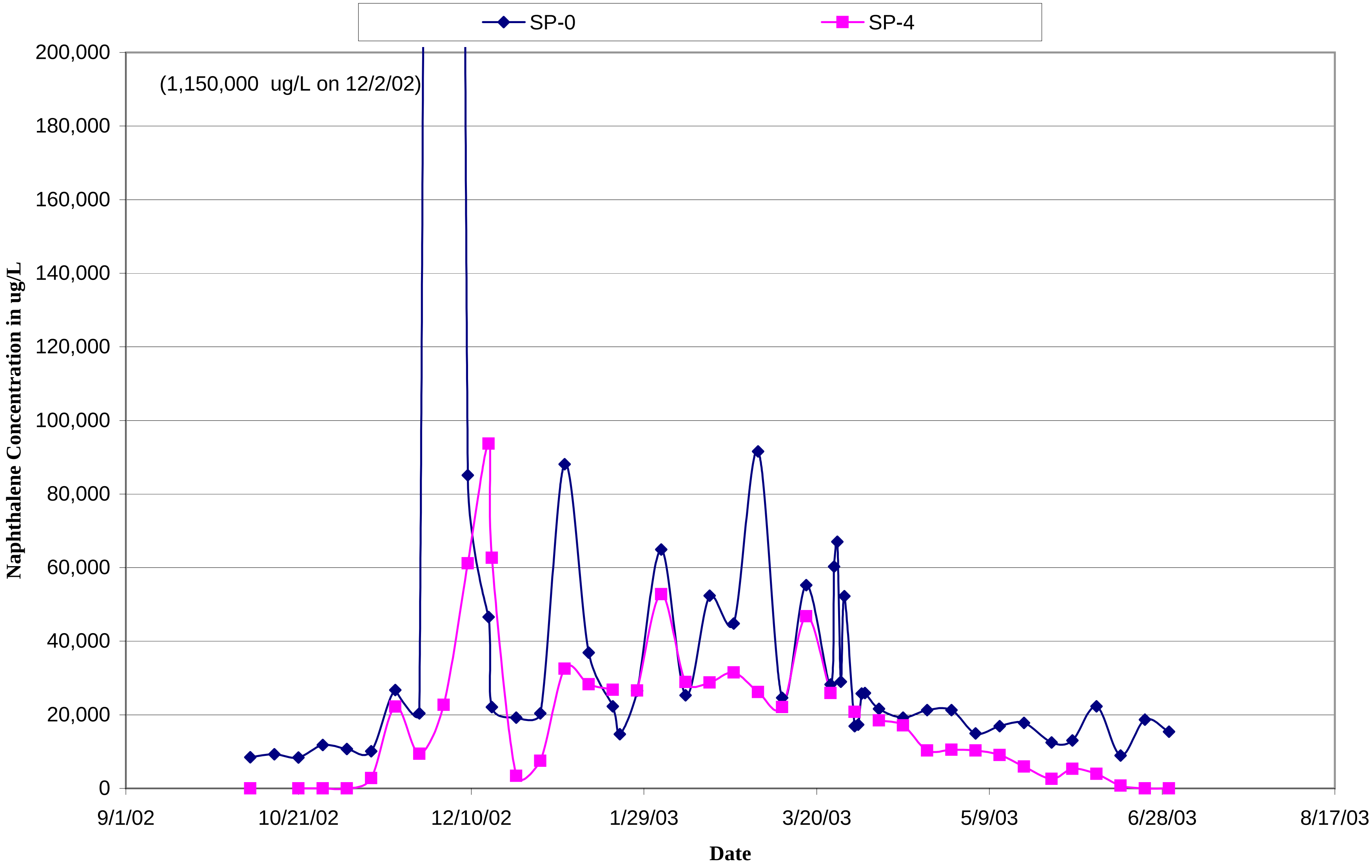


Figure 6.6-4. PCP Concentrations Into (SP-0) and Out of (SP-4) DAFT

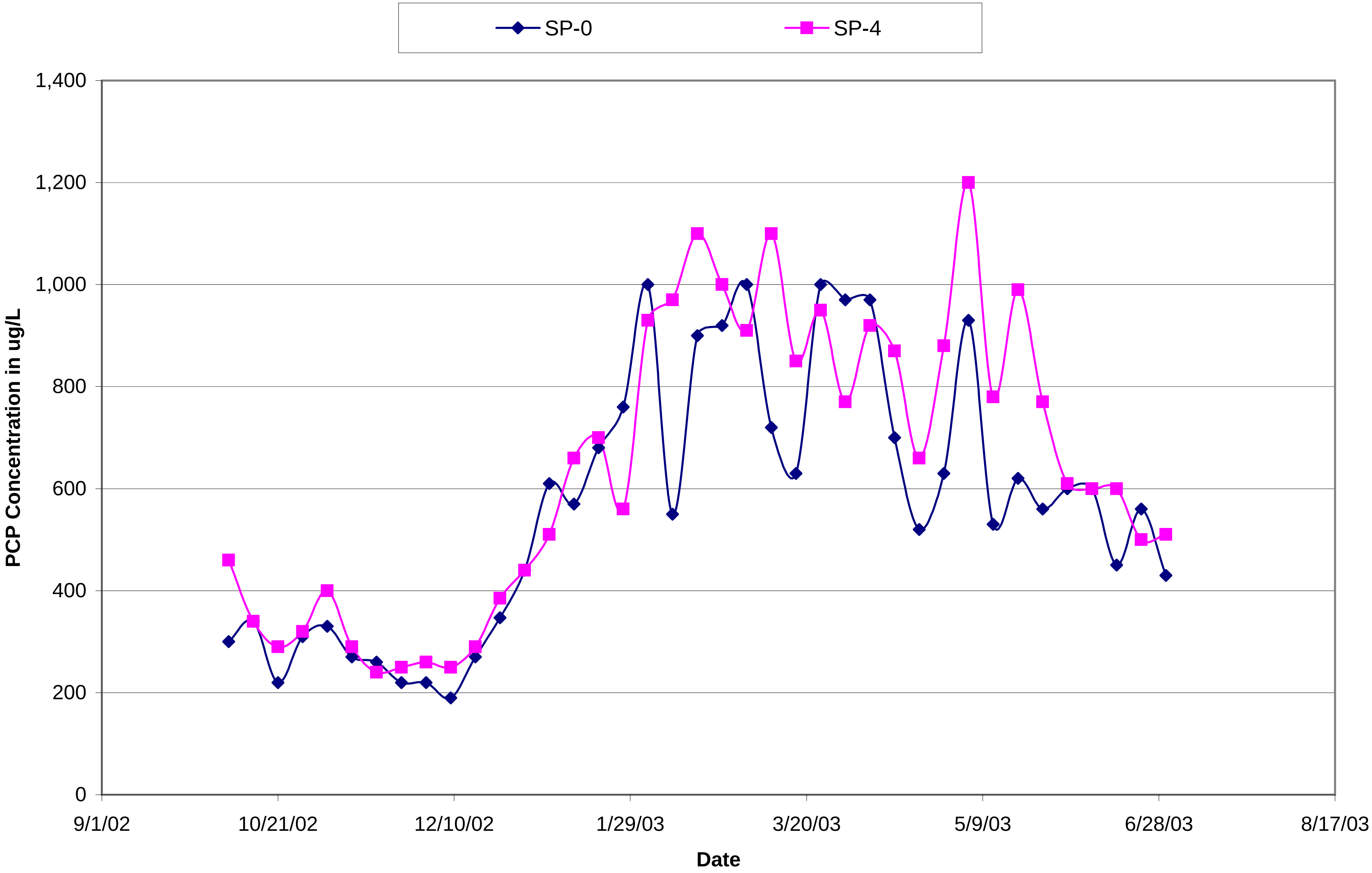


Figure 6.6-5. NAPL Removal per Month and Cumulative Total NAPL Removal

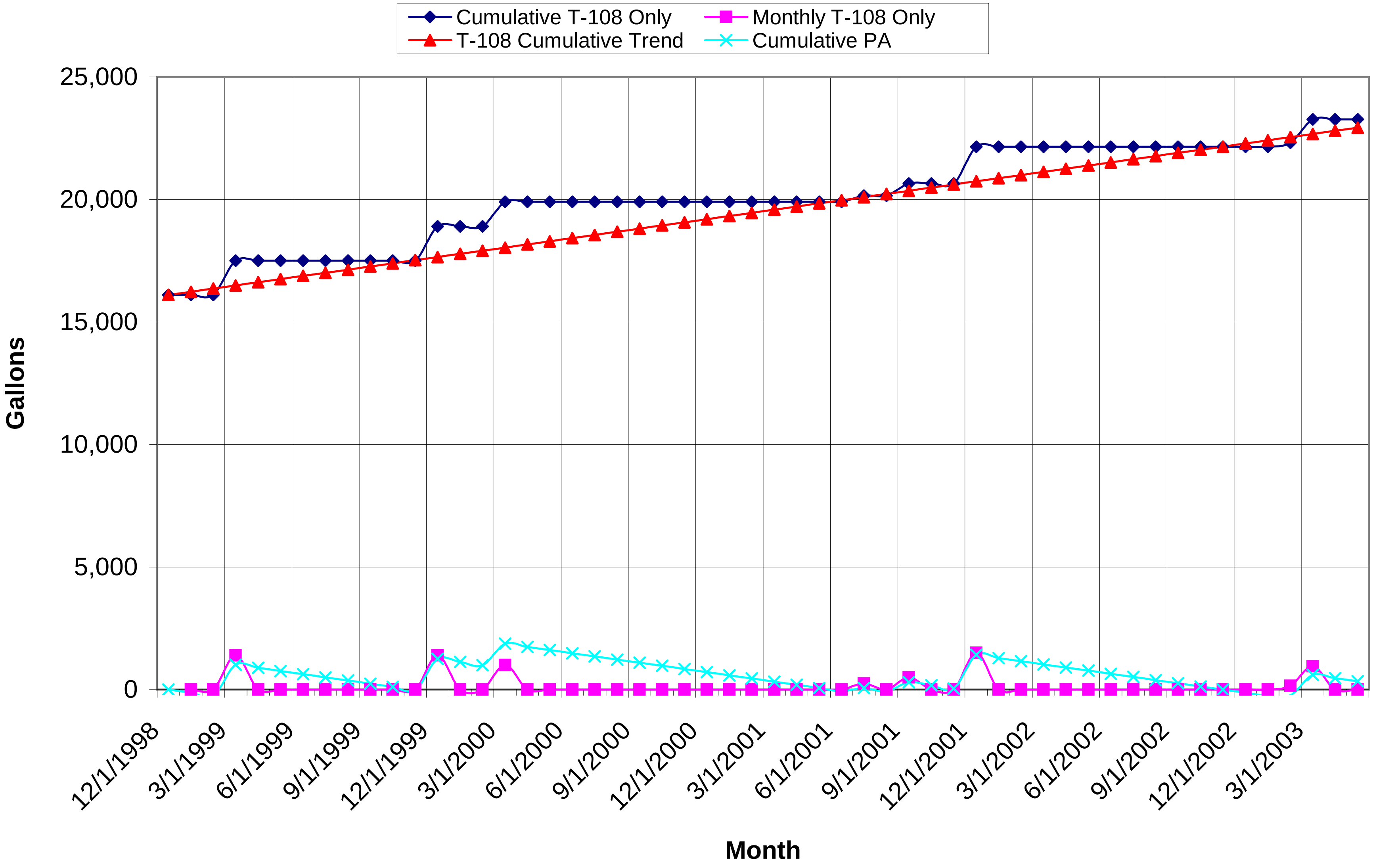


Figure 6.6-6. Total PAH Concentrations Into (SP-4) and Out of (SP-6) Aeration Basin

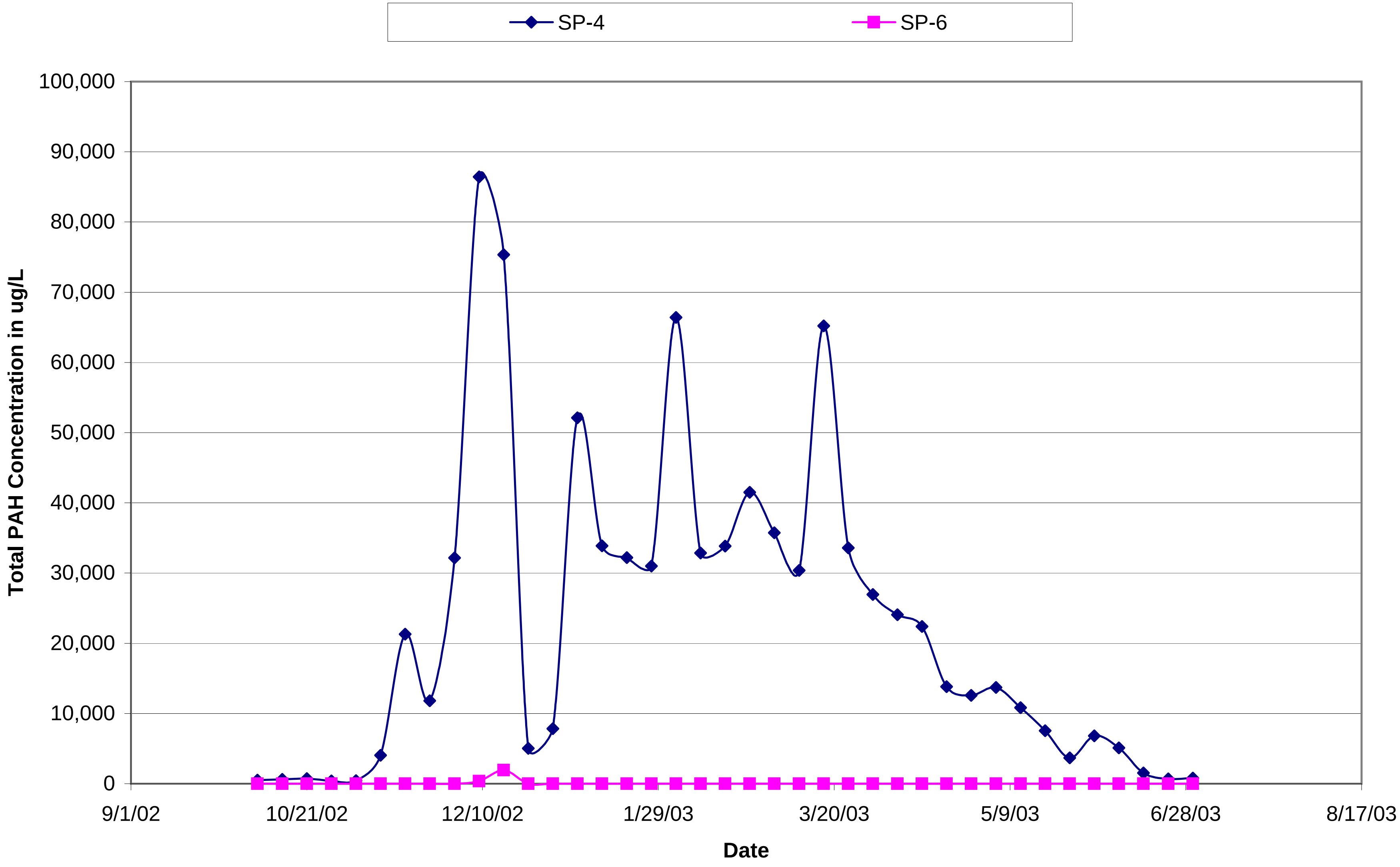


Figure 6.6-7. Naphthalene Concentrations Into (SP-4) and Out of (SP-6) Aeration Basin

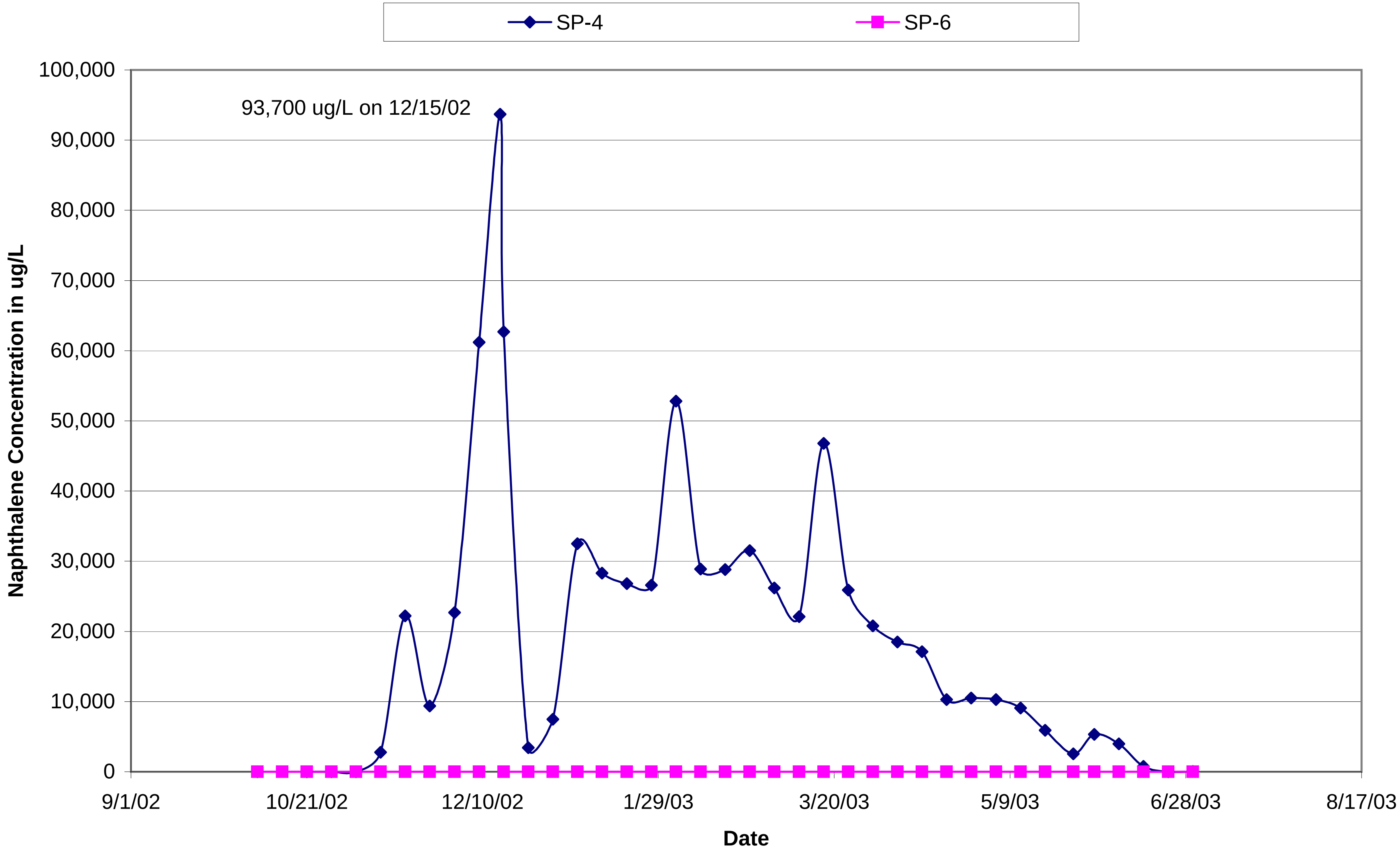


Figure 6.6-8. PCP Concentrations Into (SP-4) and Out of (SP-6) Aeration Basin

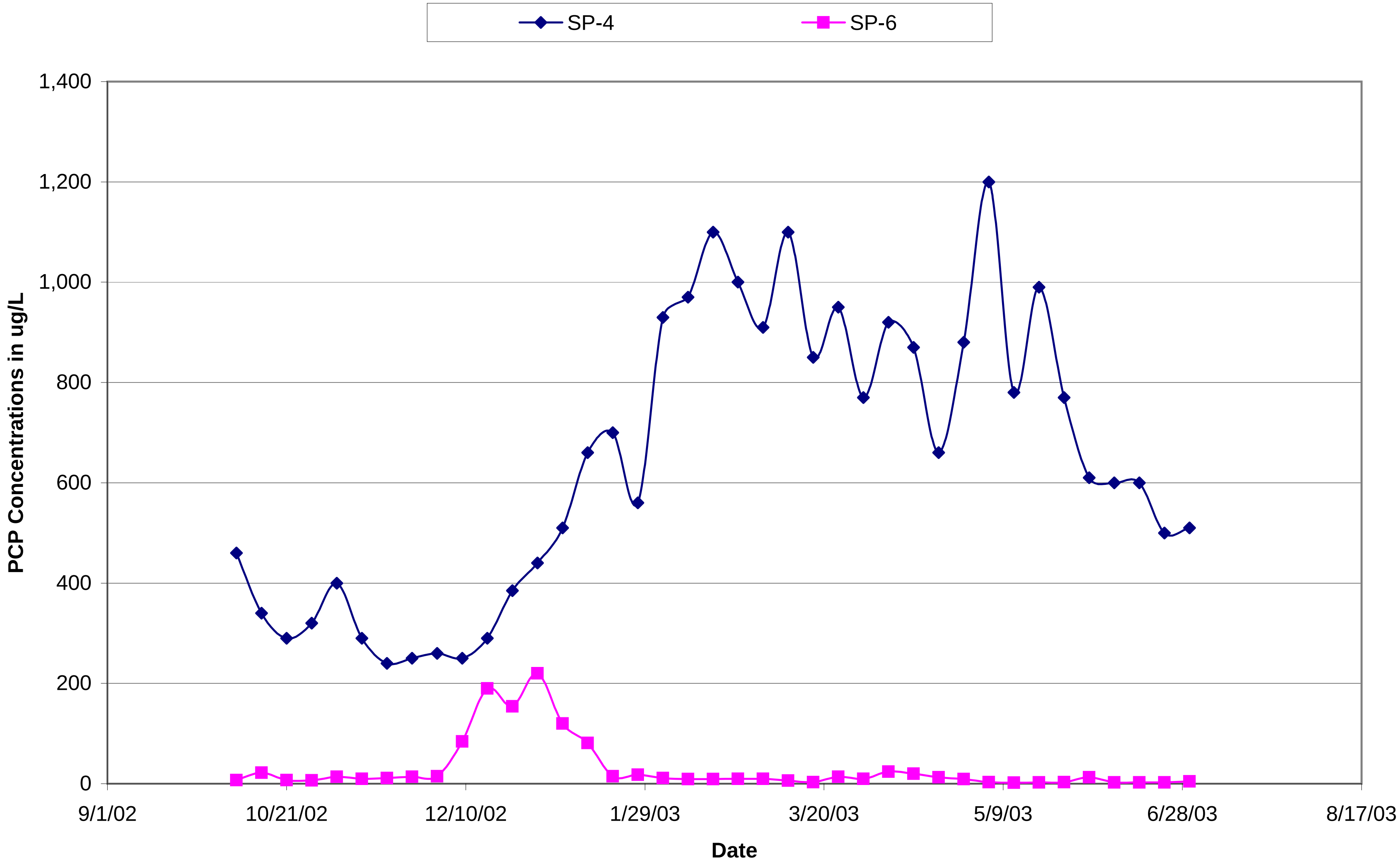


Figure 6.6-9. Aeration Basin Total PAH and PCP Removal Effectiveness

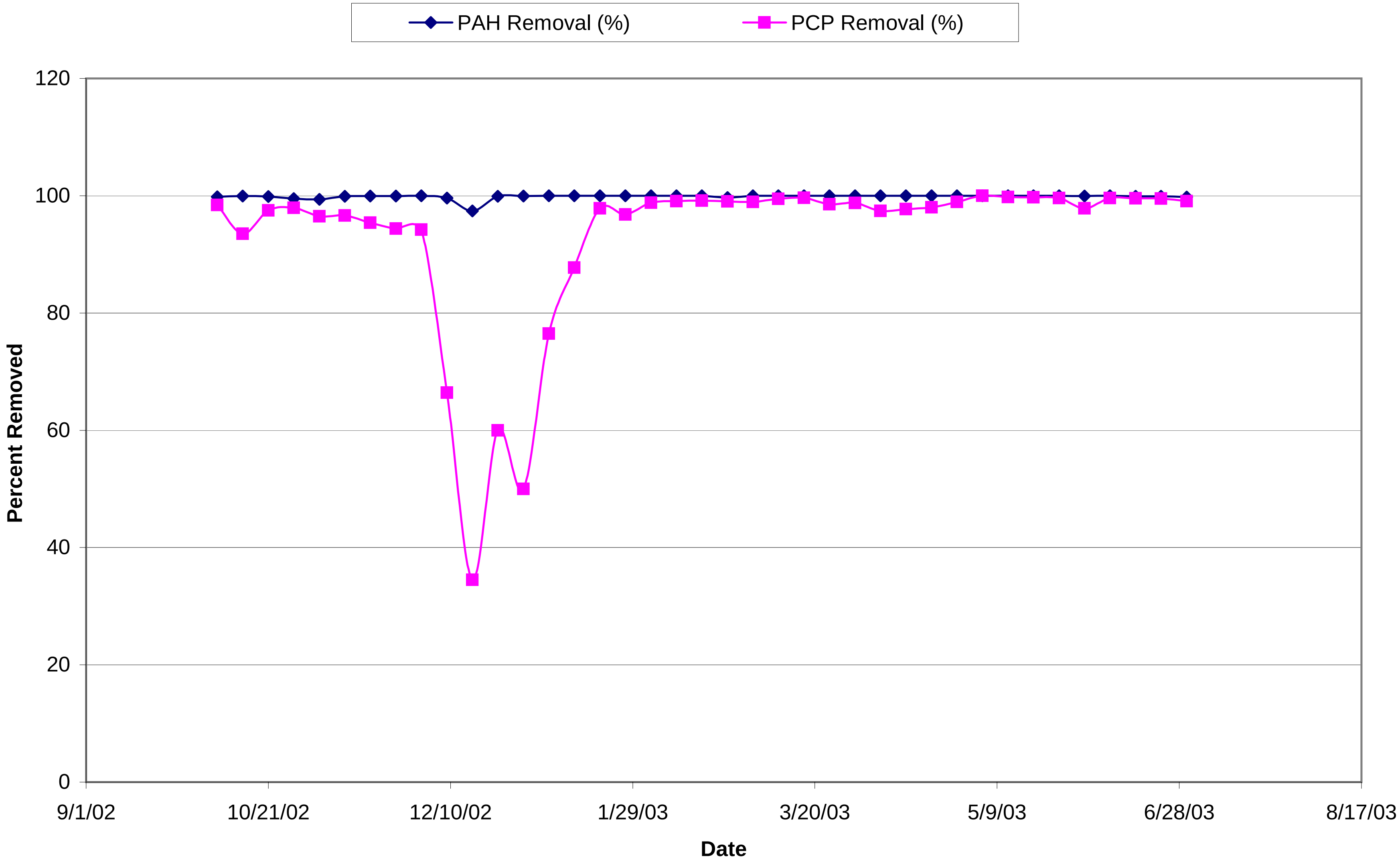


Figure 6.6-10. Dissolved Oxygen and Total PAH Concentration In Aeration Basin

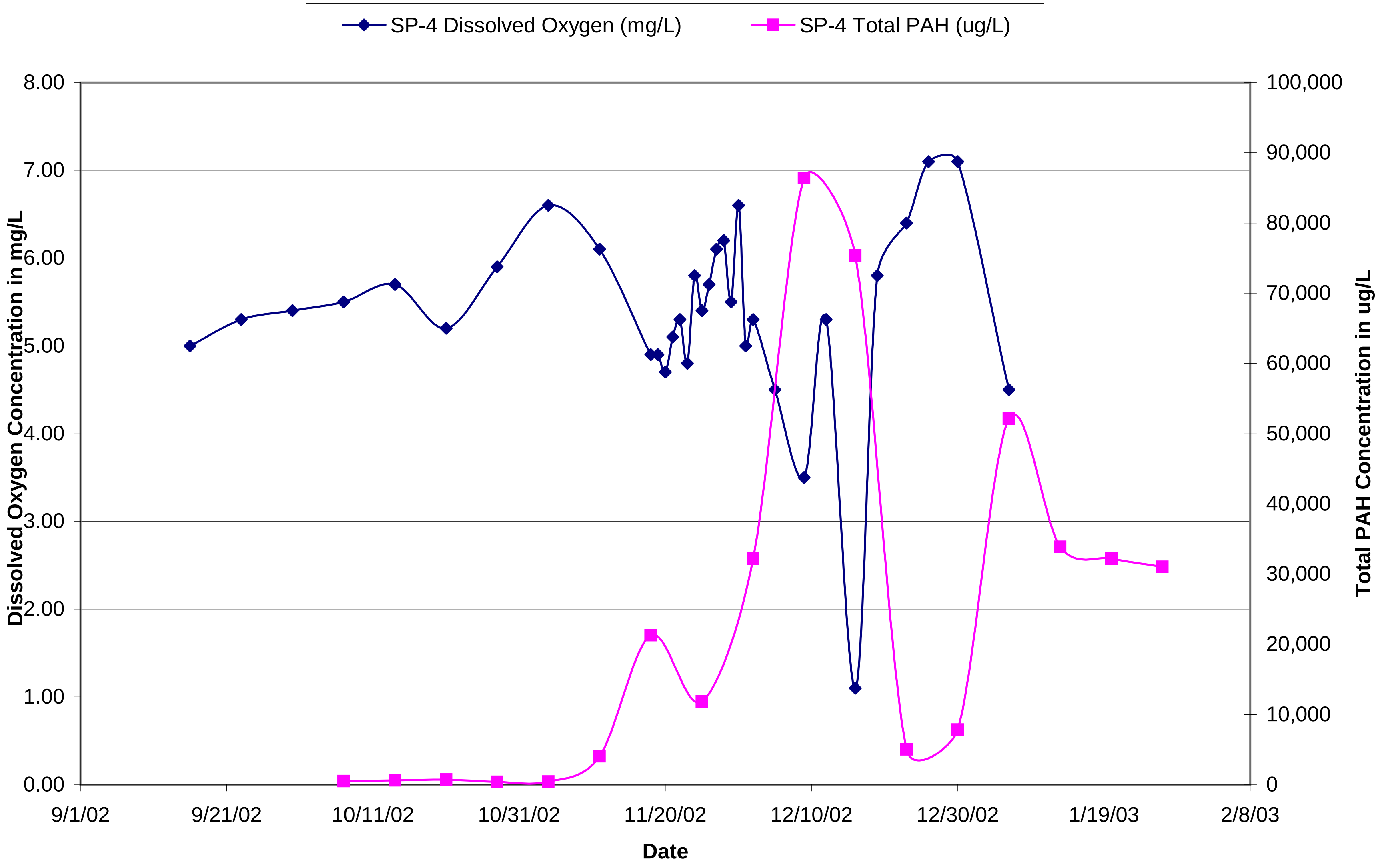


Figure 6.6-11. Total PAH Concentration Into (SP-8) and Out of (SP-10) Carbon Treatment System

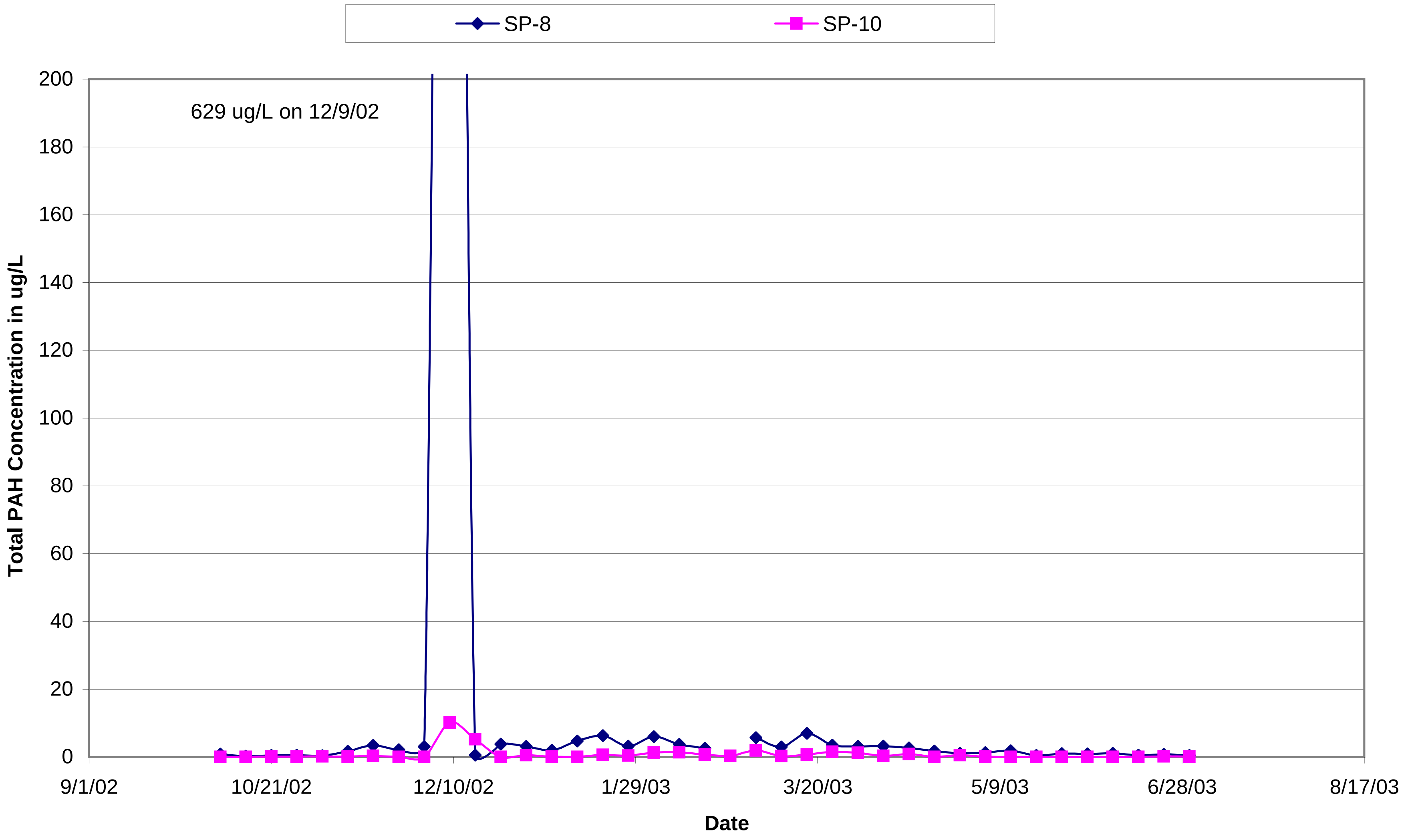


Figure 6.6-12. PCP Concentration Into (SP-8) and Out of (SP-10) Carbon Treatment System

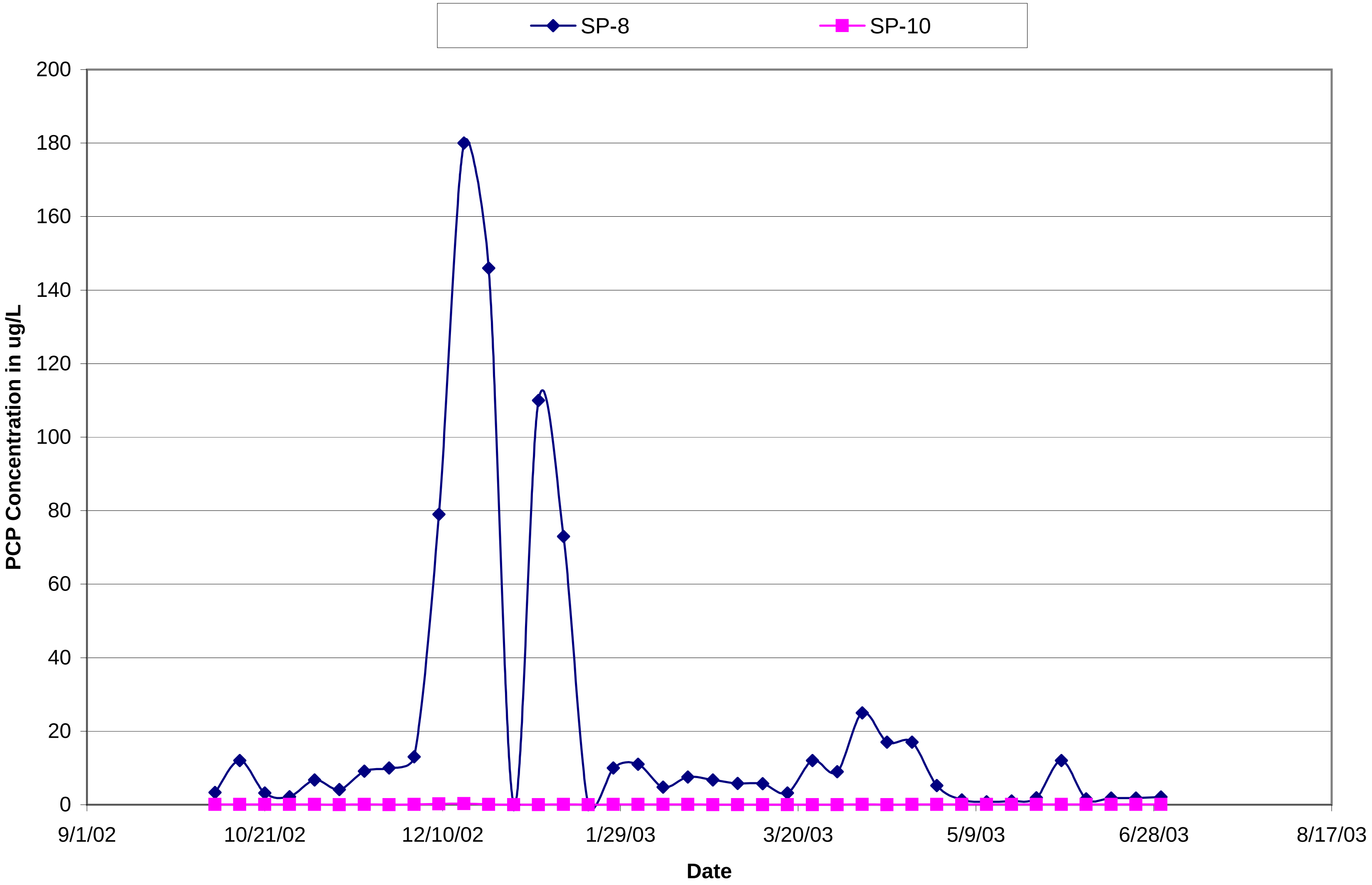


Figure 6.6-13. Carbon Treatment System Total PAH and PCP Removal Effectiveness

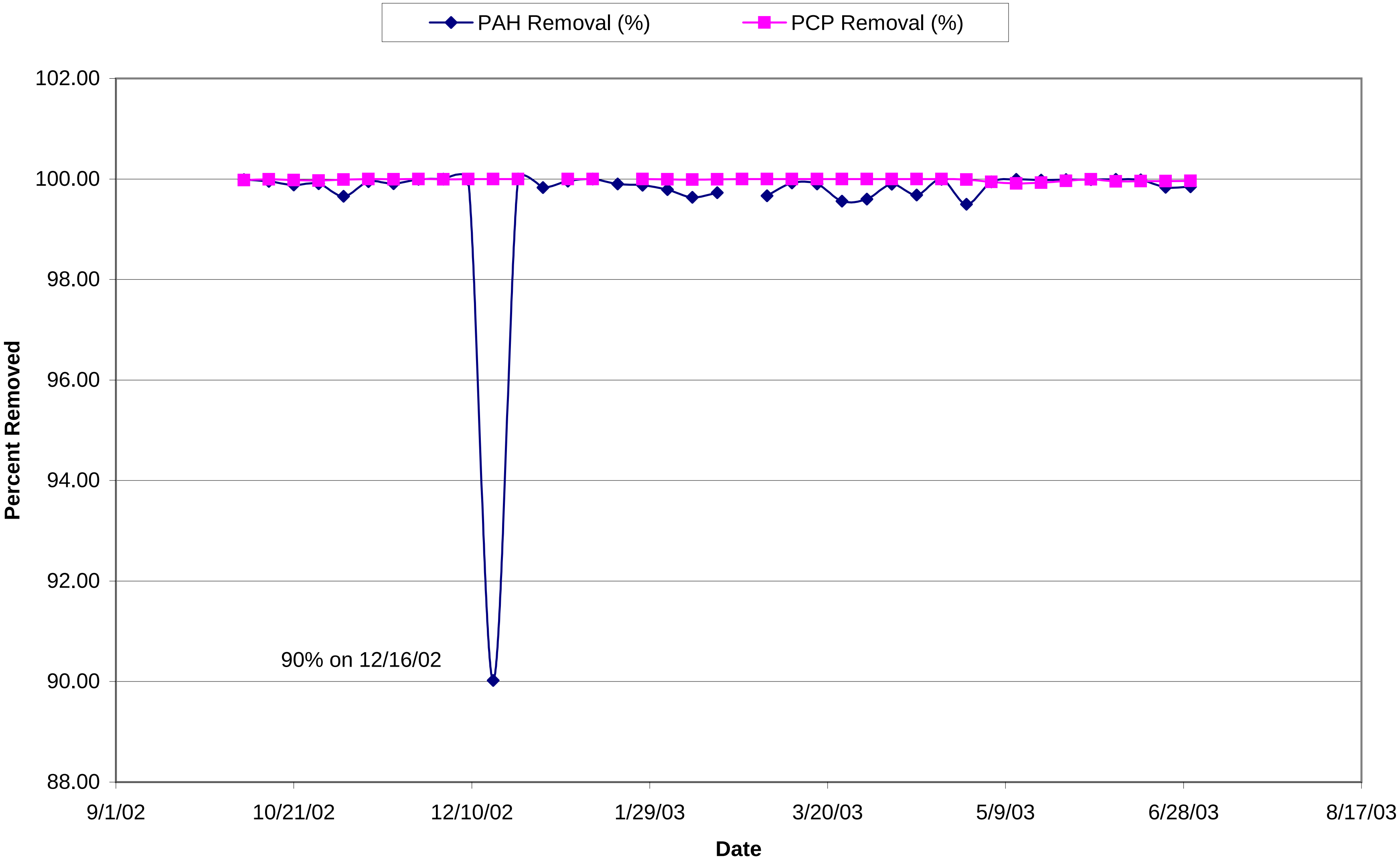


Figure 6.6-14. Total PAH and PCP Concentrations in GWTP Effluent

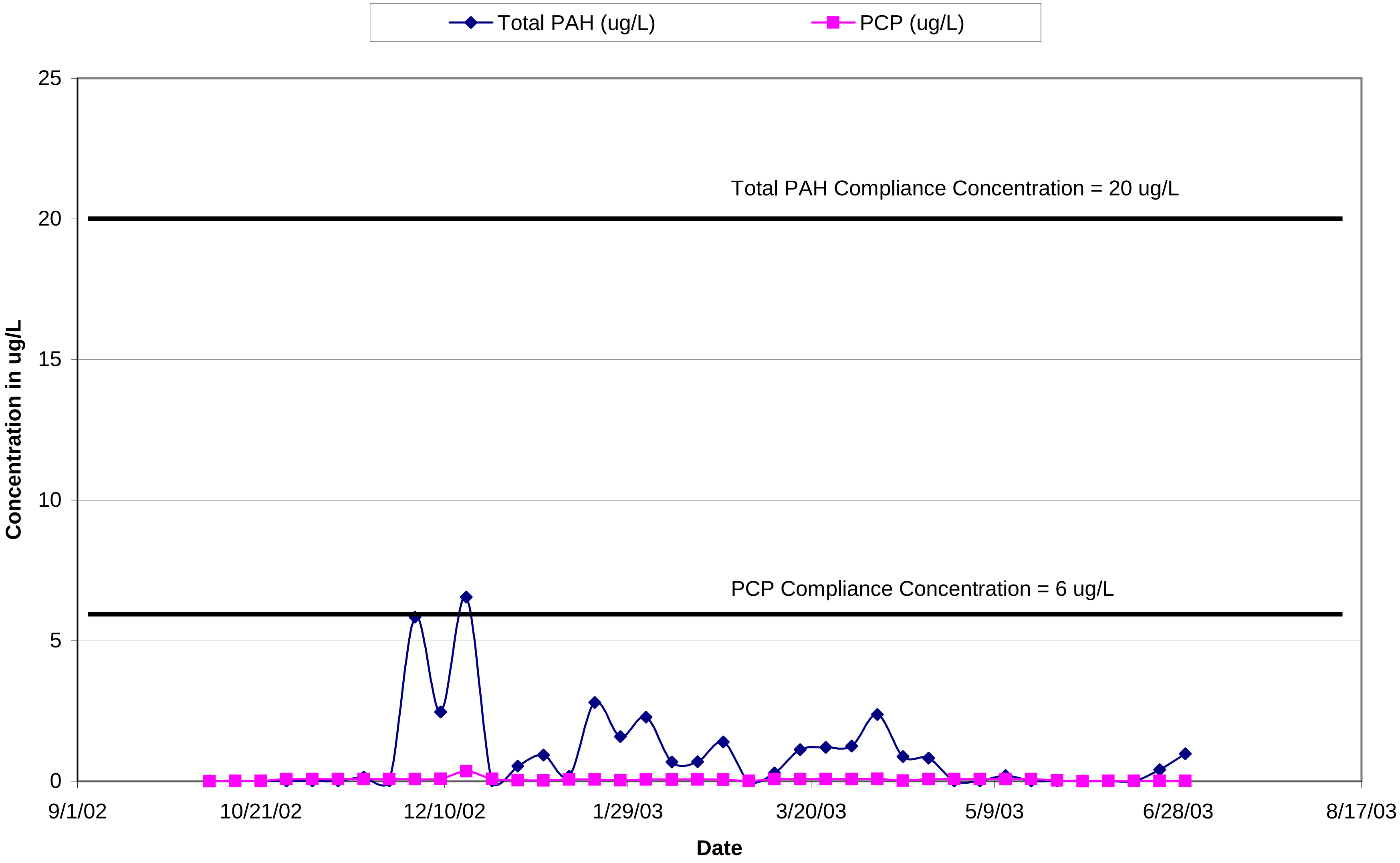


Figure 6.6-15. pH Concentration in GWTP Effluent

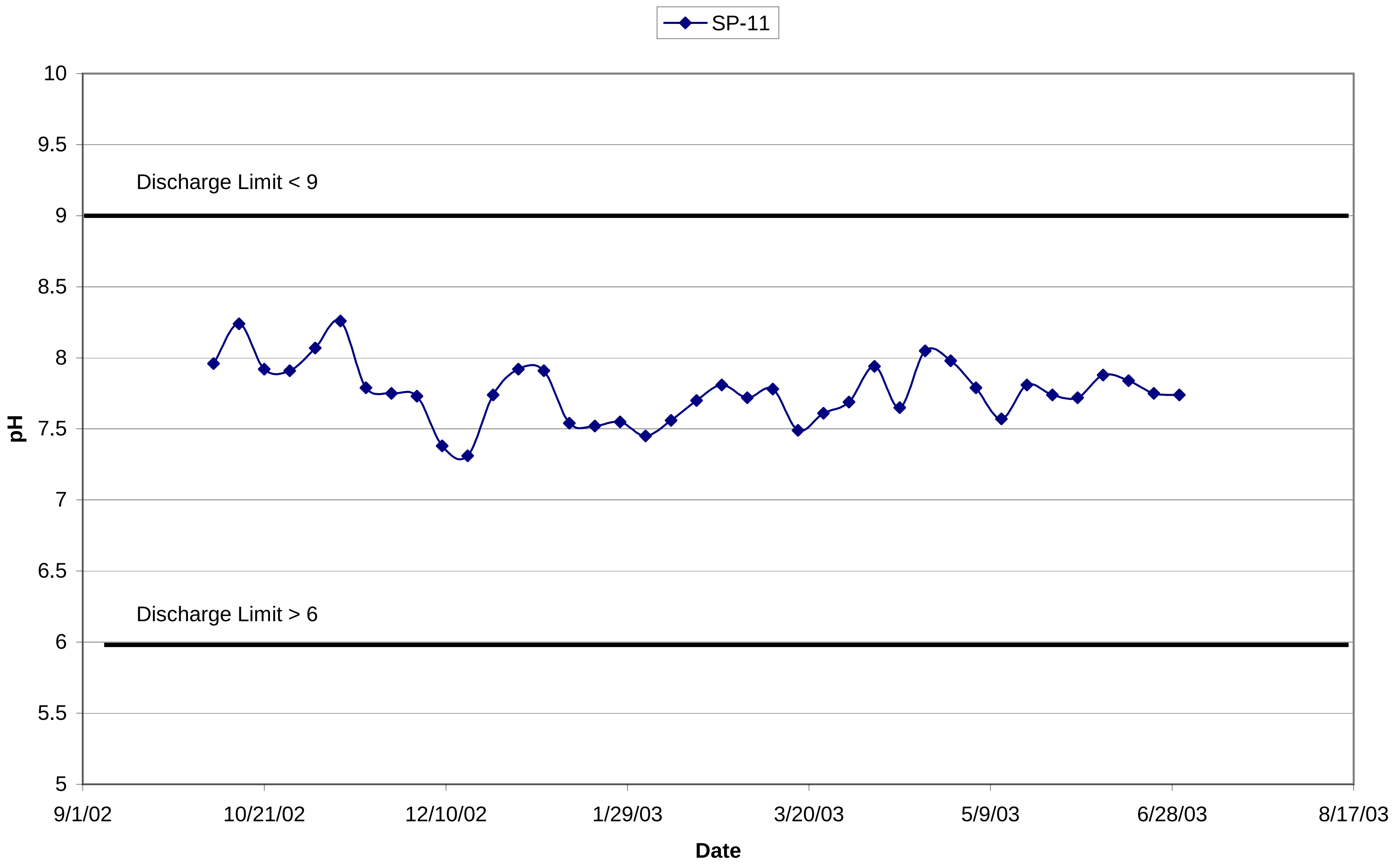
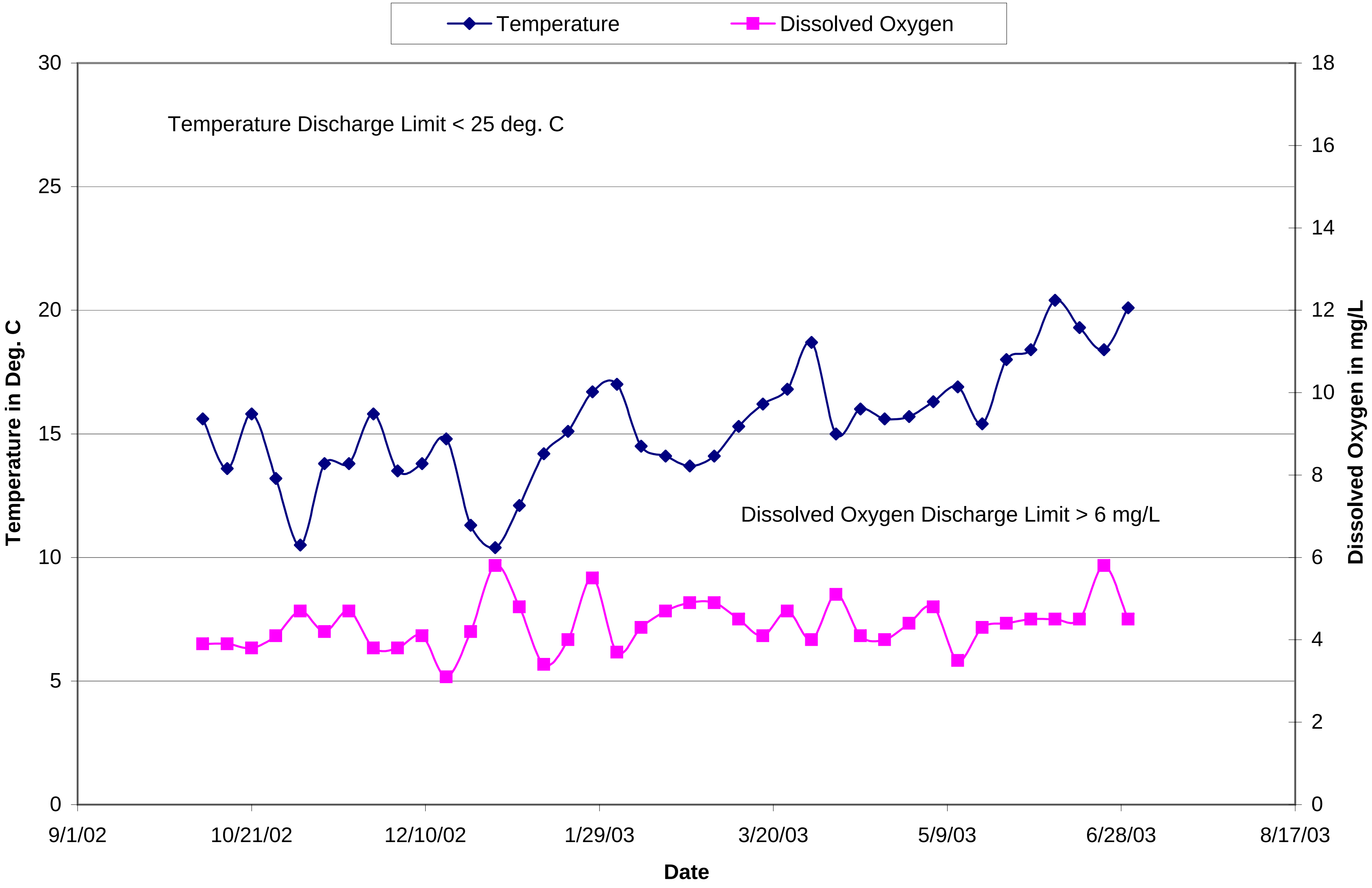


Figure 6.6-16. Temperature and Dissolved Oxygen in GWTP Effluent



Appendices

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Appendix A – Site Cleanup Levels

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U.S. Environmental Protection Agency
Region 10
Seattle, Washington

Wyckoff/Eagle Harbor
Superfund Site
Soil and Groundwater Operable Units
Bainbridge Island, Washington

RECORD OF DECISION

February 2000

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Table 13 Groundwater Cleanup Levels for Protection of Human Health and the Marine Environment (μg/L)

Contaminant of Concern	WA SW Quality Stds. (173-201A WAC)	MTCA Method B SW for Human Consumption of Organisms (173-340 WAC)[b]	Federal WQStandards/ NTR (40 CFR 131)		Federal WQ Criteria		Calculated Pore-Water Concentrations Based on SMS or HH (See Table 15)	Groundwater Cleanup Level[c]
			Marine Chronic	Human Cons. of Orgs.	Marine Chronic	Human Cons.		
Naphthalene		9880					83	83
Acenaphthylene								
Acenaphthene		643				2,700	3	3
Fluorene		3,460		14,000		14,000	3	3
Phenanthrene								
Anthracene		25,900		110,000		110,000	9	9
Fluoranthene		90		370		370	3	3
Pyrene		2,590		11,000		11,000	15	15
Benzo(a)anthracene		.0296		.031		.049	.308	.0296
Chrysene		.0296		.031		.049	.262	.0296
Benzo(b)fluoranthene		.0296		.031		.049	.079	.0296
Benzo(k)fluoranthene		.0296		.031		.049	.079	.0296
Benzo(a)pyrene		.0296		.031		.049	.102	.0296
Dibenzo(a,h)anthracene		.0296		.031		.049	.007	.007
Benzo(g,h,i)perylene								
Indeno(1,2,3-cd)pyrene		.0296		.031		.049		.0296
HPAH							0.254	0.254
Pentachlorophenol	7.9[a]	4.9	143	8.2	7.9	8.2	880	4.9

[a] Chronic criteria

[b] Values obtained from MTCA Cleanup Levels and Risk Calculations (CLARC II) Update (February 1996)

[c] Where there is no cleanup level specified for a certain chemical, benzo(a)pyrene will be used as an indicator chemical during remediation. Groundwater cleanup levels will be measured at the point of compliance (see Section 8.4.2).

Table 14
Soil Cleanup Levels[a]

Contaminants of Concern	MTCA Method B Cleanup Standards[b] (μg/kg)
Naphthalene	3.20E+06
Acenaphthylene	NA
Acenaphthene	4.80E+06
Fluorene	3.20E+06
Phenanthrene	NA
Anthracene	2.40E+07
Fluoranthene	3.20E+06
Pyrene	2.40E+06
Benzo(a)anthracene	1.37E+02
Chrysene	1.37E+02
Benzo(b)fluoranthene	1.37E+02
Benzo(k)fluoranthene	1.37E+02
Benzo(a)pyrene	1.37E+02
Dibenzo(a,h)anthracene	1.37E+02
Benzo(g,h,i)perylene	NA
Indeno(1,2,3-cd)pyrene	1.37E+02
Dioxin (2,3,7,8-TCDD)/tef[c]	6.67E-03
Pentachlorophenol	8.33E+03

[a] For surface soil to 15 feet bgs, the most stringent of Method B levels will need to be met. If the levels cannot be practically met, then a point of compliance will be established in the soils for direct contact at the ground surface (see Section 8.4.1, above).

[b] Model Toxics Control Act (MTCA) Cleanup Levels and Risk Calculation (CLARCII) Update, February 1996. Where both cancer and non-cancer values are provided, the most stringent are used.

Concentrations of individual hazardous substances shall be adjusted downward to take into account exposure to multiple hazardous substances and/or exposure resulting from more than one pathway of exposure. In making these adjustments, the hazard index shall not exceed 1 and the total excess cancer risk shall not exceed one in one hundred thousand (MTCA Chapter 173-340 WAC).

[c] Chlorinated Dioxin/Furan TEFs (expressed as 2,3,7,8 TCDD TEQ)

NA = There were no values available for these chemicals in CLARCII. For purposes of cleanup, assume they are co-located with other PAH compounds.

Table 15 Estimate of Maximum Allowable Pore-Water Concentrations of COCs

Contaminant of Concern	Sediment Management Standards WAC 173-204 (mg/kg organic carbon[a])		Protection of HH for Intertidal Sediments (mg/kg oc)	Koc[b] (ml/g)	Calculated Pore-Water Maximums Based on Sediment Mgt. Stds.		Calculated Pore-Water Based on HH	Most Stringent Pore-Water Concentration
	Quality Standards	Screening Levels			Quality Standards (μg/L)	Screening Levels (μg/L)		
Naphthalene	99	170		1,191	83	143		83
Acenaphthylene	66	66		NA				
Acenaphthene	16	57		4,898	3	12		3
Fluorene	23	79		7,961	3	10		3
Phenanthrene	100	480		NA				
Anthracene	220	1,200		23,493	9	51		9
Fluoranthene	160	1,200		49,096	3	24		3
Pyrene	1,000	1,400		67,992	15	21		15
Benzo(a)anthracene	110	270		356,938	.308	.756		.308
Chrysene	110	460		420,108	.262	1.095		.262
Total Benzofluoranthenes[c]	230	450		2,903,559	.079	.155		.079
Benzo(a)pyrene	99	210		968,774	..102	.217		.102
Dibenzo(a,h)anthracene	12	33		1,789,101	.007	.018		.007
Benzo(g,h,i)perylene	31	78		NA				
Indeno(1,2,3-cd)pyrene	34	88		NA				
HPAH[d]	960	5300	40[e]	157,213[f]	6.1	33.7	0.254	0.254
Pentachlorophenol	360	690		409	880	1687		880

[a] The listed chemical parameter criteria represent concentrations in parts per million "normalized", or expressed, on a total organic carbon basis. To normalize to total organic carbon, the dry weight concentration for each parameter is divided by the decimal fraction representing the percent total organic carbon content of the sediment.

[b] December 1998 Draft MTCA Rule Revision, Soil Organic Carbon-Water Partitioning Coefficient (Koc) Values, Table 747-4.

[c] The Total Benzofluoranthenes criterion represents the sum of the concentrations of the "B", "J", and "K" isomers.

[d] For the intertidal sediments, the cleanup goal established in the East Harbor Record of Decision (ROD), September 1994, is 1,200 μg/kg (dry weight), developed by EPA to address human health risks from consumption of contaminated shellfish in intertidal areas. This objective requires that intertidal sediment HPAH concentrations must not exceed 1,200 μg/kg (dry weight). Achievement of the HPAH objective in intertidal sediments is expected to result in corresponding reduction in clam tissue contamination.

The HPAH criterion represents the sum of the following "high molecular weight polynuclear aromatic hydrocarbon" compounds: Fluoranthene, Pyrene, Benzo(a)anthracene, Chrysene, Total Benzofluoranthenes, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Benzo(g,h,i)perylene, and Indeno(1,2,3-cd)pyrene. The HPAH criterion is not the sum of the criteria values for the individual HPAH compounds as listed.

[e] 40 mg/kg organic carbon is 1,200 μg/kg (dry weight) normalized, i.e., (1200 μg/kg dw/3% TOC) x (1/1000)

[f] Average Koc for HPAH is derived from site-specific solubility-weighted NAPL composition data (Wyckoff NAPL Field Exploration Report, U.S. Army Corps of Engineers, 2000).

NA = There were no values available for these chemicals.

Table 25

Summary of Current Effluent Limitations and Monitoring Requirements (a)

CHEMICAL MONITORING

	Discharge Limitation		Monitoring Requirements		
Effluent Characteristic	**Daily Maximum (ug/L)**	**Monthly Average (ug/L)**	**Measurement Frequency**	**Sample Type**	**Reported Value(s)**
Total of 16 Polynuclear Aromatic Hydrocarbons (PAHs)	20	–	Once per week	24-hour composite (c)	Maximum daily
Individual PAHs (b)					
Naphthalene	4	–	Once per week	24-hour composite	Maximum daily
Acenaphthylene	4	–	Once per week	24-hour composite	Maximum daily
Acenaphthene	4	–	Once per week	24-hour composite	Maximum daily
Fluorene	2	–	Once per week	24-hour composite	Maximum daily
Phenanthrene	2	–	Once per week	24-hour composite	Maximum daily
Anthracene	2	–	Once per week	24-hour composite	Maximum daily
Fluoranthene	2	–	Once per week	24-hour composite	Maximum daily
Pyrene	2	–	Once per week	24-hour composite	Maximum daily
Benzo(a)anthracene	2	–	Once per week	24-hour composite	Maximum daily
Chrysene	2	–	Once per week	24-hour composite	Maximum daily
Benzo(b)fluoranthene	2	–	Once per week	24-hour composite	Maximum daily
Benzo(k)fluoranthene	2	–	Once per week	24-hour composite	Maximum daily
Benzo(a)pyrene	2	–	Once per week	24-hour composite	Maximum daily
Dibenzo(a,h)anthracene	2	–	Once per week	24-hour composite	Maximum daily
Benzo(g,h,i)perylene	2	–	Once per week	24-hour composite	Maximum daily
Indeno(1,2,3-cd)pyrene	2	–	Once per week	24-hour composite	Maximum daily
Pentachlorophenol (d)	6	–	Once per week	24-hour composite	Maximum daily
Discharge Flow (gpm) (e)	NA	–	Continuous	Recording	Maximum daily
Total Suspended Solids [TSS] (mg/L)	NA	–	Once per week	24-hour composite	Maximum daily
Total Dissolved Solids [TDS] (mg/L)	NA	–	Once per week	Grab	Maximum daily
Temperature [degrees C]	NA	–	Once per week	Grab	Maximum daily
Dissolved Oxygen [DO] (mg/L)	NA	–	Once per week	Grab	Maximum daily
pH	6.0 - 9.0	–	Once per week	Grab	Maximum daily
Metals (f)					
Zinc	95	47	Once per week	24-hour composite	Maximum daily
Lead	140	70	Once per week	24-hour composite	Maximum daily
Mercury	2.1	1	Once per week	24-hour composite	Maximum daily
Nickel	75	37	Once per week	24-hour composite	Maximum daily
Cadmium	43	21	Once per week	24-hour composite	Maximum daily
Chromium (Total)	1100	548	Once per week	24-hour composite	Maximum daily

BIOMONITORING (g)

		Monitoring Requirements		
Organism	**Type of Toxicity Test**	**Measurement Frequency**	**Sample Type**	**Reported Value(s)**
Inland Silversides (Menidia beryllina)	Acute survival test	Quarterly	24-hour composite	LC50
Purple sea urchin or sand dollar (h)	Chronic test	Quarterly	24-hour composite	IC25
Pacific oyster or mussel larvae (h)	Chronic test	Quarterly	24-hour composite	NOEC, LOEC, EC50/LC50

Notes:

(a) Modified from EPA's Administrative Order for Necessary Interim Response Actions No. 1091-06-03-106 dated June 17, 1991.

(b) Each of the 16 priority pollutants PAHs are quantified separately using EPA Method 8310 from Test Methods for Evaluating Solid Waste, Third Edition, SW-846. The 16 individual PAHs are summed to arrive at the total PAH value.

(c) A 24 hour composite sample is collected using an automatic sampler.

(d) Pentachlorophenol is quantified using EPA Method 8040 from Test Methods for Evaluating Solid Waste, Third Edition, SW-846.

(e) Flow is measured by a continuous flow meter.

(f) Metals are quantified using EPA Contract Laboratory Program (CLP) analytical methods and QA/QC, however full documentation is not required. Documentation only includes calibration, blank, accuracy, and precision results.

(g) Specific requirements for analytical methods, QA/QC, and reporting are provided in the attached fact sheet.

(h) These organisms may be used interchangeably if required.

Reference: Interim ROD
Wyckoff Groundwater Operable Unit
Wyckoff/Eagle Harbor Superfund Site
September 30, 1994

Current Biomonitoring Requirements

I. Acute Toxicity Test Requirements:

1. For each test period (see also Paragraph I.8 below), acute survival toxicity tests are required for Inland Silversides (*Menidia beryllina*).

2. The test protocol is adapted from C.I. Weber, et al, *Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms*. EPA/600/4-90/027, 1991.

3. All quality assurance criteria used are in accordance with *Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms*, EPA/600/4-90/027. Test results which are not valid (e.g., control mortality exceeds acceptable level) will not be accepted and must be repeated.

4. The test is performed with a series of dilutions (100, 50, 25, 12.5, and 6.25 percent effluent) plus a control (0 percent effluent) to determine (1) the LC_{50}, and (2) any statistically significant differences between the results for the control and each effluent concentration tested.

5. If the test demonstrates the presence of acute toxicity, EPA will undertake the following actions as needed to determine the source of toxicity:

   (a) Chemical analyses.

   (b) Evaluation of treatment processes and chemicals used.

   (c) Physical inspection of facility for proper operation of treatment units, spills, etc.

   (d) Examination of records.

   (e) Interviews with plant personnel to determine if toxicant releases occurred through spills, unusual operating conditions, etc.

   If any toxicity remains after conducting the above steps, additional monitoring or treatment may be required.

6. A written report of the toxicity test results and any related source investigation are prepared for EPA within 60 days after the initial sampling. The report of the toxicity test results and chemical analyses shall be prepared in accordance with the Reporting Sections in the documents specified above in Section I-3.

7. Chemical testing for the parameters for which effluent limitations exist shall be performed on a split of each sample collected for bioassay testing. To the extent that the timing of sample collection coincides with that of the sampling required for the effluent limitations, analysis of the split sample will fulfill the requirements of that monitoring as well.

8. Testing shall be conducted every three months (4 times per year), until EPA modifies this requirement in writing. Additional toxicity testing is also required at any time that spills or other unusual events result in different or substantially increased discharge of pollutants.

II. Chronic Toxicity Test Requirements:

1. For each test period (see also Paragraph II.11 below), chronic toxicity tests are required for the following organisms:

   (a) *Stronglyocentrotus purpuratus* (purple sea urchin), or *Dendraster excentricus* (sand dollar).

   (b) *Mytilus edulis* (mussel) or *Crassostrea gigas* (Pacific oyster) larvae.

   The purple sea urchin and sand dollar, and the mussel and Pacific oyster may be used interchangeably if necessary.

2. In each year, the bioassay tests shall be conducted four times with each organism during the organism's natural spawning period. To the extent that these seasons overlap, testing shall be conducted on splits of the same effluent samples. Any tests which fail the criteria for control mortality as specified in the respective protocols shall be repeated on a freshly collected sample.

3. Testing is conducted on 24-hour composite samples of effluent. Each composite sample collected shall be large enough to provide enough effluent to conduct toxicity tests, as well as chemical tests required in Part II.10. below.

4. The chronic toxicity tests are performed as follows:

   (a) For the purple sea urchin/sand dollar, tests are performed on a series of dilutions, plus a control (0 percent effluent). The IC_{25} value (the incipient concentration of effluent causing a 25 percent reduction in biological measurement, e.g., fertilization, is calculated. EPA has indicated that the IC_{25} is the approximate analogue to the no observable effect concentration (NOEC) of the effluent in the control water. The NOEC is that concentration of effluent for which survival, reproduction, or growth of the test organisms is not significantly different (at the 95% confidence level) from that of the control organisms (see *Technical Support Document for Water Quality-based Toxics Control,* EPA/505/2-90-001, March 1991).

   (b) For the mussel or Pacific oyster larvae, tests are performed on a series of dilutions, plus a control (0 percent effluent). The NOEC, LOEC (lowest observable effect concentration), and the EC50/LC50 (effective concentration [EC] at which 50 percent of the population shows sublethal effects such as reduction in growth and lethal concentration [LC] at which 50 percent of the population dies, respectively), are calculated.

5. The chronic bioassays are conducted in accordance with the following protocols:

   (a) For purple sea urchin/sand dollar: *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms*, EPA/600/4-87/028 and The Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1988.

   (b) For mussel/Pacific oyster larvae: *Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Saltwater Bivalve Molluscs,* ASTM E 724-89.

6. All quality assurance criteria used shall be in accordance with *Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms*, EPA/600/4-85-013, *Quality Assurance Guidelines for Biological Testing*, EPA/600/4-78-043, and for oyster/mussel larvae test, *Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Saltwater Bivalve Molluscs,* ASTM E 724-89. The control water shall be high quality natural seawater. No exceptions will be made for artificial sea salts or concentrated brine unless Wyckoff submits data to EPA which demonstrates that the lab has reliably conducted the specified test with one of these media.

7. The results of the bioassay tests are provided to EPA within 45 days after completion of each test in accordance with the Reporting Section in *Short Term Methods for Estimating Chronic Toxicity Effluents and Receiving Water to Marine and Estuarine Organisms*, EPA/600/4-87/028, May 1988, and include any other information required by the protocols.

8. EPA and Ecology will evaluate the results to determine whether they indicate the occurrence of chronic toxicity outside the mixing zone. If it appears that this may be occurring, a toxicity evaluation and reduction plan will be prepared within 90 days. The evaluation portion of the plan may include additional toxicity testing if needed to follow up on initial results or gather information for a possible toxicity limit in the future.

9. If the sea urchin/sand dollar or mussel/oyster larvae tests prove inadequate for evaluating Wyckoff's effluent, EPA may substitute alternative tests which will provide the required toxicity information.

10. Chemical testing for the parameters for which effluent limitations exist shall be performed on a split of each sample collected for bioassay testing. To the extent that the timing of sample collection coincides with that of the sampling required for the effluent limitations, analysis of split sample will fulfill the requirements of that monitoring as well.

11. After one year, EPA may reduce the monitoring requirements to once per year, using the more sensitive species. All modifications will be approved by EPA in writing.

Modifications to the Current Effluent Limitations
Wyckoff Thermal Remediation
Pilot Study Treatment System[1]

The following modifications will be made to the Chemical and/or Biomonitoring requirements:

1. Remove metals (zinc, lead, mercury, nickel, cadmium, and chromium) as a monitoring requirement. Metals was not used during wood-preserving operations at the Wyckoff/Eagle Harbor site. Additionally, years of sampling never detected metals in the treatment plant effluent.

2. Temperature will be monitored. Ecology believes an effluent temperature discharge of 20°C (68°F) to 25°C (77°F) would not cause a water quality violation in receiving waters of Puget Sound. A mixing zone has been established at the point of discharge. Grab samples for temperature monitoring will be taken once per week.

3. Dissolved oxygen (DO) and turbidity will also be monitored by grab samples once per week. The daily maximum discharge limitations are:

DO:	Shall exceed 6 mg/L (the receiving waters of Puget Sound off Wyckoff are considered to be Class A Marine Water)
Turbidity:	If background is < 50 ntu, discharge cannot exceed background plus 5 ntu If background is > 50 ntu, discharge cannot exceed a 10% increase

4. The following Measurement Frequency will be employed during the first three months of pilot study operation:

   - Daily effluent sampling for weeks 0 to 2
   - Twice a week for week 2 to month 3
   - Biomonitoring at month 3

   Based on the results of the sampling data, the Measurement Frequency will be adjusted as appropriate after month 3. Any sampling adjustments made shall be no less than once per week for effluent chemical monitoring and quarterly for biomonitoring, for the remainder of the pilot study.

The above modifications will be employed during the thermal pilot study. Effluent Limitations will be developed/adjusted for the full-scale treatment system based on the results of the pilot study, as appropriate.

---

[1] Per agreement by the EPA Project Manager, Hanh Gold, and the Ecology Project Managers, Guy Barrett and Marian Abbett on February 2, 2000, and during subsequent communications on February 8 and 10, 2000.

Appendix B – Pilot Test Area Selection Memorandum

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-2255

REPLY TO
ATTENTION OF

CENWS-PM

MEMORANDUM FOR RECORD

RE: **Wyckoff/Eagle Harbor Superfund Site, Soils and Groundwater Operable Units, Addendum to Thermal Remediation Pilot Test Area Location Selection Memorandum dated April 21, 2000**

DATE: **August 9, 2000**

1. This memorandum provides an addendum to the Thermal Remediation Pilot Test Area Location Selection Memorandum, describing the recent changes made to the pilot study location.

2. The changes were made in consultation between EPA Region 10 and the U.S. Army Corps of Engineers (USACE), as well as USACE's expert consultants for the pilot study design: Roger Aines and Robin Newmark of Lawrence Livermore National Laboratory, Gorm Heron of SteamTech, Inc., and Kent Udell of the University of California – Berkeley.

3. The following changes were made to the pilot location:

    - 2.2 Design Data – "Total NAPL Removal" and "Aquitard Heating" are limited to the upper aquifer. NAPL contained in the aquitard will not be remediated as part of the pilot study, based upon discussions between Hanh Gold of EPA Region 10 and Kathy LeProwse of USACE in January 2000. Aquitard heating will be limited to heating at and near the upper surface of the aquitard, to allow NAPL located at the bottom of the aquifer (e.g., sitting on top of the aquitard) to be remediated.

    - 5.1 Selection Criteria – Criteria 7 (Presence of sufficient contaminated fine-grained materials (aquitard or non-marine clays) for testing of electrical resistance heating) and 8 (Presence of NAPL in the aquitard, to allow testing of thermal methods for remediation of the aquitard) are not critical to the scope of the pilot study. Use of electrical resistance heating would only be used if necessary to meet the three pilot study objectives. EPA does not require evaluation of this technology during the pilot study. See the Pilot Study Final Conceptual (10%) Design, Section 5.6, for more details regarding the use of this technology.

    - 5.2 Comparison of Alternative Test Areas – See the change to 5.1 relative to selection criteria 7 and 8.

- <u>5.3 Preferred Alternative Test Area</u> – The proposed pilot study location has been modified to reduce the total volume of soil to be treated from approximately 40,000 yd^3 to approximately 25,000 yd^3. The volume reduction was made by moving the western portion of the pilot study sheet pile wall eastward from the alignment proposed in the Pilot Study Location Selection Memorandum. The primary purpose for this size reduction was to allow successful completion of the pilot study within the EPA's budget. Due to this change, the estimated NAPL volumes decreased from 17,000 gallons of LNAPL and 41,000 gallons of DNAPL to 13,000 gallons of LNAPL and 29,000 gallons of DNAPL. EPA has indicated that the size of the pilot study will not be less than 25,000 yd^3 and, if funds allow, the size will be larger.

- <u>Figures 1, 2, and 3</u> – Area C does not extend as far west as shown in this figure, based on the changes described for 5.3 above. Please refer to Pilot Study Conceptual (10%) Design, Figure 4, to see the revised alignment for Area C.

4. This memorandum is submitted in lieu to revising the Thermal Remediation Pilot Test Area Location Selection Memorandum.

5. Any questions related to this addendum or the Thermal Remediation Pilot Test Area Location Selection Memorandum should be directed to Ms. Kathy LeProwse of USACE (206-764-3505).

END OF RECORD

Thermal Remediation
Pilot Test Area Selection
Memorandum

Groundwater and Soil Operable Units

Wyckoff/Eagle Harbor Superfund Site
Bainbridge Island, Washington

FINAL

Prepared by
Department of the Army

U. S. Army Corps of Engineers
Seattle District

21 April 2000

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All figures are located at the end of the document text.

LIST OF ACRONYMS

DNAPL	dense non-aqueous phase liquid
EPA	U. S. Environmental Protection Agency
FS	Feasibility Study
ITTAP	Insitu Thermal Technologies Advisory Panel
LNAPL	light non-aqueous phase liquid
MLLW	Mean Lower Low Water
NAD83	North American Datum
NAPL	non-aqueous phase liquid
NGVD	National Geodetic Vertical Datum
OU	operable unit
ppm	parts per million
ppt	parts per thousand
RI	Remedial Investigation
USGS	United States Geological Survey
WSPCS	Washington State Plane Coordinate System

FINAL

Wyckoff/Eagle Harbor Superfund Site
Pilot Test Area Selection Memorandum

1. INTRODUCTION

1.1 Purpose

The purpose of this memorandum is to document the decision process involved in the selection of the Thermal Remediation Pilot Test location at the Wyckoff Superfund Site. The memorandum will also include descriptions of each test area, as well as a comparison of the test areas based on the test objectives, and a proposal for a preferred pilot area.

1.2 Background

Due to the site-specific nature of thermal processes, EPA has determined that a pilot test must be completed prior to implementing a full scale thermal remediation. The pilot test area will be separated from the rest of the site by a sheetpile wall, to prevent recontamination by inflow of groundwater and NAPL from adjacent untreated soil, and to allow an objective evaluation of the results of the thermal treatment. Three possible locations for a pilot test were discussed at the ITTAP meeting on 19 October 1999:

A. Upgradient (south) end of site, east shoreline
B. Upgradient (south) end of site, west shoreline
C. Downgradient (north) end of site, east shoreline

Areas A and B were considered to be the most representative of the project site, since the sheet pile enclosure can be open at the upgradient end to allow recharge by oxygenated groundwater. Area C was eventually eliminated from further consideration due to its downgradient location, and subsequent evaluations have focussed on upgradient areas. Three upgradient alternatives will be compared in this memorandum, including the two original upgradient areas (See Figure 1):

A. East shoreline
B. West shoreline
C. Central Area

All three areas have the potential to be configured to the approximate shape of the full site, and the surrounding sheetpile walls can be terminated upgradient, in relatively uncontaminated soils, to allow lateral groundwater recharge into the treatment zone.

1.3 Site Data

The evaluations described in this memorandum are based on all available site data, including information derived from the following investigations:

- Investigations performed from 1972 through preparation of the Final RI Report (CH2M HILL, June 1997). A complete list can be found in the RI Report.
- Pre-design drilling and sampling for a proposed slurry wall, performed in 1997 and 1998 (U. S. Army Corps of Engineers, 1998b and 1998c). Although these were primarily geotechnical and geological explorations, considerable data on NAPL extent was obtained.
- Pre-design drilling, probing and sampling in 1999, for the currently proposed sheet pile wall and thermal treatment (U. S. Army Corps of Engineers, 2000a).

- Additional push-probe explorations in 2000, delineating the upgradient extent of the proposed pilot test locations, and filling data gaps revealed during conceptual thermal design (U. S. Army Corps of Engineers, 2000b).

2. PILOT TEST OBJECTIVES

The objectives of the pilot test fall into two broad categories: a) To assess the likelihood that a full-scale thermal remediation will achieve the cleanup goals for the site; b) To provide information for implementation of the potential full scale thermal remediation. Pilot area selection criteria are based on these objectives.

2.1 Performance

EPA has developed performance expectations for the pilot test, which will demonstrate the ability of the thermal technologies to meet the cleanup goals:

1. All mobile NAPL is removed from the pilot test area.
2. NAPL component concentrations are reduced sufficiently to allow site groundwater to be fully remediated by continuing thermally-enhanced natural processes, after the active treatment is completed. EPA will use site-specific laboratory testing and modeling to predict the degradation rates which will occur after treatment, and the conditions required for the residual contamination to be reduced to concentrations that are protective of marine water quality, surface water quality, and sediment standards in Puget Sound.
3. Contaminant levels in surface soils (0-15’ depth) are reduced to MTCA Method B cleanup levels.

If expectation 3. is not fully achieved, other measures such as soil capping may be implemented. Failure to meet expectations 1. and 2., however, could result in institution of the containment and pump-and-treat alternative instead of full-scale thermal remediation.

2.2 Design Data

The pilot test will also provide vital information which can be used for planning and design of the proposed full-scale thermal treatment:

- Community impacts
- Potential adverse effects to Eagle Harbor
- Vapor cap performance
- Dioxin removal from site soil
- Total NAPL removal
- Steam migration patterns
- Aquitard heating
- Treatment plant performance
- Microbial populations and contaminant oxidation rates before and after treatment

- Operational approaches
- Engineering data such as well diameter, depth, and spacing; monitoring requirements; vapor cap thickness; extraction and injection rates; surface temperatures; sheetpile permeability; construction material requirements; etc..

3. SITE DESCRIPTION

The Wyckoff property occupies approximately 57 acres, including a spit with about 0.8 miles of shoreline extending northward into Eagle Harbor. The spit has been extended and filled at least twice prior to the 1950's, and was the location of wood treatment activities that have caused the current soil and groundwater contamination. The spit covers approximately 8 acres, and contains the majority of the on-site contamination.

The Wyckoff Soil and Groundwater Operable Units (OUs) occupy a relatively flat lowland (the spit and the log peeler area) and intertidal area, bounded by a densely vegetated bluff on the south. The lowland area has an average elevation of approximately 15 feet MLLW, while the hillside area rises to elevations above 200-feet. The north and west portions of the spit are bounded by Eagle Harbor, and by Puget Sound along the eastern margin. A summary of the geologic materials present in the onshore portion of the Soil and Groundwater OUs are provided below.

3.1 Fill.

Fill material, imported from nearby sources, was placed on the property to extend the shoreline into Eagle Harbor and Puget Sound. The fill consists of silt and fine-grained sand similar in physical characteristics to the underlying marine sand and gravel unit, making it difficult to differentiate between the two units. Locally, the fill consists of fine brown sand containing bricks, broken glass, metal fragments, and other anthropogenic material, and generally lacks shell fragments.

3.2 Marine Sand and Gravel.

The marine sand and gravel unit is a nearshore marine/beach deposit present over nearly all of the Wyckoff facility. The unit underlies the fill or non-marine clay unit and is generally continuous to the top of the marine silt or the glacial deposits. The marine sand and gravel unit consists of loose to dense, poorly graded, gray to dark gray, fine to medium sand with shell fragments throughout. Gravel zones are common in this unit, and cobble zones have been observed along the east side of the site.

3.3 Non-Marine Clay.

The non-marine clay is either uplands colluvium or imported fill, generally lying stratigraphically above the marine sand and gravel. The non-marine clay consists of gray to brown, very soft to medium clay to brown clayey fine sand. Occasional plant fibers, wood fragments, and roots are present, as well as iron oxide staining.

3.4 Marine Silt.

The marine silt layer is a nearshore lagoon, tide-flat, or marsh deposit which occurs below the marine sand and gravel in the northern and eastern portions of the facility. The unit generally consists of a distinctive olive-colored silt or clay or silty sand with abundant shells and shell fragments and occasional red-brown wood debris and other organic material. The marine silt often overlies the glacial clay, silt, and sand unit, but may also be separated from the glacial deposits by thin layers of marine sand.

3.5 Glacial Clay, Silt, and Sand.

The glacial clay, silt and sand unit lies stratigraphically beneath the marine silt and the marine sand and gravel deposits. The glacial deposits consist mainly of gray to brown, stiff to hard clay and silt, with some sand and gravel, and no organic matter. Sand intervals within the glacial aquitard have been observed in the central portion of the site. The glacial portion of the aquitard has been divided into three facies: brown-gray silty sand, brown-gray sandy, gravelly silt and gray clayey silt. The gray facies is only found in the southwest corner of the site, and appears to transition to the brown-gray facies in the central portion of the site. The glacial unit acts as an aquitard between the upper and lower aquifers.

4. DESCRIPTIONS OF ALTERNATIVE TEST AREAS

Locations of the proposed test areas are shown on Figure 1. The horizontal extent of each of the test areas is based on a total treatment volume of 40,000 to 50,000 cubic yards.

4.1 Area A

Pilot Test Area A is located on the east side of the project area, directly north of the treatment plant.

4.1.1 Geology

The upper aquifer at Area A consists of fill material and marine sand and gravel totaling 26 to 53 feet thick. The fill material is 5 to 10 feet thick over most of Area A and thins slightly to the south. Marine sand and gravel underlies the fill material and is approximately 16-feet to 43-feet thick. Marine silt is present in the northern half of Area A, lying directly below the marine sand and gravel unit, and directly above the glacial clay, silt and sand unit. The maximum thickness of the marine silt is 6 feet (99CD05), thining southward and pinching out beneath the treatment plant. The glacial aquitard is composed of the brown, silty sand facies.

Two separate cobble zones up to six-feet thick have been identified in the marine sand and gravel within Area A. In addition, cobbles have been observed at the glacial contact with the marine silt (99CD05, RPW7 and 97AP22) and within the glacial aquitard (99CD05, RPW7 and CW02).

4.1.2 Contamination

Mobile NAPL is primarily restricted to the fill and marine sand and gravel units at Area A. Some small blobs of a waxy form of contaminant were noted associated with a heavy sheen within the marine silt unit in contact with the glacial aquitard at 99CD05. The maximum thicknesses of LNAPL and DNAPL in Area A are approximately 9 feet and 18 feet, respectively, at boring 97AP01.

The existence of NAPL beneath the treatment plant is a primary concern in Area A. Ten feet of DNAPL was observed at CW03 approximately 20 feet north of the treatment plant pad. Boring 00PP01, just north of the treatment pad, showed a total of 5.5-feet of mobile NAPL at various intervals. Boring 00PP05, drilled through the treatment plant pad, revealing about 1 foot of residual NAPL. Boring 00PP04, approximately midway along the seaward side of the plant, encountered 0.5-foot of mobile LNAPL as well as significant residual NAPL.

No contaminant has been observed within the aquitard at Area A. The results from 00PP16 and 99SE25 indicate that the area upgradient of Area A is free of contamination.

4.2 Area B

4.2.1 Geology

The upper aquifer at Area B consists of fill material, non-marine clay, and marine sand and gravel. These units are underlain by the glacial clay, silt and sand unit. Upper aquifer thickness ranges from 16 to 36 feet. Fill material averages about 10 feet thick, reaching a maximum thickness of 22 feet. Most of the fill in Area B consists of a sequence of a few feet of basalt cobbles, overlying silty sand which has been placed over non-marine clay fill. The maximum thickness of the non-marine clay fill is approximately 17 feet, thinning northward and pinching out at the north end of the Area (see Figure 2).

Marine sand and gravel underlies the fill material and varies from 3 to 26 feet thick. Several thin gravel deposits exist at Area B but no cobble zones have been observed. Organic-rich materials underlie the clay fill in the north and east portions of the Area (3 feet in boring 97AP18); these have been interpreted as lagoon deposits, and are mapped as either marine sand and gravel or surficial marine sediment. Both the marine sand and gravel and the lagoon deposits directly overly the glacial clay, silt and sand unit.

The glacial aquitard is composed of both the brown, sandy, gravelly silt and gray, clayey silt facies within Area B. No cobbles have been observed in association with the glacial aquitard in this area of the Wyckoff site.

4.2.2 Contamination

The maximum thickness of LNAPL and DNAPL in Area B is approximately 1.5 and 14.5 feet, respectively (borings 99SE47 and 99SE40). The extent of LNAPL is limited, and has only been detected at borings 97AP41, 99SE42, and 99SE47. Mobile NAPL is present in all units at Area B, including the glacial aquitard. In general, the thickest NAPL-contaminated intervals occur in the marine sand and gravel unit; however boring 97AP29, in the extreme northern portion of the Area, revealed a 6-foot NAPL-saturated zone in the lagoon bottom sediments. The northeastern edge of the Area may contain solid-phase PAH deposits associated with lagoon sediments (borings 00PP13, 00PP14, 00PP30, see Figure 5).

Up to 3 feet of NAPL has been observed in both the marine silt and the non-marine clay unit. Approximately 6 feet of DNAPL is in contact with the aquitard in the vicinity of boring 97AP29, and LIF data indicate that NAPL is present within the aquitard at 99SE40, 99SE46 and 99SE47. The maximum contaminant thickness in the glacial aquitard may be as much as 5 feet, penetrating as deep as 11 feet below the top of the aquitard.

Results from borings 00PP24, 99SE21 and 99SE22 indicate that the area upgradient of Area B is free of NAPL; however, a pilot soil boring 24 feet north of MW19 noted a naphthalene odor and petroleum sheen at approximately 20 feet below ground surface. A sample collected from boring 00PP24 contained 160 mg/kg diesel range hydrocarbons at the interface between the upper aquifer and the underlying glacial material. The analysis of PAHs in this sample revealed the presence of phenanthrene (33 mg/kg) and fluoranthene (16 mg/kg). Other PAHs including naphthalene, acenaphthene, fluorene, anthracene, pyrene, benzo(a)anthracene, chrysene and benzo(k)fluoranthene were each detected at concentrations less than 10 mg/kg. In addition, small pieces of asphalt-like material were visible in soils collected from 4 to 8 feet in depth.

4.3 Area C

4.3.1 Geology

Surface soils at Area C is consists of fill material and non-marine clay. The fill material consists primarily of silty sand with occasional basalt cobbles, averaging about 7 feet thick and reaching a maximum thickness of about 14 feet in the northern portion of the Area. In the southwest half of Area B, the silty sand overlies as much as 10 feet of non-marine clay; the clay thins northward and pinches out on the northeast margin.

The upper aquifer in Area C consists of marine sand and gravel, underlying the fill and nonmarine clay, with thicknesses from of 2 to 33 feet. Several thin, fine gravel deposits exist in the Area, but no cobble zones have been observed. Lagoon deposits appear to be absent from Area C, although organic debris was noted in the west side, indicating the probable eastern limit of the former lagoon. The marine sand and gravel directly overlies the glacial clay, silt and sand unit at Area C. The glacial aquitard is composed of both the brown, sandy, gravelly silt facies and the gray, clayey silt facies. No cobbles have been observed in association with the glacial aquitard in Area C.

4.3.2 Contamination

The maximum thickness of mobile LNAPL and DNAPL in Area C is approximately 13 and 9 feet respectively; both maximums were encountered at boring 00PP21. The thickest NAPL zones occur at the north end of the Area, thinning to the south as the aquitard becomes shallower. Mobile NAPL is present in all units, including the glacial aquitard. Most of the NAPL occurs in the marine sand and gravel unit; NAPL in the non-marine clay is primarily in the lower 1 foot of the unit, at the contact with the marine sand and gravel (borings 00PP22 and 97AP28). In the vicinity of boring 00PP21, approximately 6 feet of DNAPL lies directly on the aquitard. At the southwest corner of the Area, LIF data from boring 99SE45 indicate the existence of 5 feet of NAPL located 11-feet below the top of the aquitard.

Twelve direct-push borings have been completed upgradient of Area C to delineate the southern extent of contamination. With the exception of boring 00PP09, each of the pushes contained some level of residual contamination, including asphalt or charcoal debris. Analytical results indicate two broad categories of residual contamination upgradient of Area C:

- The first category is characterized by a higher concentration of motor-oil-range hydrocarbons relative to diesel-range hydrocarbons, along with a greater fraction of HPAH relative to LPAH. LPAH concentrations were below the laboratory’s reporting limit in many samples.

This pattern of contamination occurred in samples from pushes 00PP08, 00PP10, 00PP18, 00PP27 and 00PP29; with the highest concentrations occurring at 4 to 8 feet depth in push 00PP10. Hydrocarbon contamination in this sample included 2200 mg/kg motor-oil-range TPH and 20 mg/kg total HPAH; total LPAH was below the laboratory's reporting limit (USACE, 2000b).

- The second category of contamination more closely resembles chemical patterns observed throughout the Wyckoff site, associated with creosote. This pattern is characterized by higher concentrations of diesel-range hydrocarbons relative to motor-oil-range hydrocarbons, and high concentrations of LPAH relative to HPAH. The LPAH component is comprised mostly of naphthalene. These characteristics are present at pushes 00PP23, 00PP25 and 00PP26. The highest concentrations occurred in boring 00PP25 at a depth of about 5 feet, at the interface between the nonmarine clay and the glacial unit. The analysis of this sample revealed 3000 mg/kg diesel-range hydrocarbons, 1400 mg/kg motor-oil-range hydrocarbons, and 1156 mg/kg total LPAHs (USACE, 2000b). Contamination with these same characteristics was also detected in sand and gravel zones within the glacial aquitard, in pushes 00PP23 and 00PP26.

5. DEVELOPMENT OF PREFERRED ALTERNATIVE

5.1 Selection Criteria

The following criteria have been identified for selection of the best pilot test area, based on performance and design data goals listed in Paragraph 2.

1. Access available to all required drilling locations for extraction and injection wells
2. Upgradient location to allow construction of an open-ended sheetpile enclosure, allowing lateral groundwater recharge.
3. Absence of mobile NAPL upgradient of pilot area.
4. Presence of both LNAPL and DNAPL.
5. Soil characteristics and stratigraphy similar to overall site.
6. Presence of DNAPL directly overlying the aquitard, to allow evaluation of steam effectiveness at full aquifer depth.
7. Presence of sufficient contaminated fine-grained materials (aquitard or non-marine clay).for testing of electrical heating.
8. Presence of NAPL in the aquitard, to allow testing of thermal methods for remediation of the aquitard.
9. Shoreline location, to allow monitoring of thermal impacts in the intertidal zone.

The above criteria are listed in order of perceived priority. Criteria 1 through 4 are considered to be critical to the success of the pilot test or for generation of meaningful results, while Criteria 5 through 9 are desirable.

5.2 Comparison of Alternative Test Areas

The following comparison of proposed pilot test areas is based on the four critical criteria and five desirable criteria outlined in Paragraph 5.1. Results of the comparison are summarized in Table 2.

5.2.1 Access to Drilling Locations

Access to about 1/3 of Area A is restricted by the presence of the treatment plant. Explorations have shown significant thicknesses of NAPL under the plant, however it would not be feasible to install wells or electrodes on the required spacing in this area. There are no drilling access problems at Areas B and C. A large portion of Area B is covered by an asphalt pad, however this would not prohibit well installation.

5.2.2 Upgradient Location

All of the proposed pilot test areas are located at the upgradient margin of the project area.

5.2.3 Absence of NAPL Upgradient of Test Area

LNAPL is present upgradient of the current Area A location, under the treatment plant, as shown in Figure 3. The boundaries of Area A would have to be adjusted southward to include the treatment plant area; however this would result in a large total treatment volume if the northern boundary is maintained near boring 99CDO5 to include a small zone of contamination in contact with the aquitard. No mobile NAPL exists upgradient of Areas B and C. Small amounts or residual NAPL were discovered upgradient of Area C; this contamination could easily be removed by excavation to prevent any interference with the pilot study.

5.2.4 Presence of LNAPL and DNAPL

Both LNAPL and DNAPL are present in all 3 proposed test areas (Figures 3 and 4). At least 5 feet of both LNAPL and DNAPL are present over a large portion of Areas A and C. Area B contains mostly DNAPL, however, with relatively little LNAPL.

5.2.5 Soils and Stratigraphy Representative of the Total Project

Stratigraphy at Area A is representative of the majority of the Wyckoff site, with all of the onshore geologic units represented except the non-marine clay. Area B is dominated by the non-marine clay unit, which occurs only in the southwest corner of the project area. In addition, Area B contains organic-rich lagoon sediments, which are restricted to the western margin of the project area. Area C contains all of the geologic units except the marine silt; relative volumes of the geologic units are representative of the overall project area.

5.2.6 DNAPL directly overlying the Aquitard

No significant DNAPL is in contact with the glacial aquitard at Area A. Large portions of Areas B and C contain several feet of DNAPL directly overlying the aquitard.

5.2.7 Contaminant in Fine-Grained Material

Neither the marine silt nor the glacial unit at Area A appear to contain significant NAPL contamination. Areas B and C contain NAPL contamination in both the non-marine clay and in the glacial unit.

5.2.8 Presence of NAPL in the Aquitard

No NAPL has been observed within the aquitard at Area A. Areas B and C contain NAPL in the aquitard; in both instances the NAPL occurs as deep as 11 feet below the top of the aquitard.

5.2.9 Shoreline Location

The east margin of Area A consists of approximately 150-feet of intertidal shoreline. Area B is bounded on the west by about 250-feet of bulkheads, with subtidal sediment surfaces. Area C is at least 250 feet from the nearest shoreline.

5.3 Preferred Alternative Test Area

Area C appears to be best choice for a pilot test location. Area A is ruled out by restricted access to drilling locations, and also lacks NAPL on the aquitard or in fine-grained soils. Area B contains disproportionate volumes of non-marine clay and lagoon-bottom sediments, and is LNAPL-deficient.

No structures which would restrict drilling activity are present in Area C. Approximately 17,000 gallons of LNAPL and 41,000 gallons DNAPL are present, with no mobile NAPL detected upgradient of the Area. The stratigraphy is similar to the overall project area, including about 7% (by volume) non-marine clay in the southwest corner (see Figure 2). DNAPL is in contact with the glacial aquitard over a large area, primarily in the north end of the Area. Area C also provides an opportunity to test electrical heating technology, with NAPL present in both the glacial aquitard and in the non-marine clay.

6. RECOMMENDATIONS

- It is recommended that Area C be accepted as the Pilot Test Area for thermal remediation at the Wyckoff Superfund Site.
- Although Area C exhibits all of the critical characteristics for pilot testing, it does not have an intertidal shoreline which would allow evaluation of thermal impacts to the marine environment. Thermal monitoring during the pilot study should be used to refine the thermal parameters employed for pilot test design, and these improved parameters should then utilized to make better predictions of heat transfer along the shoreline.
- A limitation common to all upgradient test areas is the shallow depth of testing, compared to average aquifer depths over the project site. Well installation costs, injection pressures, steam temperatures, and extraction rates will all increase as deeper portions of the aquifer are treated. These differences need to be considered when extrapolating pilot test results to the full-scale remediation.
- Residual hydrocarbons detected upgradient of Area C may be a source of contaminated groundwater which could affect the interpretation of the pilot test results. This issue should be evaluated, and the contaminated soils should be removed as necessary.
- Although sufficient explorations exist to allow selection of a test area, well screen and electrode locations can only be estimated at this time. The exact locations should be determined in the field, utilizing data obtained during drilling for the wells, electrodes, and thermal probes.

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TABLES

Table 1. Alternative Pilot Area Data

PARAMETER (AVERAGE)	AREA A	AREA B	AREA C
Ground surface elevation	17	16	17
Depth to groundwater	10	8	10
Aquifer thickness	35	26	26
Non-marine clay thickness	0	8	5
Aquitard thickness	17	30	26
LNAPL thickness	4	0.7	6
DNAPL thickness	9	7	5

Table 2 Comparison of Alternative Pilot Test Areas by Selection Criteria

	CRITERION	AREA A	AREA B	AREA C
1	Access to drilling locations		X	X
2	Upgradient location	X	X	X
3	Absence of NAPL upgradient of test area	X	X	X
4	Presence of both LNAPL and DNAPL	X		X
5	Soil characteristics and stratigraphy similar to overall site	X		X
6	Presence of DNAPL on the aquitard		X	X
7	Presence of sufficient contaminated fine-grained materials for testing of electrical heating		X	X
8	Presence of NAPL in the aquitard		X	X
9	Shoreline location	X	X	

FIGURES

Appendix C – Well E4 Pumping Test Results

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Wyckoff Superfund Site
Thermal Remediation Pilot Test
WELL E4 PUMPING TEST SUMMARY

1. TEST PROCEDURES.

1.1 General

Pumping tests at extraction well E4 were conducted to provide estimates of subsurface hydraulic parameters for thermal treatment design and operations. The tests consisted of: 1) an 8-hour step-discharge test with overnight recovery; 2) followed by a 3-day constant-discharge test and 3-day recovery. Well locations are shown on Figure 1, and well data are shown on Table 1. Discharges and durations for the pumping tests are shown on Table 2.

1.2 Equipment

Pumping was performed using a 3.75-inch Goulds submersible pump driven by a Franklin 2-horsepower electric motor. The pump and motor combination were designed to deliver a maximum of 30 gpm at the maximum total dynamic heads which would be incurred with anticipated water levels along with the pipeline and treatment plant.

A check valve was mounted just above the pump, and the pump and motor assembly was suspended on a 1.25-inch ID flexible polyethylene column long enough to position the pump intake at the bottom of the well screen. A 1-inch PVC stilling pipe was clamped alongside the column pipe, extending to a few feet above the pump intake. The flexible column pipe curved from vertical to horizontal as it exited the well, and was laid on the ground surface. A spigot for sample extraction was mounted on the horizontal portion of the pipe, followed in the down stream direction by two flow meters and a globe valve. The column and discharge pipe extended 150 feet to a Baker tank, where the discharge was collected before pumping to the site groundwater treatment plant.

Flows were measured using two 2-inch totalizer meters: a Precision meter measuring cubic feet per minute, and a Master Meter measuring gallons per minute. The meters were calibrated and sealed by the manufacturer prior to shipping, and were found to agree within 1% during simultaneous testing before the step-discharge test. The meters were also checked every 8 hours during each pumping test, and showed continuing agreement within 1%. Totalizer readings were used to calculate average discharges for each test period.

1.3 Water level monitoring

Water levels were recorded in the pumping well, 5 extraction wells within a 100-foot radius of the pumping well (see Figure 1), and in 3 monitoring wells outside the Pilot Area, using 9 Druck down hole transducers connected to three Geomation data loggers. Electronic data were collected from 3 days before the step-discharge test through the recovery period, and manual data collection continued for 3 days after recovery. Tide data were recorded by a fourth data logger, from a transducer placed in a stilling pipe in the Log Rafting Area. During the pumping tests and recovery, water levels were recorded whenever a change of 0.05 foot was sensed, or at minimum 1-hour intervals. Barometric pressure readings were also recorded by data logger, and all data continuously downloaded to a desktop computer in the project office. Manual backup water-level readings were taken every 8 to 16 hours from the wells containing transducers. The background wells for the test were: MW19, 1040 feet southwest of well E4, in the upper aquifer; PO5, 470 feet northeast, in the upper aquifer, and 9CDMW04, 300 feet north in the lower aquifer. There was no significant precipitation during the testing, until the second day of the constant discharge test (see Table 3).

1.4 Step-Discharge Test

The step-discharge test began at 11:25 AM on 15 October 2001, pumping at 3 gpm. The water level was fairly stable at about 3.4 feet of drawdown throughout the 2-hour step. The pumping rate was then increased to 6.1 gpm, and drawdown increased to 8.5 feet, continuing to increase to 9.2 feet over the next 2 hours. After the pumping rate was increased to 9.5 gpm, the water level dropped to within 3 feet of the pump intake, and the pumping rate was gradually reduced to 8.1 gpm over a period of about ½ hour. Finally, the pumping rate was reduced to 6.7 gpm and continued for another 1.5 hours. During this time, drawdown was steady at about 13.8 feet.

1.5 Constant-Discharge Test

The constant-discharge test was conducted at 2.9 gpm, less than ½ of the maximum sustainable rate determined from the step-discharge test. The test started on 16 October 2001 at 0930 hr. Initially the drawdown was 4.8 feet, gradually increasing to over 6 feet during the next 72 hours. During the test period, the water level in the pumping well appeared to fluctuate over a range of about 0.4 feet in response to tides.

2. AQUIFER TEST ANALYSES

2.1 Procedures.

2.1.1 General.

Data logger files for the 72-hour constant discharge pumping tests were converted to separate computer files of elapsed time and drawdown for each well, which were imported to customized EXCEL spreadsheets. The spreadsheets were used to make data corrections, to plot graphs, and to perform data analyses. Neuman (1975) analyses and numerical model data fits were performed for all of the observation wells in the Pilot Area except E5 and E6; these data were not analyzed due to strong tidal effects. The Neuman method is the standard analysis for unconfined aquifer test data, however review of the Neuman results indicated the need for additional work with the existing numerical model. Pumping well (E4) data were not analyzed because head losses and uncertainties regarding effective diameters for pumping wells preclude accurate estimates of formation parameters (Driscoll, 1986; Fetter, 1980; Todd, 1980; U.S. Dept. of Interior, 1985). Well E4 data was used, however to perform well efficiency calculations.

2.1.2 Data Corrections.

The background water-level trend was determined by calculating the average daily static water-level drop from the pre-test background period through the post-test background period. Water levels in the wells appeared to increase in response to rainfall over the last two days of the post-test background period (see Table 3); therefore these data were not included in the trend calculation. Background corrections for the observation wells ranged from 0.03 to 0.06 feet/day. Using these corrections, the background water-level decline since the start of pumping was calculated for, and subtracted from each drawdown measurement.

Barometric effects were not discernable in the water-level data, primarily because of tidal and trend effects, therefore no barometric corrections were made. An attempt was made to correct data from wells E5 and E6 for tidal effects, however the relative amplitude of well fluctuations was different from the marine tidal fluctuations, preventing effective scaling and superposition of well and tide data. All observation well data was corrected for unconfined conditions by the method of Jacob (1963).

2.1.3 Neuman Analyses.

Pumping test data from observation wells E1, E2, and E3 were analyzed by Neuman's (1975) method for partially penetrating wells in unconfined aquifers, modified for dual-boundary conditions (Easterly, 1995). The modification of Neuman’s method is implemented by locating image wells which simulate impermeable boundaries, and generating type curves by superimposing dimensionless drawdowns for the pumping well and image wells. Image well locations were derived from two intersecting linear boundaries, which were defined by linear regressions through the sheet pile wall surrounding the Pilot Area. Custom type-curve data were generated for each observation and pumping well pair by the computer program DELAY2.2. The type curves and the test data were both plotted on EXCEL® (Microsoft, 1999) spreadsheets and hard copies were printed of both plots. A preliminary manual fit was performed with the printed plots, and a final fit was obtained on the computer screen with the test data overlaid on the type curve plot. Aquifer parameters were automatically calculated by the spreadsheet, based on the match points used for the fit.

2.1.4 Efficiency Calculations.

The well efficiency for the pumping well (E4) was estimated using the method proposed by Todd (1980) (see Table 2). The method consists of plotting specific capacities for each step of the step-discharge test, and comparing the estimated laminar head loss (formation head loss) with the maximum drawdown (formation head loss plus well head loss) for each step.

2.1.5 NUFT Model Data Fits.

The Neuman analyses appeared to produce anomalous estimates of storativity, specific yield, and vertical anisotropy (see Table 4). The vertical anisotropy results were of particular concern because they seem to contradict field observations which show only moderate stratification in the upper aquifer sands. The discrepancies between the Neuman results and expected or typical formation parameters are consistent with findings by Nwankwor et al (1992), Akindunni and Gillham (1992), and Halford (1997):

- Application of Neuman’s fully-saturated-vertical-flow assumption to fine-grained materials with significant capillary retention can cause overestimation of storativity and horizontal hydraulic conductivity, and underestimation of vertical hydraulic conductivity and specific yield.
- A 3-dimensional numerical multiphase model is the most reliable analysis tool for test data from unconfined aquifers.

For these reasons, additional data analyses were performed by calibrating an existing numerical model to the well drawdown data.

The numerical model had been previously prepared as an independent project with no cost to the Government, for the purpose of simulating steam injection operations. It utilizes the multiphase code NUFT, and contains the same stratigraphy, material and fluid parameters as the NUFT and MODFLOW models used in the 90% Design Analysis (USACE, 2001). The Pilot Area and surrounding vicinity was simulated by a 3-dimensional grid consisting of 50,000 nodes, with a horizontal grid spacing of 2 meters inside the Pilot Area, and a vertical grid spacing of 1.5 meters in the upper aquifer. Fixed head boundaries were used on the north and south sides of the domain, to create average northward flow conditions at the site. This model provides a valid representation of partially-saturated delayed-yield conditions, as well as an accurate portrayal of the sloping aquitard and irregularly-shaped sheet pile wall. Some error is inherent in the use of a numerical model for pumping test analyses, however, because wells can only be located at the centers of cells. Since the Pilot Area NUFT model has a 2-meter horizontal grid spacing, wells might be simulated at locations as far as 3 feet from their actual locations.

2.2 Results.

2.2.1 General.

Results of the test data analyses are shown in Table 4. Data points were scattered over early portions of the drawdown curves, probably due to a combination of instrument sensitivity and heavy equipment operations near the test area. Nevertheless, data from wells E1, E2, and E3 generated drawdown curves of good quality that matched well with the Neuman type curves. Matches with NUFT model output were fair to good, and could be improved with additional model runs. Wells E5 and E6 were strongly affected by tides, and reliable fits could not be obtained. For all curve fits, emphasis was placed on late time data, since the early data may be affected by borehole conditions. The results of pumping test analyses for both pumping tests are shown on Table 4. In general, results from Neuman analyses show higher horizontal hydraulic conductivities and vertical anisotropy ratios (Kr/Kz) than the NUFT model fits.

2.2.2 Background Wells

Water levels in the background wells did not appear to be influenced by the pumping test. All of the background wells were affected by tidal fluctuations, with amplitudes of 0.7 feet at well MW19 (upper aquifer, upgradient), 0.8 feet at well PO5 (upper aquifer, downgradient), and 4.5 feet at well 99CD04 (lower aquifer, downgradient).

2.2.3 Neuman Analyses.

Test data fits to the Neuman type curves are shown in Figures 2, 3, and 4. The hydraulic conductivity for the three wells which were analyzed ranged from 29.7 at well E2 to 66.8 feet/day at well E3, averaging 46.3 ft/day. Specific yields range from 0.033 at well E2 to 0.007 at well E3, averaging 0.019. These specific yield values are lower than the expected range for sands (10% to 35%; Fetter, 1988), suggesting that saturated soils are not draining completely as the phreatic surface is lowered by pumping. Vertical anisotropy ratios (Kr/Kz) varied from 27.9 to 388.7, with a average of 156.2. These values are normally indicative of a high degree of stratification, which has not been apparent in Pilot Area soils. Because of the anomalous results for both specific yield and vertical anisotropy, the Neuman method appears to be inappropriate for the fine to medium silty marine sands in the Pilot Area.

2.2.4 NUFT Model fits

Test data fits to the NUFT model predictions are shown in Figures 5, 6, and 7. NUFT model output did not fit the test data as well as the Neuman type curves, primarily because of the large number of model runs required to produce exact fits. Early time data-fitting was not attempted because NUFT does not have a storativity parameter, and elastic storage simulated in the early portion of the drawdown curve is solely a function of the compressibility of water.

Twenty-five model runs were performed, with horizontal hydraulic conductivities ranging from 10 feet/day to 31 feet/day, and vertical anisotropy ratios ranging from 2 to 55. The best data fits were for model runs with 26 feet/day and vertical anisotropy values ranging from 3 to 7, averaging 4.7. All model runs employed the porosity and residual saturation values used for Pilot Test design: 0.28 and 0.15 respectively, or a specific yield of 0.13. The best-fit modeled drawdown curves are still offset slightly from the test data. This offset may be caused by discretization error, or by differences in the formation specific yield versus the modeled storage capacity. The groundwater storage capacity in the model can be adjusted as a function of porosity and pressure-saturation-permeability characteristics, however several more model runs would be required to obtain exact fits with the test data.

3. CONCLUSIONS

- The NUFT model data-fitting appears to be the most appropriate method of analysis for the test data, because it incorporates partially-saturated vertical drainage, sheet pile boundaries, and 3-dimensional stratigraphy.
- The average horizontal hydraulic conductivity in the Pilot Area appears to be about 26 feet/day, greater than the value of 10 feet/day used for Pilot Test design.
- The average vertical hydraulic conductivity in the Pilot Area appears to be about 5 feet/day; i.e. the average vertical anisotropy ratio is about 5, considerably less than the value of 20 used for Pilot Test design.
- Pumping test results are consistent with the porosity value used for Pilot Test design (0.28) and also with the pressure-saturation-permeability relationships used for design.
- Pumping test data show strong tidal influence at well E6, and moderate influence also at well E5. This phenomenon suggests that the aquitard is thin on the east side of the Pilot Area, particularly in the deepest portion around well E6.

4. RECOMMENDATIONS

- Because of the unique conditions at the Wyckoff site, upper aquifer pumping test analyses should be performed using a 3-dimensional numerical model. The most reliable results will be obtained from a multiphase model.
- Since the average permeability of soils in the Pilot Area is greater than anticipated, the injection well screen length can be reduced to 5 feet. Injection rates for the reduced screen length will be similar to design assumptions for 10-foot screens.
- The low vertical anisotropy values predicted from pumping test data also support a reduced injection screen length. Conditions appear to be favorable for upward steam

migration into near-surface soils, the shorter screens should not significantly inhibit vertical steam flow.

- The steam injection model used for Pilot Test design should be revised using the aquifer parameters predicted from the pumping test data.
- Future site operations should emphasize vertical hydraulic control in the well E6 vicinity. The aquitard may be thin or absent at this location, and the lower aquifer may be vulnerable to contamination from above.

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TABLES

Table 1.
Pumping Test Well Data

Well no.	Coordinates		Elevation (MLLW)		Hole		Screen				Static water level			Aquifer base		Completion	
							Diameter (in)										
	N	E	Casing	Ground	Dia.(in)	Depth	ID	OD	Top depth	Bottom depth	Depth	Elevation (MLLW)	Date	Depth	Elevation	Date	Method
E1	229375.7	1229072.3	21.20	18.60	16.00	36.4	10.00	10.75	6.6	31.5	10.36	8.2	10/16/01	31.35	-12.75	10/1/01	Cable tool
E2	229389.7	1229136.6	21.10	18.66	16.00	40.5	10.00	10.75	6.7	35.5	10.52	8.1	10/16/01	35.50	-16.84	10/1/01	Cable tool
E3	229318.5	1229064.0	20.00	18.57	16.00	38.8	10.00	10.75	7.7	31.0	10.79	7.8	10/16/01	28.80	-10.23	10/9/01	Cable tool
E4	229332.0	1229124.0	20.80	18.84	16.00	36.5	10.00	10.75	7.2	31.6	11.04	7.8	10/16/01	31.50	-12.66	10/8/01	Cable tool
E5	229287.8	1229171.7	20.70	18.30	16.00	35.0	10.00	10.75	6.8	29.6	10.47	7.8	10/16/01	30.00	-11.70	10/2/01	Cable tool
E6	229348.1	1229191.8	20.00	18.50	16.00	43.0	10.00	10.75	7.7	38.1	10.05	8.5	10/16/01	38.00	-19.50	10/4/01	Cable tool

Notes:

1. All dimensions are in feet unless otherwise noted.
2. Static water levels were measured just prior to the E4 constant-discharge test.

Table 2
Well E4 Pumping Test Summary

Test		Start date	Q (gpm)	Duration (min)	s max (ft)	SC (gpm/ft)	Efficiency (%)
Step	1	10/15/01	3.01	125	3.5	0.85	39.7
	2		6.13	121	9.3	0.66	30.7
	3		8.10	30	18.3	0.44	22.5
	4		6.73	90	13.9	0.48	20.6
Constant Discharge		10/16/01	2.90	4320	6.01	0.48	

Q = discharge
smax = maximum drawdown in the pumping well
SC = specific capacity

Table 3
Precipitation Data for Wyckoff Superfund Site

Test Period	Day (October 2001)	24-Hour (Midnight-Midnight) Precipitation (Inches)
Pre-test background	12	0.04
	13	0.04
	14	0.03
Step test	15	0.00
Constant discharge test	16	0.08
	17	0.00
	18	0.60
Recovery	19	0.05
	20	0.00
	21	0.20
Post-test recovery	22	0.05
	23	0.20
	24	0.10
	25	0.05

Table 4
Results of Pumping Test Analyses

							Bounded Neuman Analyses						NUFT Model Fits				
Well	Location	Q (gpm)	r (ft)	b (ft)	s max (ft)	Background Correction (ft/day)	Kr (ft/d)	Kr/Kz ()	S (ft/ft)	Sy (ft/ft)	Fit quality		Kr (ft/d)	Kr/Kz ()	Sy (ft/ft)	Fit quality	
											A	B				A	B
E1	wall		67.69	20.99	0.98	-0.059	42.4	52.0	0.0135	0.0182	fair	good	26.0	4.0	0.13		fair
E2	wall		59.06	24.98	1.08	0.000	29.7	27.9	0.0118	0.0325	fair	good	26.0	3.0	0.13		fair
E3	interior		61.50	18.01	0.88	0.000	66.8	388.7	0.0055	0.0073	fair	good	26.0	7.0	0.13		good
E4	interior	2.904	0.00	20.46	6.01	-0.046											
E5	interior		65.03	19.53	0.59	-0.033											
E6	wall		69.69	27.95	1.365	-0.032											
Average						-0.028	46.3	156.2	0.0103	0.019			26.0	4.7	0.13		

Q = discharge
r = distance from pumping well to observation well
b = saturated aquifer thickness
smax = maximum drawdown
Kr = horizontal hydraulic conductivity
Kz = vertical hydraulic conductivity
S = storativity
Sy = specific yield

Notes: 1. E4 (pumping well) data were not analyzed.
2. E5 and E6 data were strongly affected by tides and were not analyzed.

FIGURES

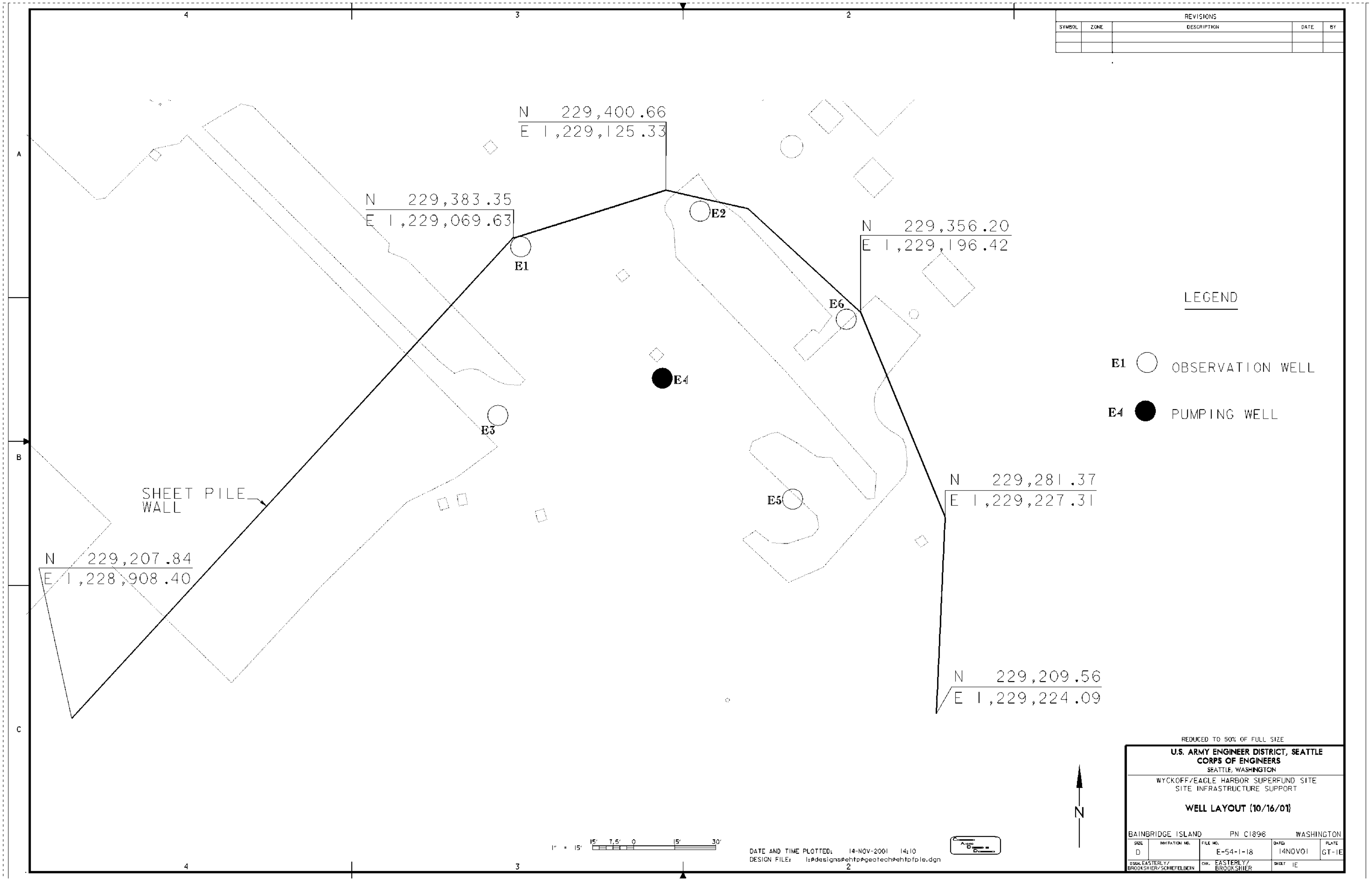

Figure 1. Pumping Test Well Layout

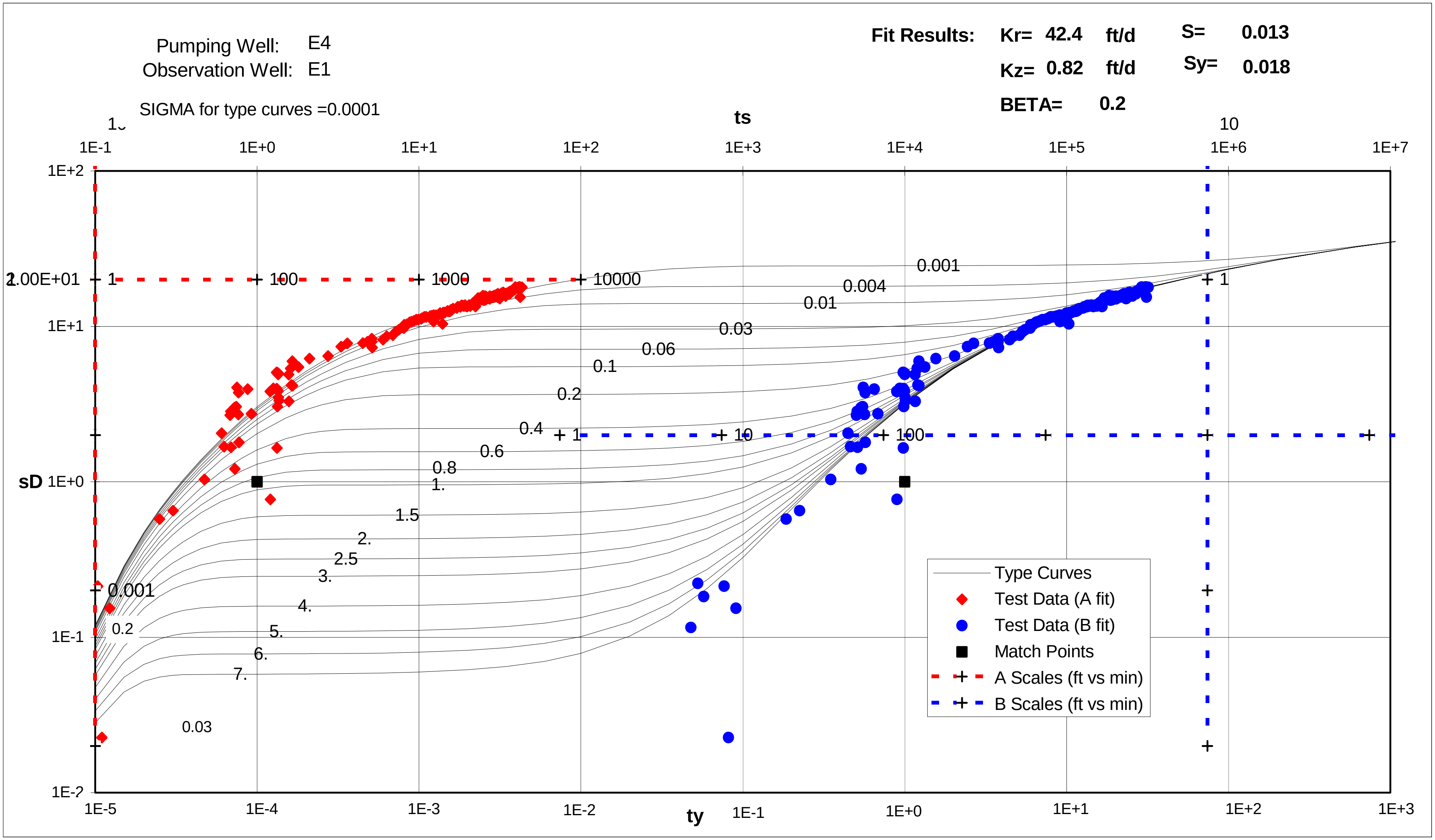

Figure 2. Well E1 Neuman Analysis

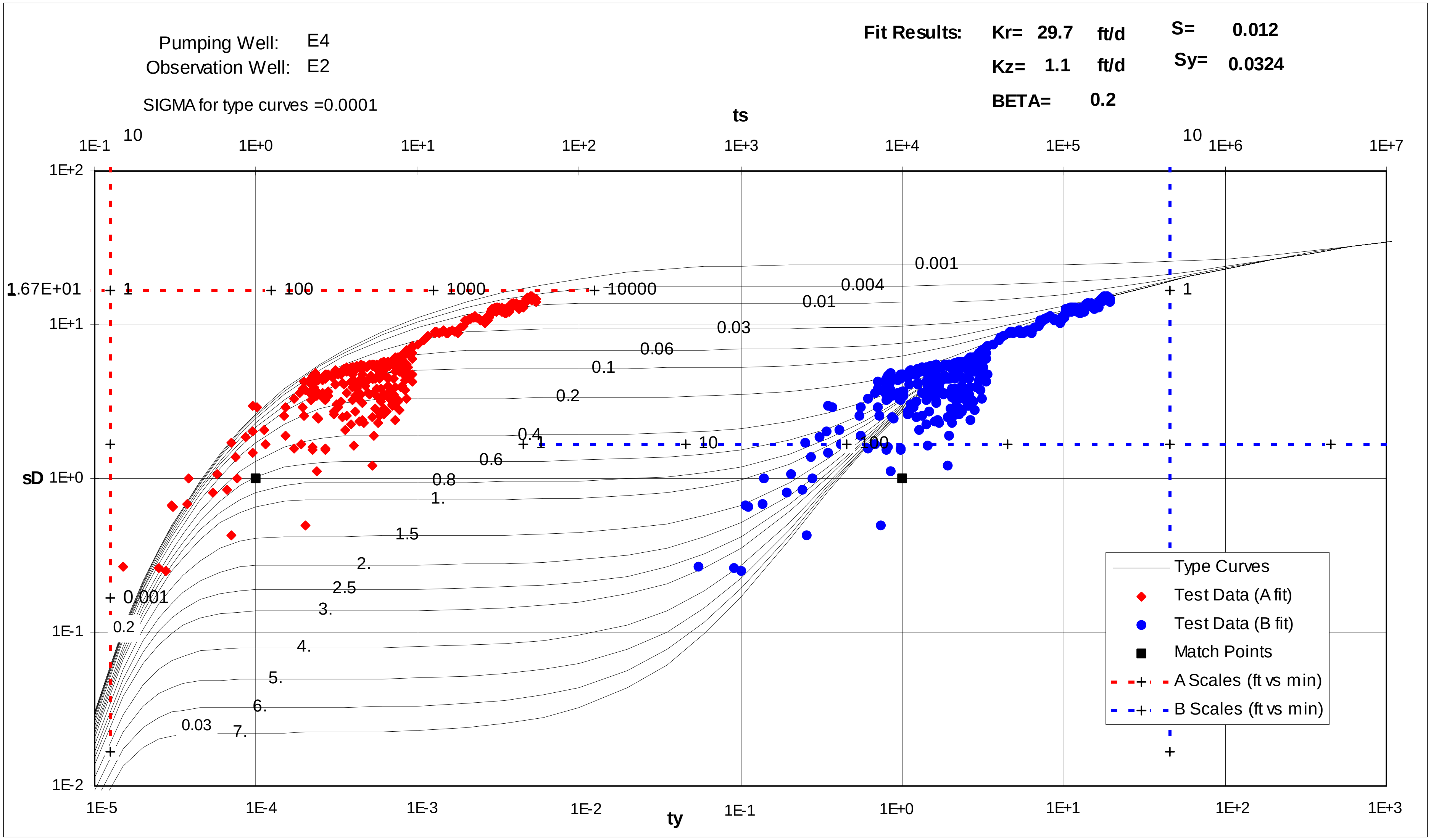

Figure 3. Well E2 Neuman Analysis

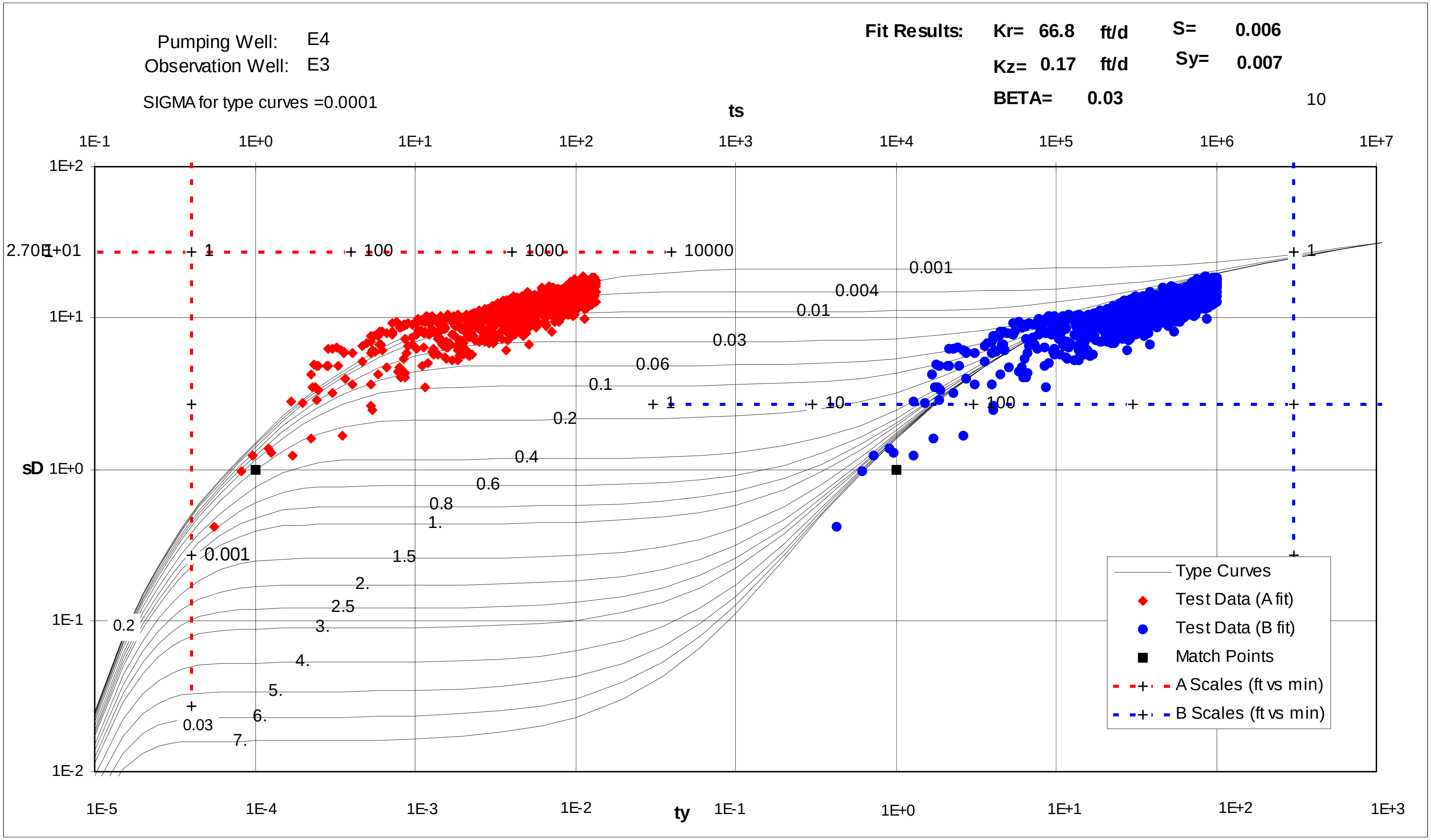

Figure 4. Well E3 Neuman Analysis

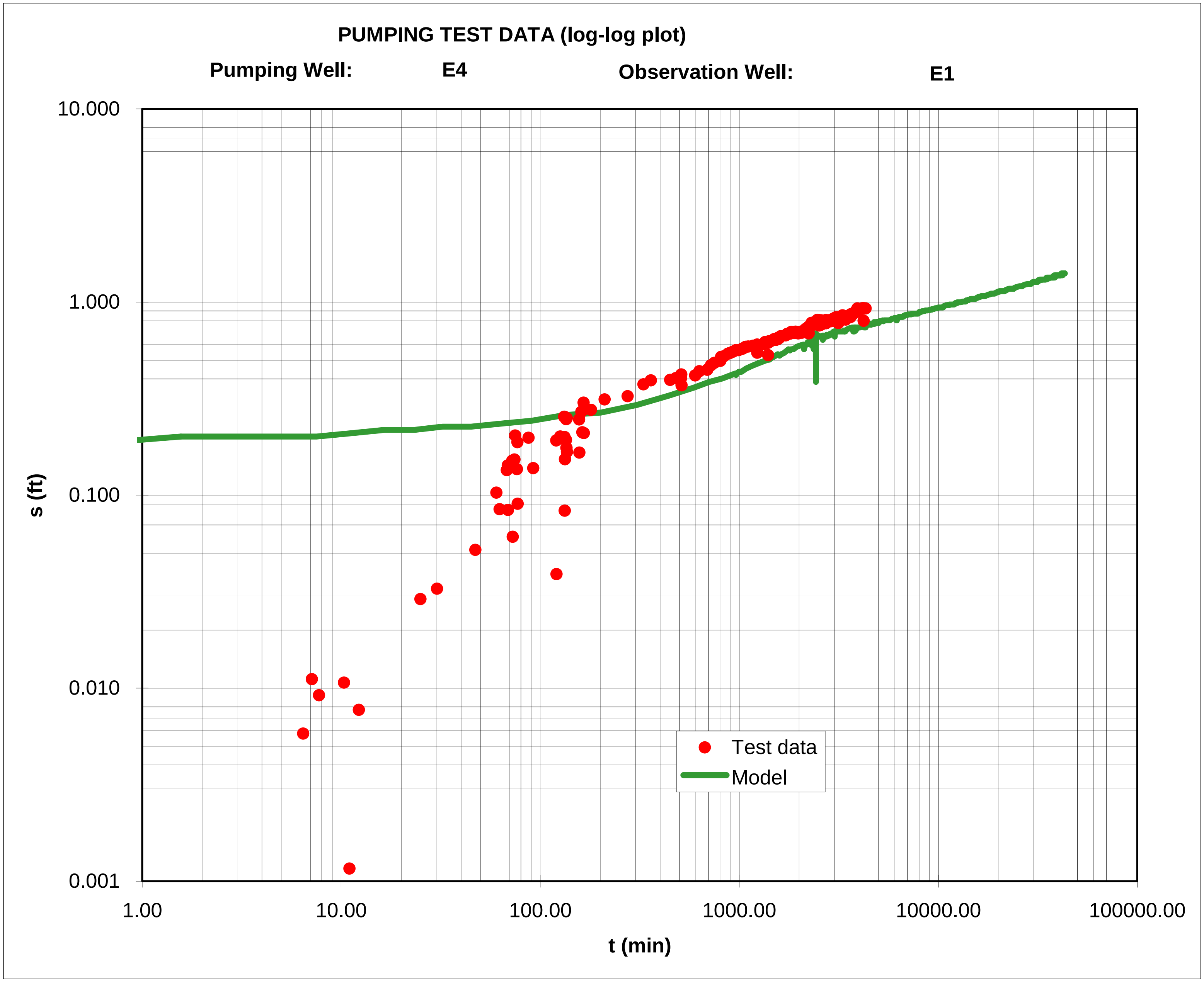

Figure 5. NUFT data fit for well E1

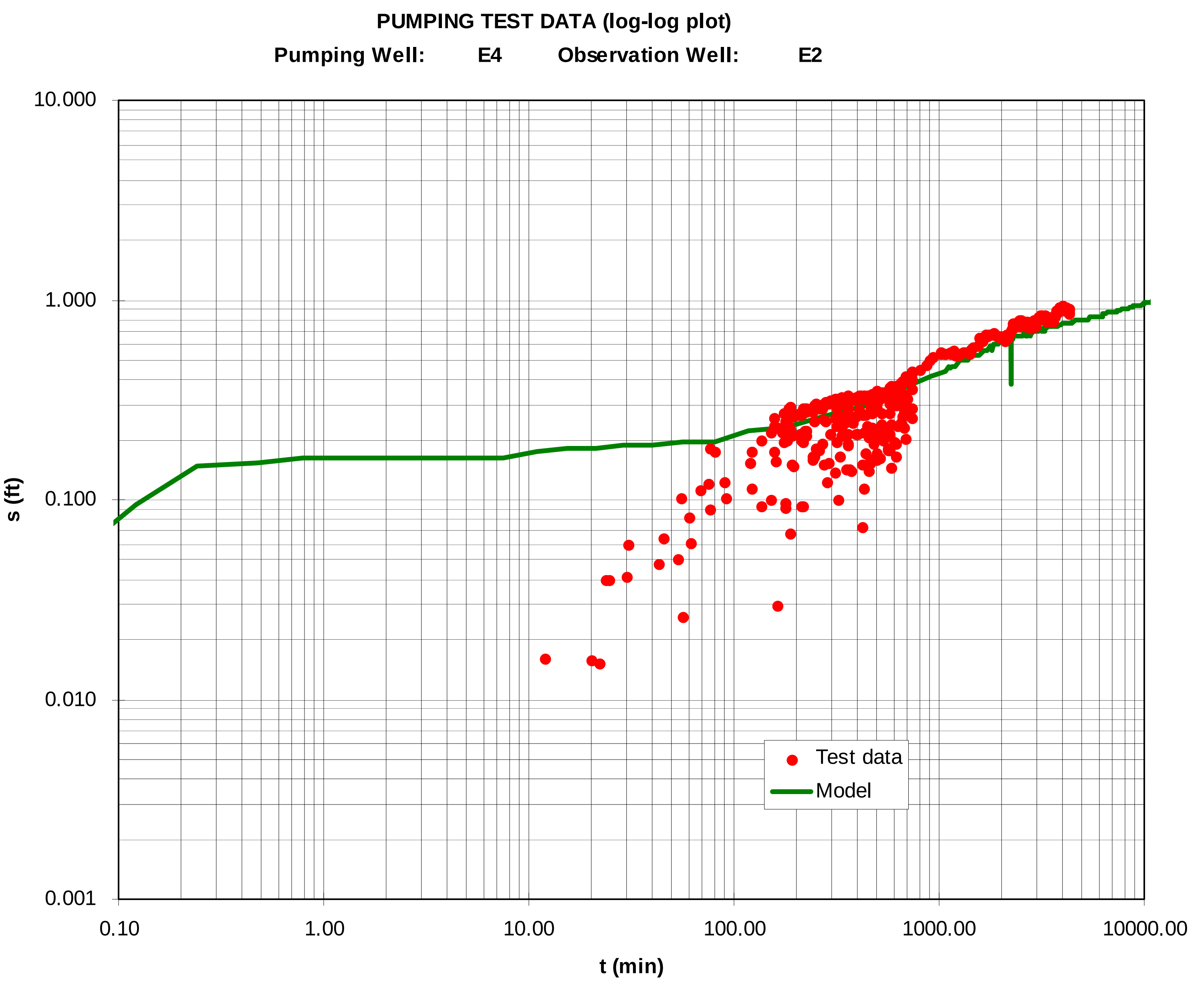

Figure 6. NUFT data fit for well E2

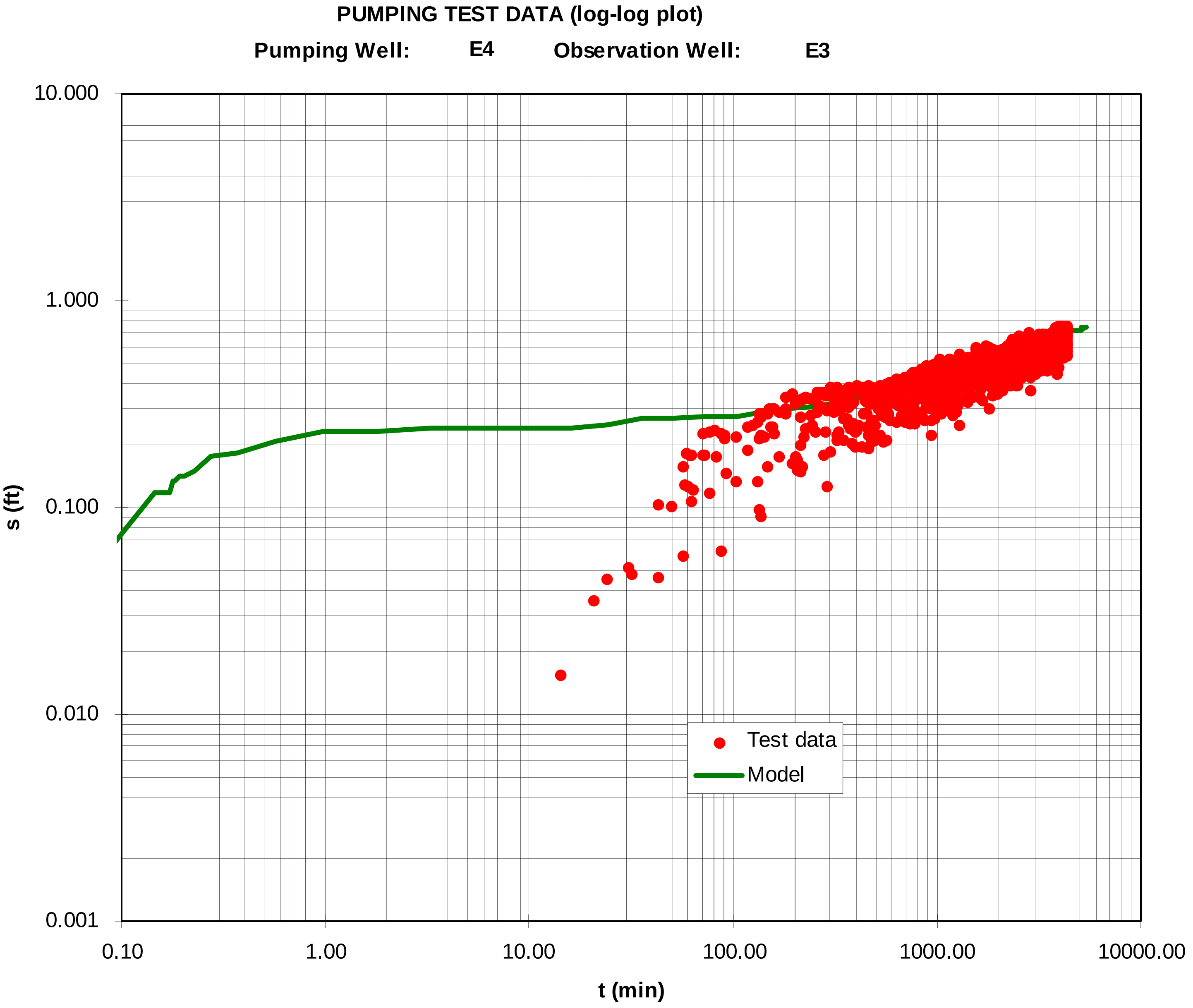

Figure 7. NUFT data fit for well E3

Appendix D – Microcosm Study

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Microbial Analysis Report

Client: Marta Richards
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Phone: (513) 569-7692

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MI Identifier: 9bat

Date Rec.: 10/30/01

Report Date: 12/18/01

Analysis Requested: PLFA

Project: Eagle Harbor

Comments:

Microbial Analysis Report

Executive Summary

The microbial communities from eighteen soil samples from a microcosm study were characterized by phospholipid fatty acid content (PLFA Analysis). Results from this analysis revealed the following:

- Generally, biomass estimates were higher in the vadose zone samples than in the saturated zone samples.

- PLFA profiles showed that there were noticeable differences between the microbial communities in the vadose and saturated zones.

- Ratios of fatty acid biomarkers that provide indication of activity showed that overall turnover rates appeared to be noticeably slower in the vadose zone samples, as compared to the saturated zone samples.

- Ratios of fatty acids biomarkers that indicate a metabolic response to environmental conditions showed that the Gram-negative bacteria in the saturated zone were showing a much greater response to environmentally induced stress conditions (i.e. toxicity, starvation) than in the vadose zone samples.

Overview of Approach:

Phospholipid Fatty Acid (PLFA) Analysis

The analysis of microbial membrane lipids, specifically phospholipid fatty acids (PLFA), is an effective tool for monitoring microbial responses to their environment. Lipids are essential cellular components of the membrane of all cells and play a role as storage materials. The PLFA profiles simultaneously contain general information about the phylogenetic identity and physiological status of microbes. The microbial membrane reflects the nature of both the intracellular components and the extracellular environmental conditions. Thus, PLFA analysis tells us what types of microbes are present in a system and how they are reacting to environmental factors (e.g., pollution or disturbance). PLFA analysis is based on the extraction and separation of lipid classes, followed by quantitative analysis using gas chromatography/mass spectrometry (GC/MS). The individual fatty acids differ in chemical composition depending on the organism and environmental conditions. PLFA analysis provides quantitative insight into three important attributes of microbial communities: viable biomass, community structure, and metabolic activity.

Procedures:

PLFA analysis

Lipids were recovered using a modified Bligh and Dyer method (3). Extractions were performed using one-phase chloroform-methanol-buffer extractant. Lipids were recovered, dissolved in chloroform, and fractionated on disposable silicic acid columns into neutral-, glyco-, and polar-lipid fractions. The polar lipid fraction was transesterified with mild alkali to recover the PLFA as methyl esters in hexane. PLFA were analyzed by gas chromatography with peak confirmation performed by electron impact mass spectrometry (GC/MS). PLFA nomenclature follows the pattern of A:BωC. The “A” position identifies the total number of carbon atoms in the fatty acid. Position B is the number of double bonds from the aliphatic (ω) end of the molecule. Position “C” designates the carbon atom from the aliphatic end before the double bond. This is followed by a “c” for *cis* or a “t” for *trans* configuration. The prefix “i” and “a” stand for *iso* and *anteiso* branching. Mid-chain branching is noted by “me,” and cyclopropyl fatty acids are designated as “cy” (4). Example: 18:1ω7c is 18 carbons long with one double bond occurring at the 7th carbon atom from the ω end, and the hydrogen molecules attached to the doubly bonded carbon molecules are in the cis conformation.

Results and Discussion:

Biomass Content

Phospholipid fatty acids are found in the membranes of all living cells but decompose quickly upon cell death because cellular enzymes hydrolyze the phosphate group within minutes to hours of cell death (3, 5). Thus, measuring the total amount of PLFA content provides a quantitative measure of the viable microbial biomass present.

Generally, biomass estimates (as determined by the total concentration of PLFA) showed that the vadose zone samples contained higher biomass levels than in the saturated zone samples. Biomass levels averaged 2,461 pmoles of PLFA/g dry wt. (±1,312) in the vadose zone as compared to 1,628 pmoles PLFA/g dry wt. (±1,004) in the saturated zone samples.

Within the saturated zone samples, biomass concentrations were at least 2 times higher in the P1-A and P1-B samples.

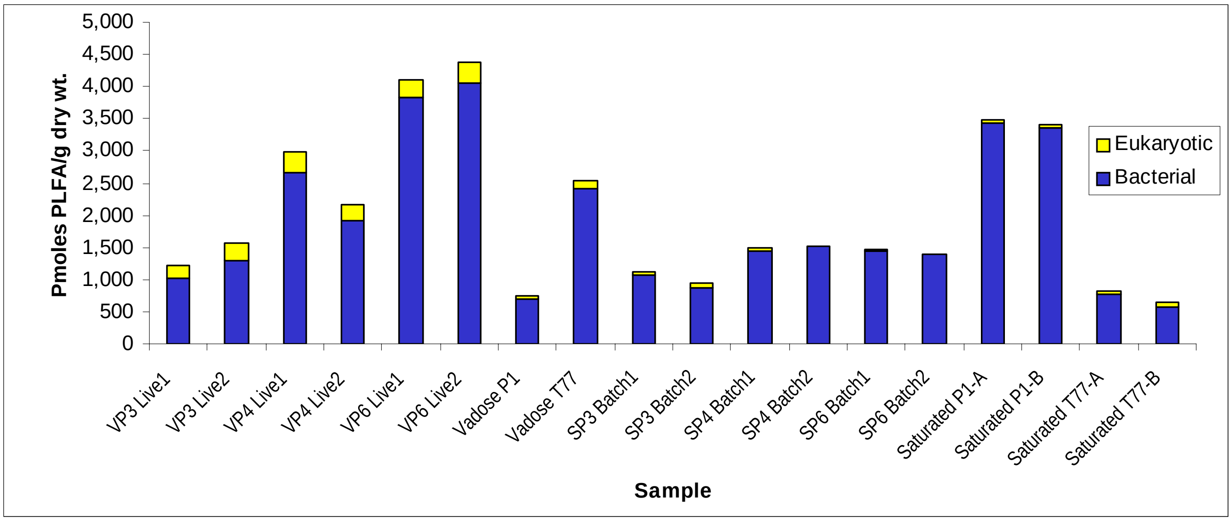

Figure 1. Biomass content is presented as the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Bacterial biomass is calculated based upon PLFA attributed specifically to bacteria, whereas eukaryotic biomass is based on PLFA associated with higher organisms.

Community Structure

The PLFA patterns derived from environmental samples provide a quantitative profile of the microbial population, which accurately mirrors differences in community composition among samples. Specific groups of microbes contain different fatty acid profiles making it possible to distinguish between them (1, 2, 4, 6). Table 1 describes the six major structural groups employed.

Table 1. Description of PLFA Structural Groups.

PLFA Structural Group	General classification
Monoenoic (Monos)	Found in Gram-negative bacteria, which can be fast growing, utilize many carbon sources, and adapt quickly to a variety of environments.
Terminally Branched Saturated (TerBrSats)	Representative of Gram-positive bacteria, but also are found in the cell membranes of some Gram-negative bacteria.
Branched Monoenoic (BrMonos)	Commonly found in the cell membranes of obligate anaerobes, such as sulfate- or iron-reducing bacteria
Mid-Chain Branched Saturated (MidBrSats)	Common in actinomycetes, sulfate-reducing bacteria, and certain Gram-positive bacteria.
Normal Saturated (Nsats)	Ubiquitous in both prokaryotic and eukaryotic organisms, though dominant fatty acids within this group will vary among organisms.
Polyenoic	Found in organisms such as fungi, protozoa, algae, higher plants, and animals.

Comparison of the PLFA profiles from these samples showed that there were noticeable differences between samples collected from the vadose and saturated zone (see Figure 2). Cluster analysis of the PLFA profiles clearly shows distinct branching for samples collected from each zone (Figure 3). Within each cluster, replicate samples from the various sampling locations (P3, P4, etc.) cluster together indicating that each replicate were similar in community composition.

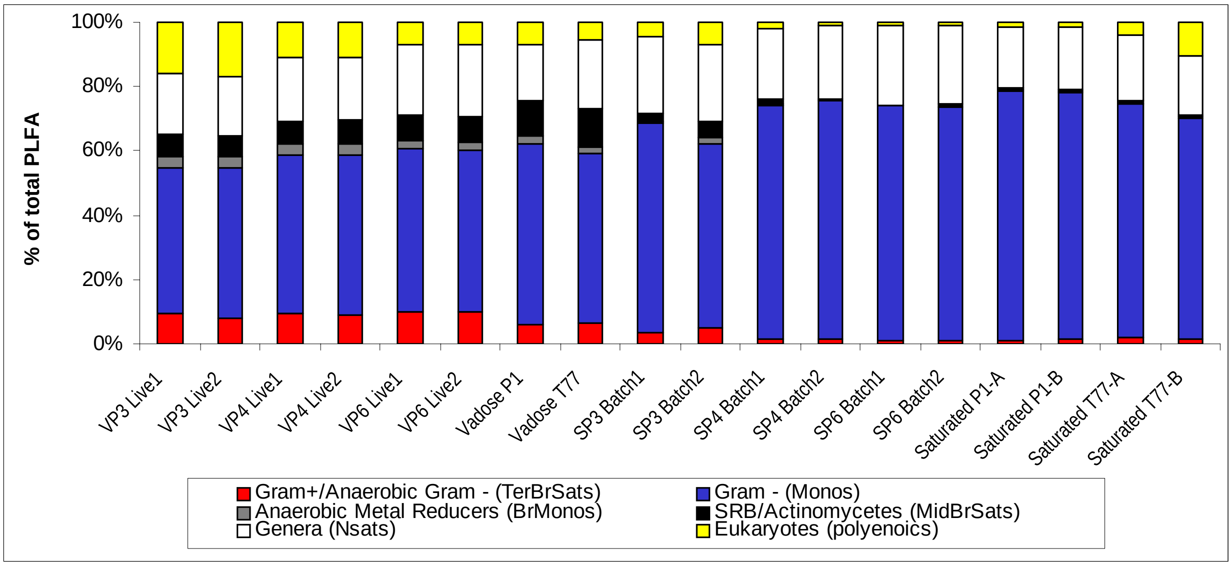

Figure 2. A comparison of the relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis. See Table 1 for detailed descriptions of structural groups.

Samples collected from both the saturated and vadose zones were primarily composed of Gram negative bacteria (indicated by percentage of monoenoic PLFA). High proportions of Gram-negative bacteria are of particular interest in contaminated ecosystems due to their ability to utilize a wide range of carbon sources and adapt quickly to environmental conditions. Proportions of Gram-negative bacteria were higher in the saturated zone samples (~71±6%) than in the vadose zone (~50±3%).

Principal components analysis (PCA) indicated that all of the vadose zone samples formed a tight cluster together indicating few differences within their microbial communities. This clustering was strongly influenced by the proportion of cy19:0, cy17:0, 18:1w9c and 10me16:0. The Gram-negative biomarkers cy17:0 and cy19:0 are produced when the turnover rates of bacteria decrease (discussed in further detail in the metabolic status section). Further insight into this trend will be evaluated after the final event, as high proportions of cyclopropyl fatty acids have also been found in certain anaerobes (members of *thiobacillus* contained unusually high proportions of cy17:0 and cy19:0). The biomarker 18:1ω9c, is a precursor for eukaryotic organisms but is also found in Gram negative bacteria. Due to its strong correlation with 18:2ω6 (prominent in fungi) it is considered to be from eukaryotic origin (correlation 0.89). The mid-chain branched biomarker 10me16:0 is common in anaerobic metal reducing bacteria (*Desulfobacter*-type) and likely indicate increased proportion of this type of bacteria in the vadose zone samples.

Saturated zone samples formed a loose cluster together, which was mainly influenced by the Gram-negative biomarkers (18:1ω7c, 16:1ω7c, 18:1ω7t, and 16:1ω7t) and the normal saturated biomarker 16:0 (found in higher proportions in bacteria). High proportions of *trans* fatty acids (18:1ω7t and 16:1ω7t) within several of the saturated zone samples are indicative of a metabolic response due to environmentally stress full conditions such as toxicity or starvation (again further details provided in the metabolic status section).

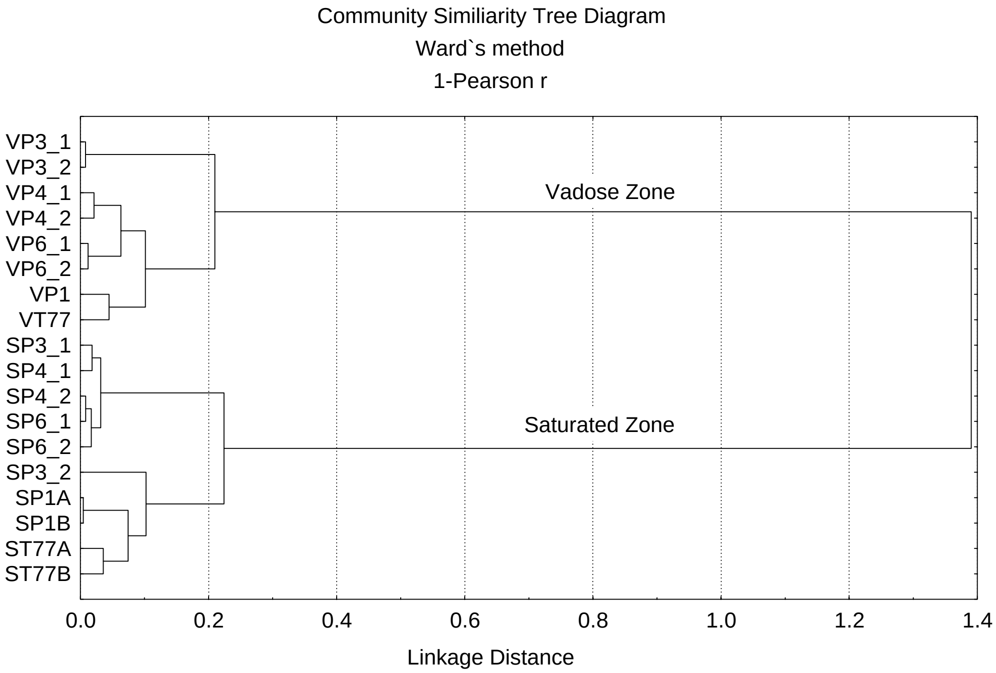

Figure 3. Hierarchical Cluster Analysis (HCA) of the PLFA profiles. Similarities between pairs of samples in a data set are calculated and compared. When distances between samples are relatively small, this implies that the samples are similar. The primary purpose of HCA is to present data in a manner that emphasizes natural groupings.

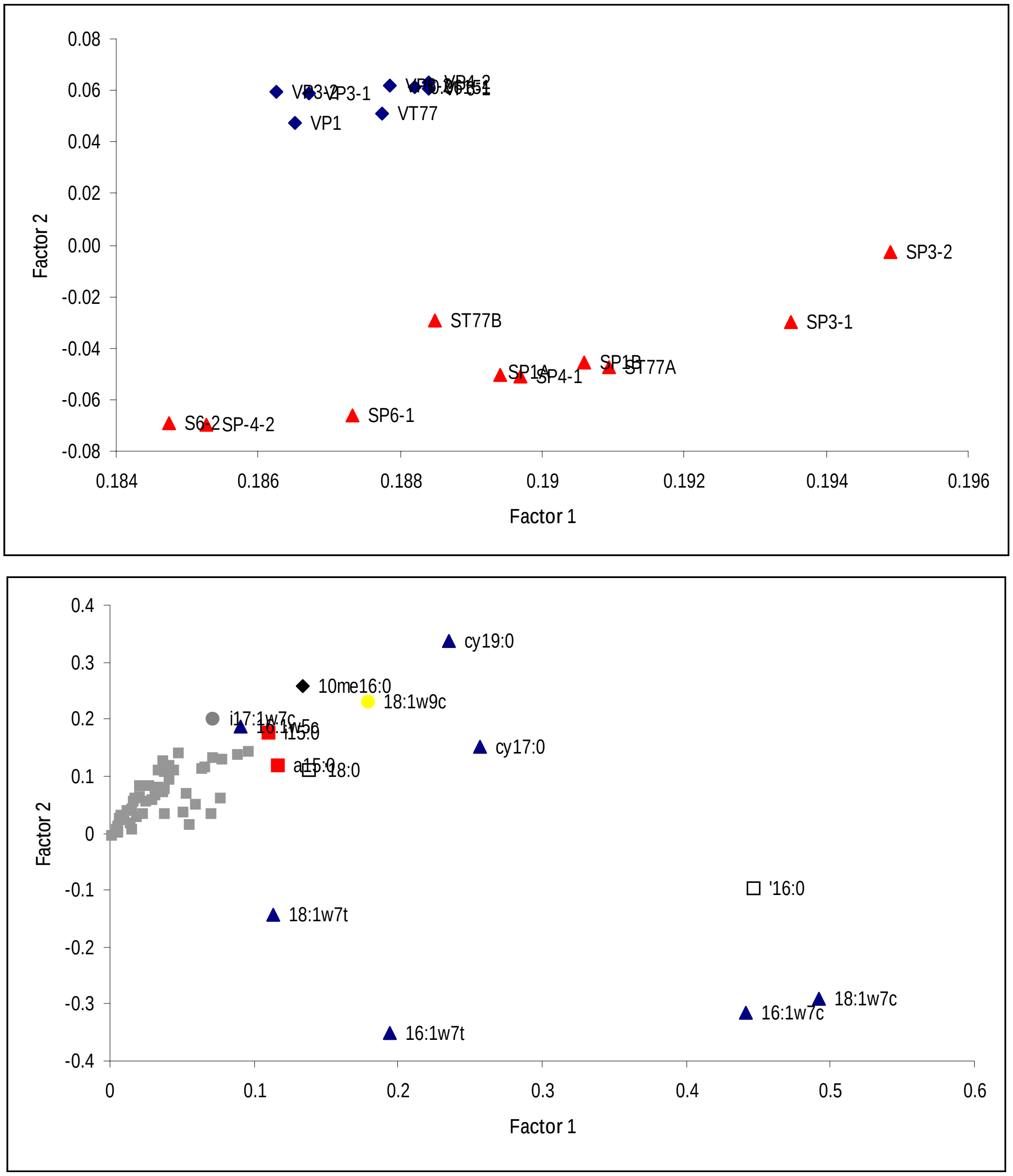

Figure 4. Principal components analysis (PCA) is built on the assumption that variation implies information in the same way that HCA is built on the assumption that short multivariate distance implies similarity. Principal components analysis projects the multivariate data (PLFA profiles) onto a reduced number of dimensions (principal components) thereby simplifying the data so relationships between sample sets can be observed easily. Thus, PCA analysis can show which microbial communities are similar by visually overlaying the top graph onto the bottom graph.

Metabolic Activity

Lipid composition of microorganisms is a product of metabolic pathways and thus reflects phenotypic responses of the organisms to their environment. Knowledge of specific lipid biosynthetic pathways can provide insight into the metabolic activity of the microbial community because certain fatty acids provide indications of turnover rate and physiological responses to environmental conditions. In Gram negative bacteria there are two main biosynthetic pathways: one that preferentially synthesize 16:1ω7c (herein referred to as Group A Gram negative bacteria) and another that preferentially synthesize 18:1ω7c (Group B). Ratios of cy/ω7c and ω7t/ω7c can be used as quantitative indicators of how a portion or all of the Gram-negative community is responding to environmental factors (toxicity, starvation, etc.) and/or engineered treatment. Specifically, Gram-negative bacteria form cyclopropyl fatty acids (f.a.) (cy17:0 & cy19:0) preferentially over monoenoic f.a. (16:1ω7c and 18:1ω7c) as the turnover rate decreases.

Ratios of cy /ω7c showed that overall turnover rates appeared to be noticeably slower in the vadose zone samples, as compared to the saturated zone samples. However, as mention previously some anaerobic bacteria contain high proportions of cyclopropyl fatty acids. Further insight into this trend will be evaluated after the final event of the microcosm study.

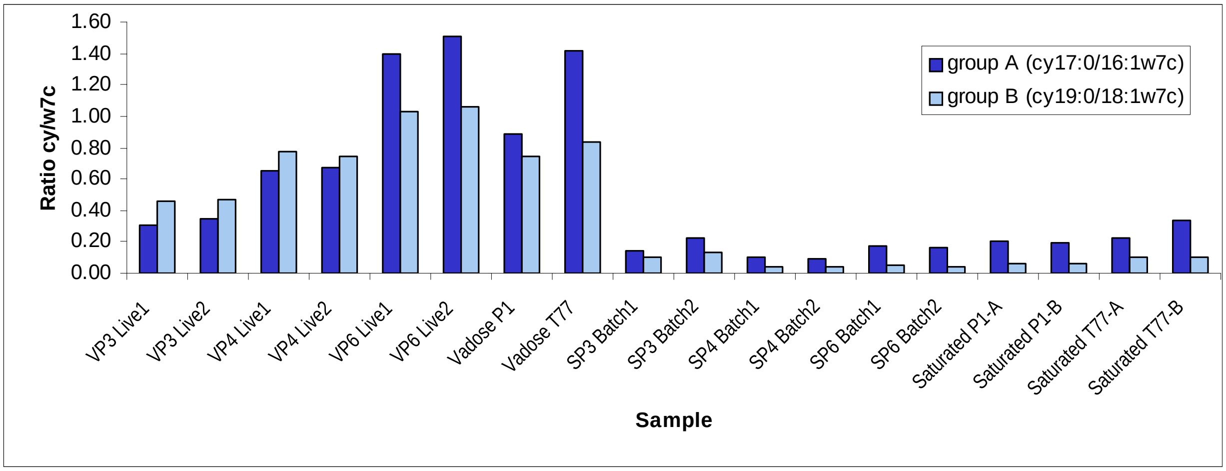

Figure 3. Growth rate of the Gram-negative community as assessed by the ratio of cyclopropyl f. a. to ω7c f. a. Specifically, 16:1ω7c and 18:1ω7c fatty acids are converted to cyclopropyl fatty acids (cy17:0 & cy19:0) as microbial growth slows (i.e., a high ratio indicates decreased turnover rate).

Gram-negative bacteria also generate *trans* fatty acids to minimize the permeability of their cellular membranes as an adaptation to less favorable environments (5). Ratios of *trans* to *cis* fatty acids were markedly higher in the saturated zone samples than calculated in the vadose zone samples. This observation suggests that the Gram-negative bacteria (particularly the Group A Gram negatives) were showing a much greater response to conditions of environmentally induced stress (i.e. toxicity, starvation) in the saturated zone samples.

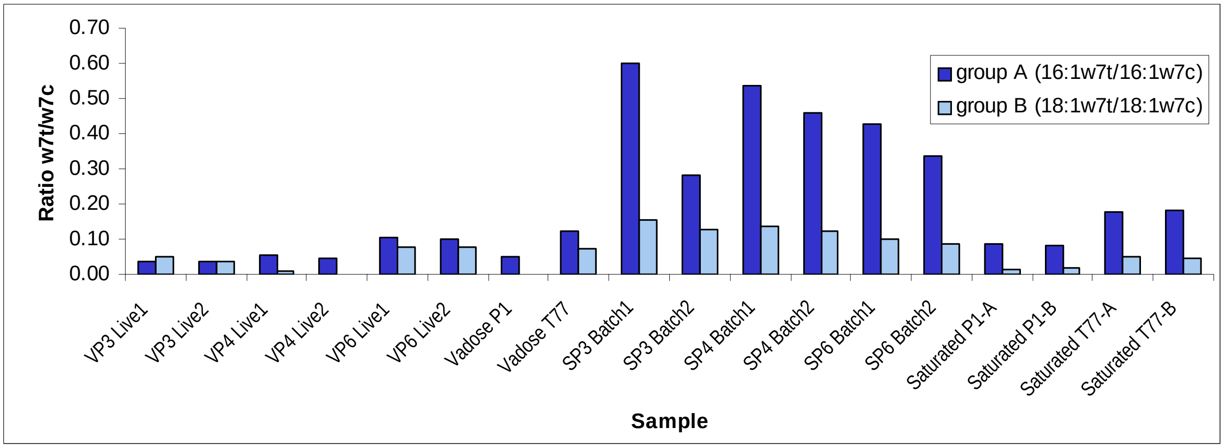

Figure 4. Adaptation of the Gram-negative community to changes in the environment is determined by the ratio of ω7t/ω7c fatty acids. Ratios (16:1ω7t/16:1ω7c and 18:1ω7t/18:1ω7c) greater than 0.1 have been shown to indicate an adaptation to a toxic or stressful environment, resulting in decreased membrane permeability.

Table 2. Summary of PLFA results.

	Biomass (pmoles PLFA/g dry wt. of sample)					Community Structure (% of total PLFA)						Metabolic Activity		Physiological Response	
Sample Name	Total Biomass	Cell equivalent value[1]	Bacterial biomass	Eukaryotic biomass	Ratio bacteria/ eukarya	Gram+/ anaerobic Gram - (TerBrSats)	Gram - (Monos)	Anaerobic metal reducers (BrMonos)	SRB/ Actinomycetes (MidBrSats)	Genera (Nsats)	Eukaryotes (polyenoics)	Group A Gram – (cy17:0/16:1ω7c)	Group B Gram – (cy19:0/18:1w7c)	Group A Gram – (16:1ω7t/16:1ω7c)	Group B Gram – (18:1ω7t/18:1ω7c)
VP3 Live1	1,212	2.42E+07	1,017	195	5	9.3	45.6	3.5	6.9	18.5	16.1	0.31	0.46	0.03	0.05
VP3 Live2	1,572	3.14E+07	1,303	269	5	8.2	46.6	3.4	6.8	18.0	17.1	0.34	0.47	0.04	0.04
VP4 Live1	2,986	5.97E+07	2,665	321	8	9.7	49.1	3.2	7.4	19.9	10.8	0.66	0.78	0.05	0.01
VP4 Live2	2,155	4.31E+07	1,923	233	8	9.0	49.7	3.3	7.6	19.7	10.8	0.67	0.74	0.05	0.00
VP6 Live1	4,110	8.22E+07	3,824	286	13	10.2	50.5	2.5	8.1	21.7	7.0	1.39	1.03	0.10	0.08
VP6 Live2	4,370	8.74E+07	4,059	310	13	10.1	50.1	2.7	7.8	22.2	7.1	1.51	1.06	0.10	0.08
Vadose P1	739	1.48E+07	685	53	13	6.1	56.2	2.5	10.7	17.2	7.2	0.88	0.75	0.05	0.00
Vadose T77	2,547	5.09E+07	2,411	137	18	6.2	52.9	1.8	12.1	21.6	5.4	1.41	0.84	0.12	0.07
SP3 Batch1	1,130	2.26E+07	1,077	53	20	3.7	64.8	0.6	2.6	23.5	4.7	0.14	0.10	0.60	0.15
SP3 Batch2	943	1.89E+07	876	68	13	5.2	57.2	2.0	4.7	23.8	7.2	0.22	0.13	0.28	0.13
SP4 Batch1	1,481	2.96E+07	1,448	33	44	1.6	72.5	0.5	1.7	21.5	2.2	0.10	0.04	0.54	0.14
SP4 Batch2	1,529	3.06E+07	1,512	17	90	1.4	74.2	0.0	0.4	22.9	1.1	0.10	0.04	0.46	0.12
SP6 Batch1	1,468	2.94E+07	1,450	17	83	1.2	72.7	0.0	0.2	24.6	1.2	0.18	0.05	0.43	0.10
SP6 Batch2	1,394	2.79E+07	1,382	11	122	1.2	72.7	0.0	0.7	24.6	0.8	0.16	0.04	0.34	0.09
Saturated P1-A	3,479	6.96E+07	3,435	44	78	1.2	77.5	0.3	0.7	19.0	1.3	0.20	0.06	0.09	0.02
Saturated P1-B	3,412	6.82E+07	3,361	52	65	1.6	76.5	0.6	0.7	19.2	1.5	0.20	0.06	0.08	0.02
Saturated T77-A	814	1.63E+07	783	31	26	2.0	72.9	0.0	0.5	20.8	3.8	0.22	0.10	0.18	0.05
Saturated T77-B	635	1.27E+07	569	66	9	1.4	68.7	0.4	0.5	18.6	10.4	0.34	0.10	0.18	0.05

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[1] The cell equivalent value is calculated from experiments with typical bacteria isolated from soil and water. This value is based on 2.0 x 10^{12} cells per gram dry weight of cells and 10^{8} picomoles of phospholipid/gram dry weight of cells. The number of cells/gram of dry weight may vary and is dependent on the environmental conditions from which the microorganisms were recovered.

Quality Assurance Section

Sample Arrival and Holding Times:

Eighteen samples were received between 10/30/01 and , accompanied by a chain of custody form. All arrival conditions and required holding times were acceptable according to SOP #SREC.

Sample Analysis and QA/QC Parameters:

Samples were analyzed under the U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures.

Notes: No QC or analytical problems were encountered.

Calibrations and Solvent Checks:

All laboratory equipment and instruments used throughout the analyses were calibrated and operated within acceptable ranges. The instruments were calibrated according to Standard Operating Procedures (EQ4). All solvents used in these analyses were tested for purity.

Data Validation:

All data analyses were performed correctly. All calculations and transcriptions of raw and final data were verified.

References:

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Appendix E – Instrumentation Design and Construction

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Appendix E - Instrumentation Design and Construction

E.1.0 Subsurface Monitoring Design

E.1.1 Temperature Monitoring

The USACE decided to operate two different subsurface temperature-monitoring systems at the Wyckoff site. One was composed of a series of thermocouples; the other was a DTS system using fiber optic technology. This decision was based on the fact that since the Wyckoff project was a pilot test site, it would be a good idea to test a promising new technology, DTS. The DTS fiber optic lines were installed in 18 wells total (seven in extraction wells and 11 in instrumentation (Geoprobe) borings), primarily in the SE and SW corners of the project. Both DTS and thermocouples were installed in instrumentation boring T7, located on the north side of the project, just inside the sheet pile wall, so that values of the two systems could be directly compared. See Figure 6.2-2 for well locations and Table E1.1-1 for a complete list of instrument types and numbers in each well or boring.

DTS. The DTS purchased was from Sensa, Inc. (Sensa), of Bakersfield, California. Sensa began installing the DTS in about 1998 in oil wells to monitor temperatures during steam injection and oil recovery operations. The Wyckoff site was their first experience installing the DTS equipment at a Superfund site. The DTS is measured by sending a pulse of laser light down the fiber optic line. Molecular vibration, which is directly related to temperature, creates weak reflected signals that are detected in an opto-electronic surface readout unit (controller) and converted to values of temperature at one meter intervals along the fiber. The system components include a ¼” OD stainless steel control line, ¼” flexible fiber optic line, controller, and a portable computer running the operating software. Specially coated optical fiber is pumped into the control line. The controller is capable of monitoring six control lines simultaneously. Two controls lines were used on the site, each line strapped to the electrical supports under the steam lines and branching off along the ground surface and installed in nine wells or borings. The control lines were connected to the flexible fiber leads in a junction box in the vicinity of extraction well E5. These flexible leads then ran to the north end of the instrumentation trailer where the controller was located. The leads ran underground between borings T73 and T78 to allow for the passage of vehicles into the site.

Thermocouples. The thermocouples used for the subsurface monitoring of temperatures were type E. Type K would have been acceptable, but type E was selected because it produces a higher voltage per degree output (better resolution) and is more repeatable in thermal cycling over the temperature range. The two metals used in type E are Constantan and Chromel. The other two standard types, J and T, were not considered because they use iron and copper conductors respectively and are thus more susceptible to corrosion. There was some evidence that at other monitoring projects thermocouples had a high rate of failure. For this reason, care was taken in selecting the appropriate insulation material for the thermocouples. The typical insulation used in thermocouple construction is Magnesium Oxide (MgO). MgO is hydroscopic (absorbent), therefore not an ideal insulation material to use in subsurface installations. The insulation used in the construction of the Wyckoff thermocouples was Teflon, with Teflon jacketing, and a stainless steel overbraid to protect the leads from physical damage. They were purchased from Conax Buffalo Technologies.

E.1.2 Pressure Monitoring

The transducer selected for monitoring subsurface pressures was a vibrating wire transducer manufactured by Geokon, model number 4500ALX-25X. This is the only subsurface transducer that could be found to stand up to the high temperatures. Absolute pressures were read (corrected for water temperature), then corrected for standard barometric pressure to arrive at an approximate pressure or water level depth.

E.2.0 Above Ground Monitoring Design

E.2.1 Pump Stroke Counters

The pump stroke counters supplied by the contractor were analog stroke counters which also provided a contact closure output, capable of being read by the Geomation 3300 ADAS.

E.2.2 Vapor Extraction Flows at E4

The contractor supplied a 4-20mA output differential flow meter to monitor the vapor extraction flow rate from E4, capable of being read by the Geomation 3300 ADAS. This flow meter was not installed until after operations began. It was activated on December 27, 2002, but never monitored because the vapor extraction system was not operational.

E.2.3 Total Organic Carbon of Extracted Liquid

A TOC instrument was purchased by the USACE to monitor and measure the contaminant concentration in the extraction liquid flow stream. This instrument also provided a 4-20mA output and was read by the Geomation 3300 ADAS.

E.3.0 Automation Systems Design

The ADAS that was selected is the Geomation System 3300 manufactured by Geomation, Inc. of Golden, Colorado. The system was selected because of its capability of reading all of the instrument types at the project in all weather conditions, and that it had built-in transient (lightning) protection. The system is a secure supervisory and data acquisition (SCADA) system which is a computer system designed to gather and analyze real-time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining, and transportation. A SCADA system is centrally driven, meaning that all data requests are initiated from a central computer.

The hardware components of the System 3300 include remote terminal units (RTUs), input/ouput (IO) module assemblies, and a PC running the SCADA software. At the Wyckoff site six RTUs were used, five attached on the steam line supports in various locations monitoring all the field instruments and one in the boiler room monitoring readings from the TOC instrument. The RTUs ran off alternating current (AC) power distributed along the steam line and were connected by wireline to a PC located in the instrumentation trailer adjacent to the DTS PC. The appropriate number of modules were housed in a rainproof enclosure mounted on a 4”x4” wooden post adjacent to each well or boring. The module is the device that contains the electronics to read each type of instrument. Four types of modules were used; thermocouple, 4-20mA, pulse counter, and vibrating wire. As many as two thermocouples could be attached to each thermocouple module, one 4-20mA transmitter to each 4-20mA module, two stroke counters to each pulse counter module, and one vibrating wire instrument with thermistor to each vibrating wire module. A single cable carrying power and communications was run from each RTU to a number of module enclosures. The all-weather cable was laid on the surface of the gravel pad.

The SCADA software used to run the Geomation 3300 ADAS was Intellution iFix. Intellution iFix is an operating software normally used for data acquisition, process visualization, and supervisory control of plant operations (wastewater, manufacturing, utilities, etc). The driver used to communicate with the Geomation 3300 system was Modbus. The iFix software is extremely powerful and therefore complex. It was overkill for this application but was recommended by Geomation as the appropriate software to run the 3300 system.

E.4.0 Data Management Processes

A data management and review process was designed for the Wyckoff project. The goal of the process was to make all data available in plot format on a commercial web site so that all parties concerned (USACE, USEPA, contractor, and consultants) could review the data on a daily basis and use the data to make decisions on the operation of the system. The following tasks had to be accomplished to meet this goal.

1. Convert the DTS data stored in bin files and load into a master database
2. Query the Geomation data stored in an iFix database and load it into the master database with the DTS data
3. Query the master database on a daily basis to create a series of ASCII files used for plotting and for loading into a GMS package
4. Create temperature sections and slices of the pilot site with the GMS software
5. Plot data time history and temperature profile data
6. Store the plotted data on the commercial web site
7. Store the contractor's plots and data on the commercial web site
8. Incorporate a review and comment procedure (message board) accessed via a link on the web site
9. Automate the procedure as much as possible to keep labor to less than one hour per day

Items one through three were accomplished with a single visual basic program which ran automatically via Windows scheduler. Grapher form Golden Software was used to create the time history and profile plots. This process was also automated so that the numerous plots could be created in just a couple of minutes. All data plots were transferred to the extranet web via ftp protocol. The message board was called Simple Message Board and was hosted on the same commercial web site at no additional cost.

E.5.0 Instrumentation Construction

E.5.1 Thermocouples and Pressure Transducers

The thermocouples and pressure transducers were attached to a 3/8 in diameter fiberglass rod and strapped to injection and extraction wells using fiberglass channels as spacers to keep the instruments separated from the stainless steel casing screen.

The initial seven vibrating wire pressure transducers installed in the instrumentation borings were grouted in the formation using silica fume grout. Grouting in vibrating wire piezometers has been a favored method used by various installers for many years and has proven to work very well. The piezometers grouted in with the silica flour grout, however, did not function properly. This was attributed to either intrusion of the grout through the porous filter stone, locking the diaphragm in place or the grout was too tight to allow for the transfer of pressure to the sensor.

Nine additional transducers were therefore installed to replace the failed instruments. Five were located adjacent to the original piezometer borings inside the steam line loop, since they were easily accessible. The four outside the loop were not replaced due to access difficulties; instead an additional three were installed inside the loop in various locations to improve the understanding of groundwater pressures in the E4 quadrant and one was installed near instrumentation string T46 to provide better up-gradient data on the east side of the pilot test area. The new transducers were installed with a sand filter around the sensor then grouted up with the silica flour grout.

E.5.2 DTS

The installation of the DTS was conducted in two phases. The first phase was the installation of the ¼ in stainless steel tubing in each of the wells or borings. The tubing was delivered to the site in pre-designated lengths, uncoiled and strapped to 3/8 in diameter fiberglass rods. The fiberglass rods helped to keep the tubing straight and allowed for easier transport around the site. The rods were then strapped to the extraction well casing, using fiberglass channel spacers to keep the tubing separated from the stainless steel casing. A representative from Sensa was on site during the drilling of the first two extraction wells to assist with the installation. The tubing was also installed in eleven instrumentation borings drilled with a Geoprobe rig. The tubing strapped to the fiberglass rods was installed inside the drill casing, once a final depth had been achieved, and the boring was then grouted up.

The second phase of the installation was completed by two Sensa personnel after all subsurface tubing had been installed. In this phase the Sensa personnel made ¼ in stainless steel tubing surface connections to all 18 wells, pumped fiber into each of the two control lines, installed the splice enclosure, spliced the tubing to the flexible fiber cable, installed the controller and portable computer (pc) in the instrumentation trailer, connected the flexible fiber to the controller and the controller to the pc, and programmed the operating software on the pc. This installation phase took one week.

E.5.3 Geomation 3300 ADAS

The Geomation hardware was installed in six man-weeks by in-house labor. A representative from Geomation was on site for one week to assist with the software programming. The communication cable from the RTUs to the PC was run underground alongside the flexible DTS fiber optic cable between instrumentation borings T73 and T78.

E.5.4 USACE Involvement

- Subsurface and automated instrumentation. USACE designed, procured, installed, and operated the instrumentation system with assistance from Sensa (two weeks) for the installation of the DTS and from Geomation (one week) for assistance in programming the iFix software. The monitoring system was operational at the start of the pilot test.

E.6.0 Recommendations for Future Projects

E.6.1 Automated Monitoring System

- Geomation Operating Software (Intellution Fix). Due to the complexity of the iFix software, it is recommended that simpler options be considered on future projects. Geomation currently has one additional possibility on the market and is developing an easier interface software package that should be available for purchase in the summer of 2004. Neither of these options was available at the time of purchase of the equipment for this project.
- Power Outages. The Geomation RTUs were AC powered and plugged into an adjacent GFI receptacle. The GFI would occasionally trip due to moisture intrusion. It would therefore be advantageous to have battery backup at the RTUs for future similar installations. A rechargeable battery is a standard option supplied by Geomation.
- DTS Operating System. Communication between the controller and the PC would occasionally lock up, requiring someone to close and restart the software and/or reboot the controller. The graphics on the pc monitor would also occasionally not display properly. The display problem was solved by reconfiguring the video mode selection for pcAnywhere to compatibility mode. The communication problem was never solved even after swapping out the laptop twice. This problem appeared to be related to the Windows 98 operating system. The DTS operating software has now been upgraded to run under Windows 2000/XP, but has not been tested by Seattle District personnel.

Additionally, by comparing the temperature in instrumentation boring T7 it was noted that temperatures read by the DTS were about three °C higher than the temperatures read by the thermocouples. To verify this manual temperatures were taken with a portable probe in extraction well E-5 before it was sealed. The readings verified the 3 °C offset. Sensa explained that the calibration of the system could be modified to correct this, but it was never done. The offset was constant and independent of temperature so it was easy to correct for.

- DTS versus Thermocouples (Geomation 3300). The DTS worked very well except for the communication problem discussed above. Assuming this problem is solved with upgraded software, DTS is an excellent option for monitoring temperatures in future projects. The thermocouples and Geomation 3300 system also worked very well. Although the installation was more complex, it functioned almost perfectly. A few thermocouple modules failed (6-10) but were easily repaired or replaced. The main advantage of the system is that it is also capable of reading other types of instruments (i.e., 4-20mA, pulse counters, vibrating wire). Geomation 3300 systems also have the capability of communicating via radio to meet more complex site requirements. A combination of the two systems would be an ideal solution for future projects; DTS to monitor temperatures and Geomation 3300 to monitor everything else.
- Silica Grout. The ITTAP panel recommended that silica flour grout be used in areas where steam would be injected. Some of the pressure transducers (7) failed when installed with silica grout. The use of standard grout or a sand filter should be investigated to see if either are acceptable alternatives.
- Pump Stroke Counters. The pump stroke counters on the extraction wells manufactured by Severn Trent did not function properly. Both the rotating dial and the digital output failed routinely.

E.6.2 Data Management

- Automated data collection. This part of the project worked extremely well. Little lag time was noticed for those monitoring systems where data were generated automatically and managed by the USACE. Generally the daily process was completed in about an hour. The most time consuming task was the creation of the sections and slices in GMS.
- Non-automated data collection. There was a lag time between data collection and posting to the web page. Data such as steam injection rates and well pumping rates were not transferred to the webpage fast enough for daily decision making, therefore, the data were compiled every morning and reported verbally to the team during the daily operations call. When data became available, it was posted, making the webpage more effective as an accessible data archive, but less effective as a real-time source of data. The manual nature of this data gathering

was inefficient and costly. Better data collection tools need to be designed for this part of the project.

- Web page. Having data and communications logs posted to the project web page was an effective method for team communication.

Table E 1.1-1 Instrument Types and Numbers in Each Well or Boring

Well	Thermocouples	DTS	Pressure Transducer
I-1	3		
I-2	3		
I-3	3		
I-4	3		
I-5	3		
I-6	3		
I-7	3		
I-8	3		
I-9	3		
I-10	3		
I-11	3		
I-12	3		
I-13	3		
I-14	3		
I-15	3		
I-16	3		
E-1		11	1
E-2		12	1
E-3		10	1
E-4		11	1
E-5		10	1
E-6		13	1
E-7		9	1
T-1	8		
T-2	8		
T-3	10		
T-4	8		
T-5	8		
T-6	8		
T-7	9	11	
T-8	9		
T-9	9		
T-10	9		
T-11	8		
T-12	8		1*
T-13	9		
T-14	7		1*
T-15		8	
T-16		8	
T-17		8	
T-18	7		
T-19	7		
T-20	7		
T-21		8	
T-22	7		1*
T-23	7		

Well	Thermocouples	DTS	Pressure Transducer
T-24	7		
T-25	8		1*
T-26	8		
T-27	8		1*
T-28	8		
T-29	8		1*
T-30	8		
T-31	8		
T-35	8		
T-36	8		
T-37	7		
T-38	8		
T-39	8		
T-40	8		1*
T-41	7		
T-42	7		
T-43		9	
T-44		9	
T-45	7		
T-46	7		1*
T-47		9	
T-48	8		
T-49	9		
T-50	9		
T-51b	9		
T-52	8		
T-53	8		
T-55	7		
T-56		7	
T-57		8	
T-58		7	
T-63	7		1*
T-72	7		
T-73	7		
T-74	7		
T-75	7		
T-76	8		
T-77	8		
T-78	2		
T-79	2		
T-80	2		
T-81	9		

* Vibrating wire replacement pressure transducer located in Geoprobe boring adjacent to original boring.

Appendix F – Operations Logs (CD ROM Only)

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Operations Team Meeting Minutes 29 October 2002

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 office) Ginny Dierich – USACE PM – Acting (District office) Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site)

Construction Update: Treatment plant plumbing work to correct flow restrictions is completed and appears to be working. In addition, the new HDPE effluent line between the boiler building and the treatment plant is complete and on-line. Issues that still need to be wrapped up prior to full operation include the TOC instrument drain, installation of temperature and pH instruments on tank T-402 and installation of the sump pump in the floor drain vault. The TOC drain and T-402 instrumentation should be completed this week.

Treatment Plant Operations: The treatment plant is operating normally. The operators are continuing to optimize operations of the new DAF. This includes testing the new plumbing between T-108 and the DAF to determine the actual maximum flows that can be achieved through the system. Initial trails indicated that an operation capacity of 70 gpm can be achieved without causing back-ups into T-108. Testing will continue at increasing flow regimes until the operational capacity of the plant is determined.

Boiler Room Operations: Construction is substantially complete with only minor work continuing. Training for the boiler operators should conclude by the end of this week.

Thermal Monitoring/Subsurface Conditions: The DTS monitoring system continues to have software problems. Steve Meyerholtz has been in contact with the vendor to obtain technical assistance in troubleshooting the problem. Heating of the subsurface continues, particular in the area around E-7. Instrument string T-55 indicated elevated temperatures (approx. 20 degrees C) moving from I-11 toward E-7.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete. Travis has directed SCS to begin monitoring process data including extraction rates from the Pilot Area, fuel consumption, injection pressures and other physical parameters. The goal is to attempt a data transfer between SCS and the Corps this week and to fine-tune the data management and transfer systems.

Operational Issues: Given the apparent movement of heat toward E-7, Travis suggested that injection at I-11 be reduced to avoid extracting heated fluids during the continued training and commissioning period. The goal of continued operations this week will be to operate the boiler and conveyance systems to allow training but not to begin extraction of heated fluids until all of the required Management and Health and Safety plans are completed and provisionally approved.

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Operations Team Meeting Minutes 30 October 2002

Attendees:

Ginny Dierich – USACE PM – Acting (District office) Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site)

Construction Update: Treatment plant plumbing work to correct flow restrictions hasn't completely resolved the flow problems associated with the DAF. While the situation is improved, it is still possible to overflow T-108 at high flow levels. The design branch engineers have been providing assistance in obtaining a final fix for this problem.

Treatment Plant Operations: The treatment plant is operating normally. The operators are continuing to optimize operations of the new DAF. This includes testing the new plumbing between T-108 and the DAF to determine the actual maximum flows that can be achieved through the system. As mentioned above, it is still possible for the operators to overflow T-108 under certain conditions that may occur during thermal operations. The operators have been directed to carefully monitor the flow in and out of T-108 under different flow regimes in order to provide more information to the design engineers.

Boiler Room Operations: Construction is substantially complete with only minor work continuing. Training for the boiler operators should conclude by the end of this week.

Thermal Monitoring/Subsurface Conditions: The DTS monitoring system continues to have software problems. Steve Meyerholtz has been in contact with the vendor to obtain technical assistance in troubleshooting the problem. Mike will request that Lawrence Lin add a thread topic to the message board to provide a posting site for data quality issues to be posted and documented. The temporary loss of the DTS system last night has impacted the data presentation posted to the web site resulting in a larger heat signature in today's plots than actually exists. Consequently, the message board should be checked prior to looking at the heat plots to learn of any data qualifications.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete.

Operational Issues: The continued goal of operations this week will be to operate the boiler and conveyance systems to allow training but not to begin extraction of heated fluids until all of the required Management and Health and Safety plans are completed and provisionally approved.

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Operations Team Meeting Minutes 31 October 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10 office) Travis Shaw – USACE Site Manager (District office) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site) Construction Update: Treatment plant plumbing work to correct flow restrictions hasn't completely resolved the flow problems associated with the DAF. While the situation is improved, it is still possible to overflow T-108 at high flow levels. The design branch engineers have been providing assistance in obtaining a final fix for this problem. Treatment Plant Operations: The treatment plant is operating normally. The operators are continuing to optimize operations of the new DAF. This includes testing the new plumbing between T-108 and the DAF to determine the actual maximum flows that can be achieved through the system. As mentioned above, it is still possible for the operators to overflow T-108 under certain conditions that may occur during thermal operations. The operators have been directed to carefully monitor the flow in and out of T-108 under different flow regimes in order to provide more information to the design engineers. Boiler Room Operations: Construction is substantially complete with only minor work continuing. Training for the boiler operators should conclude by the end of this week. Overnight, the feed water pumps to the boiler tripped off. Evaluation of the problem this morning by the electrician revealed variable amperage from the transformer. The electrician has theorized that the cold weather has increased demand in the surrounding community and is creating an unstable supply from the power company. Travis contacted PSE and requested that the new transformer be re-balanced to stabilize the power supply to the site.

Thermal Monitoring/Subsurface Conditions: Heating continues across the well field with injection well I-11 shut down to prevent excessive heating in the vicinity of E-7. This strategy appears to be reducing the heat plume towards E-7 that was observed earlier in the week and will be continued. Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete. Operational Issues: The continued goal of operations this week will be to operate the boiler and conveyance systems to allow training but not to begin extraction of heated fluids until all of the required Management and Health and Safety plans are completed and provisionally approved.

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Operations Team Meeting Minutes 1 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Ginny Dierich – USACE PM – Acting (District office); Travis Shaw – USACE Site Manager (On-site); Brenda Bachman – USACE Monitoring Coordinator (District office); Mike Bailey – USACE Hydrogeologist (District office); Cliff Leeper – SCS Engineers (On-site)

Construction Update: Treatment plant plumbing work to correct flow restrictions hasn't completely resolved the flow problems associated with the DAF. While the situation is improved, it is still possible to overflow T-108 at high flow levels. The latest test rums indicated that the system can be run at a liquid flow rate of 85 gpm with 6.5 gpm flowing from the DAF to T-108. The 6.5 gpm is lower than the flow rate usually used to clear product from the old depurator and we do not know what flow rate may be required once significant product is recovered from the Pilot Area. Other significant construction issues currently being addressed include: a. Drain line for the TOC instrument. b. Connection of the non-contact cooling water line to the GWTP outfall line.

Treatment Plant Operations: The treatment plant is operating normally. The operators are continuing to optimize operations of the new DAF. This includes testing the new plumbing between T-108 and the DAF to determine the actual maximum flows that can be achieved through the system as discussed above. Boiler Room Operations: Construction is substantially complete with only minor work continuing. Training for the boiler operators should conclude by the end of this week. Once again, the feed water pumps tripped off early this morning. PSE is going to install a recorder on the transformer today to verify that unstable voltage from the power supply is contributing to this problem.

Thermal Monitoring/Subsurface Conditions: Heating continues across the well field with injection well I-11 shut down to prevent excessive heating in the vicinity of E-7. This strategy appears to be reducing the heat plume towards E-7 that was observed earlier in the week and will be continued. Mike reported elevated temperatures in the vadose zone at T-21 (between I-11 and I-12), which is not full expected but does not impact current operations during training and commissioning.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete. Operational Issues: The continued goal of operations this week will be to operate the boiler and conveyance systems to allow training but not to begin extraction of heated fluids until all of the required Management and Health and Safety plans are completed and provisionally approved.

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Operations Team Meeting Minutes 4 November 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10 office) Ginny Dierich – USACE PM – Acting (District office) Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete with the exception the boiler chemical feed system and treatment plant acid/caustic chemical feed system. The boiler chemical feed system is experiencing problems associated with a malfunctioning feed pump. The boiler vendor (Proctor Sales) is concerned about releasing the boiler until the feed system pump is working properly. Consequently, Proctor Sales will provide a boiler operator at no cost to the government to monitor the system during operations until the pump is repaired or replaced. The treatment plant acid/caustic feed system was repaired after incorrect initial installation by the sub-contractor. The repaired system needs to undergo final commissioning and training, however, since the system's purpose is to break emulsions which are not anticipated to develop until hot fluids are extracted, the delay in completion will not impact system operations in the short term. Treatment Plant Operations: The treatment plant is operating normally. The operators are continuing to optimize operations of the new DAF. This includes testing the new plumbing between T-108 and the DAF to determine the actual maximum flows that can be achieved through the system. The design engineers are planning to visit the site today to evaluate this part of the system and formulate a solution to the apparent flow restrictions.

Boiler Room Operations: Construction is substantially complete with only minor work continuing and training is complete (with the exception of the boiler chemical feed system discussed above). Once again, the feed water pumps tripped off early this morning. PSE is did install a recorder on the transformer last week to determine whether unstable voltage from the power supply is contributing to this problem.

Thermal Monitoring/Subsurface Conditions: Mike reported elevated temperatures in the vadose zone at T-21 (between I-11 and I-12), which is not full expected but does not impact current operations during training and commissioning.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete.

Operational Issues: The continued goal of operations this week will be to operate the fluid extraction system pending review of the revised Health and Safety Plan. If provisional approval is granted, the goal will be to initiate full thermal operations by the middle of the week. In the meantime, the O&M staff will do a final check of the data collection and data management systems.

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SiteOpLog: Ops Meeting Minutes - 5 Nov.

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Operations Team Meeting Minutes 5 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office) Ginny Dierich – USACE PM – Acting (District office) Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site) Construction Update: The new systems are substantially complete with the exception of the boiler chemical feed system and treatment plant acid/caustic chemical feed system. Drainage for the TOC instrument, DAF flow problems and the non-contact water connection to the outfall are still awaiting engineering support.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete with only minor work and training to finish this week.

Thermal Monitoring/Subsurface Conditions: Heating continues across the well field with injection well I-11 shut down to prevent excessive heating in the vicinity of E-7. Brenda noticed an apparent lack of heat propagation in the vicinity of I-6 and I-13. Cliff will verify pressure settings at the wellheads.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete. Operational Issues: The continued goal of operations this week will be to operate the fluid extraction system pending review of the revised Health and Safety Plan. If provisional approval is granted, the goal will be to initiate full thermal operations by the middle of the week.

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Operations Team Meeting Minutes 6 November 2002 Attendees: Ginny Dierich – USACE PM – Acting (District office) Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site) Joe Harrington (SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. The chemical feed system is undergoing repair today with training scheduled for tomorrow. The equipment required to finish installation of the TOC instrument arrived on site and will be installed by tomorrow. Treatment Plant Operations: The treatment plant is operating normally. Boiler Room Operations: Construction is substantially complete with only minor work and training to finish this week.

Thermal Monitoring/Subsurface Conditions: Heating continues across the well field with injection well I-11 shut down to prevent excessive heating in the vicinity of E-7. Vadose zone heating in the vicinity T-21 continues. Mike questioned the pressure readings in well E-7 and will follow-up with Steve Meyerholtz to determine if the apparent drawdown in the well may be instrument related.

Contaminant Recovery: Data will not be available until system commissioning and plan approval is complete. Operational Issues: The required Management and Safety Plans have been received and meet the basic requirements of the specifications. Unless any unanticipated issues arise today, 24-hour operation of the boiler will begin with initial injections pressures set at approximately 0.5 psi/foot of overburden. Liquid extraction rates will be maintained at 1 gpm in each extraction well to maintain the current liquid level in the Pilot Area.

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Operations Team Meeting Minutes 7 November 2002

Attendees:

Travis Shaw – USACE Site Manager (On-site) Brenda Bachman – USACE Monitoring Coordinator (District office) Mike Bailey – USACE Hydrogeologist (District office) Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a. TOC instrumentation – drain line installation to be completed today. b. DAF plumbing – design team assessment is completed and work is scheduled to begin today. c. Non-contact cooling water outfall connection – the design engineers have requested that a pressure gauge be installed on the outfall line to evaluate flow before the connection is completed. The gauge is scheduled for installation today.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete with only minor work and training to finish this week. The boiler was operated continuously for the past 24 hours without any issues.

Thermal Monitoring/Subsurface Conditions: Water levels across the Pilot Area have rebounded rapidly (approx. 1-2 feet over the last 24 hours). Vadose zone heating continues to be evident in a couple of areas (T-11 and T-55 for example).

Contaminant Recovery: Data will not be available until the TOC instrument is fully operational which should be today. However, data is being recorded and has been over the last week.

Operational Issues: The boiler has been continuously injecting steam for 24 hours. Given the increase in water levels across the Pilot Area, pumping rates will be increased to approx. 3 gpm from each extraction well. Simultaneously, the field team will attempt to verify the liquid equivalent of injected steam. If there is a large differential between the liquid equivalent of steam and the extraction rate, the extraction rate will be adjusted in an attempt to maintain consistent liquid levels in the Pilot Area. Steam injection pressures will be rebalance to approximately 0.5 psi/feet of overburden across the entire Pilot Area in each injection well.

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Operations Team Meeting Minutes 8 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Brenda Bachman – USACE Monitoring Coordinator (District office); Mike Bailey – USACE Hydrogeologist (District office); Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a. DAF plumbing – design team assessment is completed and work is being phased to avoid plant shut downs. b. Non-contact cooling water outfall connection – the design engineers have requested that a pressure gauge be installed on the outfall line to evaluate flow before the connection is completed. The gauge has been installed. Sven Lie and Anne Marie Moellenberndt are scheduled on-site Tuesday to evaluate the flow rates.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete with only minor work and training to finish this week. The boiler was operated continuously for the past 48 hours without any issues.

Thermal Monitoring/Subsurface Conditions: Data collection issues have arisen that did not allow a complete data set to be displayed prior to today's meeting. Vadose zone heating continue in the northern part of the Pilot Area. Gorm Heron (Steamtech) recommended that injection pressures be adjusted in all the injection wells to the target levels to promote even heat distribution.

Contaminant Recovery: The TOC instrument is fully operational and collecting data. Posting to the wed-site should begin early next week.

Operational Issues: In preparation for the long weekend, the steam injection system will be re-balanced to align all the injections wells to 400-800 lbs/hr. In addition, the real-time data will be used to assure that each injection well has steam moving across the entire well screen. Liquid extraction rates will remain set at approximately 3 gpm. Mike, Travis and Cliff will conference by telephone on Monday (11/11) to assess the operational situation.

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Operations Team Meeting Minutes 12 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a. DAF plumbing – design team assessment is completed and work is being phased to avoid plant shut downs. b. Non-contact cooling water outfall connection – the design engineers have requested that a pressure gauge be installed on the outfall line to evaluate flow before the connection is completed. Sven Lie and Anne Marie Molellenberndt are on-site conducting flow and pressure tests.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete. The boiler is currently shut-off to allow repairs to the vapor collection system. The downtime began Sunday afternoon at approx. 1640.

Thermal Monitoring/Subsurface Conditions: Data collection issues have arisen that did not allow a complete data set to be displayed before the meeting. Based on Monday's data, the site is cooling slightly. Water levels have dropped significantly from the weekend high levels to about 4-5 feet MLLW.

Contaminant Recovery: The TOC instrument is fully operational and collecting data. Posting to the wed-site should begin early next week.

Operational Issues: The boiler is currently down to allow repairs to be completed in the vapor conveyance system. Once the repairs are complete, the boiler will be re-started and injection rates in the well field will be set to 400-800 lbs/hr and a liquid extraction rate of approximately 20 gpm.

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Operations Team Meeting Minutes 13 November 2002 Attendees: Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Dave Roberson – SCS Engineers (On-site); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include:

a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations.

b) Vapor conveyance system continues to draw water into the vacuum pumps. It now appears that a check valve is sticking which is allowing contaminated water to be pulled into the vapor system.

c) Final connection of the non-contact cooling water is awaiting an engineering evaluation. Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete. The boiler was re-fired yesterday afternoon and set to 30 psi at the header.

Thermal Monitoring/Subsurface Conditions: Water levels have increased about 3-6 feet overnight. It is apparent from the pressure transducers in the Pilot Area that a wave of water is moving into the pilot area from the south and represents an influx of groundwater coming from the hillside south of the pilot. Heating is evident throughout the Pilot Area. At monitoring points between injection wells, heat propagation appears to be uniform (vertically). Monitoring points between extraction and injection points indicate heating in the vadose zone.

Contaminant Recovery: The TOC instrument is fully operational and collecting data. Posting to the wed-site was initiated today.

Operational Issues: In order to maintain water levels, liquid extraction rates will be increased to approximately 30 gpm. Specifically, extraction rates will be increased at wells 2, 4, 5 and 6. Real time data will be used to verify response to the increased pumping within the formation. Steam injection will be maintained between 400-800 lbs/hr. Injection well I-1 and I-5 will remain shut down to allow the condensate receiver in the well field to be repaired. Once the repairs are complete, the wells will be brought back on-line.

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Operations Team Meeting Minutes 14 November 2002 Attendees:

Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations. b) Final connection of the non-contact cooling water is awaiting an engineering evaluation. Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete. The boiler continues to be run on low-fire producing 30 psi at the header.

Thermal Monitoring/Subsurface Conditions: Water levels are stable across the Pilot Area. Thermal monitoring data was not available prior to today's meeting.

Contaminant Recovery: The TOC instrument is fully operational and collecting data. Posting to the wed-site was initiated soon.

Operational Issues: Liquid extraction rates will be maintained at 30 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be maintained at approximately 400-500 lbs/hr across the well field. Injection wells I-1 and I-5 remain off line to avoid a steam break-through at E-2 until the field condensate receiver level control is repaired.

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Operations Team Meeting Minutes 15 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Dave Roberson – SCS Engineers (On-site); Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations. b) Final connection of the non-contact cooling water is awaiting an engineering evaluation. Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete. The boiler continues to be run on low-fire producing 30 psi at the header.

Thermal Monitoring/Subsurface Conditions: Water levels are gradually decreasing across the Pilot Area. Contaminant Recovery: The TOC instrument is fully operational and collecting data. Plots of the TOC data from the past week are now available on the web site. Samples from the Pilot Area well field have been collected all week. Analytical results are expected in 14 days. The quality of effluent from individual wells is beginning to change. Samples from E-1 and E-2 are significantly darker, contain sheen and have crystal formation on the lids of the jars.

Operational Issues: Liquid extraction rates will be maintained at 30 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be maintained at approximately 400-500 lbs/hr across the well field. Vapor conveyance system repairs were completed today. Consequently, injection wells 1,2,5 and 6 were brought back on line this afternoon. Injection pressures will maintained at 30 psi at the steam header through the weekend.

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Operations Team Meeting Minutes 18 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations. Work is continuing this week. b) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: Construction is substantially complete. The boiler was shut down at approximately 0600 Saturday morning after failures in both the vapor recovery and liquid conveyance system. The problems began when the overnight operator notice decreasing pressures on the inlet side of the vacuum pumps. Eventually, the low-pressure situation caused a low-level pressure warning to automatically shut down the vacuum pump. After a teleconference between Travis and Cliff early Sat. morning, the decision was made to run hot water through the condenser to reduce fouling of the condenser by naphthalene crystals. While the operator was setting up for this procedure, the product tank overfilled and the liquid conveyance pumps failed. With both the vapor and liquid conveyance system off-line, Travis and Cliff again conferred by phone and decided to shut off the boiler to allow repairs to be completed.

Troubleshooting of the liquid conveyance system revealed that a cone screen on the product tank had become fouled with a waxy creosote material, which restricted the flow of liquid to the pumps. Once the material was cleaned off, liquid flow was re-established and the liquid extraction system was brought back on-line. Since the on-site staff had been dealing with the troubleshooting for approximately 8 hours and was fatigued,Travis suggested that Cliff allow his crew to go home and rest before tackling the vapor recover system on Sunday. The procedure for flushing the condenser involved hot water or steam and Travis was concerned about a fatigued work crew attempting a new procedure without proper rest.

The condenser was successfully cleaned on Sunday morning using hot water. This procedure turned out to be fairly straightforward and was accomplished easily. Now that the procedure has been tested, a SOP will be developed and become part of the standard O&M activities for the boiler operators. With both systems back in working order, the boiler was re-started at approximately 1200 delivering 30 psi of steam pressure at the steam header.

Thermal Monitoring/Subsurface Conditions: Water levels appear to be stable. Over the weekend, steam breakthrough through occurred at extraction wells 2 and 6. Due to system problems in the boiler room, steam flow was interrupted between 0600 Saturday morning (11/16) and 1200 Sunday (11/17), which allowed for some cooling. Temperatures at extraction wells 1, 2, and 6 indicate close to steam temperature at about +5 feet MLLW with warmer temperatures (below 100° C) advancing at lower elevations. Temperatures at extraction wells 3 and 4 have not increased at this time.

Contaminant Recovery: The TOC instrument is off line. A programming issue that requires technical assistance from the manufacturer appears to be the problem. SCS's on-site operators are attempting troubleshoot the problem with the vendor.

Operational Issues: Liquid extraction rates will be maintained at 30 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be targeted at 450-500 lbs/hr across the well field.

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Operations Team Meeting Minutes 19 November 2002 Attendees: Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations. Work is continuing this week. b) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The field condensate pump seals have failed. Likely cause of the failure (given recent experience) is the formation of naphthalene crystals in the receiving tank, which prevented the low level switch from shutting of the pump. Consequently, the pump ran dry and the seals were damaged. The system will be manually drained until the pump is repaired.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Elevated temperatures are being recorded at extraction wells 4 and 5 for the first time. Temperatures on the west side of the Pilot Area are decreasing since the injectors were turned-off to allow maintenance of the pumps in E-1 and E-7. Mike noted an initial drop in water levels in E-1 that may have resulted from steam front collapse in that area.

Contaminant Recovery: The TOC instrument back on-line. The programming issue that requires technical support from the manufacture is still being resolved.

Operational Issues: Liquid extraction rates will be maintained at 30 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be targeted at 450-500 lbs/hr across the well field except in arrays around E-1 and E-7. These pumps will be pulled to the surface and serviced today.

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Operations Team Meeting Minutes 20 November 2002 Attendees: Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work has been initiated and is being accomplished in phases to minimize interruptions in treatment system operations. Work is continuing this week. b) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The condensate pumps in the boiler room have failed due to chemical attack on the pump seals (naphthalene appears to be the culprit). New chemically resistant seals have been order and should be on site tomorrow. Due to the failure, the vapor system will be off-line for the next 24 hours.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Temperatures on the west side of the Pilot Area continue to decreasing since the injectors were turned-off to allow maintenance of the pumps in E-1 and E-7.

Contaminant Recovery: The TOC instrument back on-line. The programming issue that requires technical support from the manufacture is still being resolved. Operational Issues: Liquid extraction rates will be maintained at about 23 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be targeted at 450-500 lbs/hr across the well field except in arrays around E-1 and E-7. Extraction well E-1 is back on-line. The pump stopped functioning due to naphthalene crystal formation in the exhaust port (part of the above ground well casing assembly). Repairs took about 10 minutes and resulted in an addition checklist item for the operators to look for during their daily rounds in the well field.

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Operations Team Meeting Minutes 21 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site); Dave Roberson – SCS Engineers (On-Site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) DAF plumbing work is substantially completed and appears to be working as designed. b) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The condensate pumps in the boiler room have failed due to chemical attack on the pump seals. Replacement seals have been ordered and should arrive via overnight delivery today.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Temperatures on the west side of the Pilot Area continue to decreasing since the injectors were turned-off to allow maintenance of the pumps in E-1 and E-7. Temperatures in the surface collector layer are close to steam temperatures in the vicinity of E-2 and E-6.

Contaminant Recovery: The TOC instrument back on-line. The TOC electronic data collection is still topping out at 1000 ppm. Steve Meyerholtz (USACE) is working with the vendor and the on site personnel to resolve the problem. Manual reading will continue to guard against the lost of data until the problem is solved.

Operational Issues: Liquid extraction rates will be maintained at about 23 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be targeted at 450-500 lbs/hr across the well field except in arrays around E-1 and E-7. Extraction well E-1 has failed again. The pump will be removed from the well today to trouble shoot the problem. Every attempt will be made to put the vapor recovery system back on-line today to assist in cooling the high surface temperatures in the vicinity of E-2 and E-6.

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Operations Team Meeting Minutes 22 November 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The condensate pumps in the boiler room have failed due to chemical attack on the pump seals. Replacement seals have been ordered and were scheduled to be delivered yesterday but did not arrive. Seals were temporarily removed from the redundant feed water pump in an effort to enable operation of the vapor condensate system. The thermox arrived on site yesterday. Pease Construction will begin installation today.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Temperatures on the west side of the Pilot Area continue to decreasing since the injectors were turned-off to allow maintenance of the pumps in E-1 and E-7. The pressure readings from instrument well 12 may be malfunctioning and should be viewed with caution until troubleshooting is complete. The array around E-4 is beginning to heat more uniformly with heat propagation observed from the south and southwest sides.

Contaminant Recovery: The TOC instrument back on-line. The TOC electronic data collection is still topping out at 1000 ppm. Steve Meyerholtz (USACE) is working with the vendor and the on site personnel to resolve the problem. Manual reading will continue to guard against the lost of data until the problem is solved.

Operational Issues: Liquid extraction rates will be maintained at about 23 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be targeted at 450-500 lbs/hr across the well field except in arrays around E-1 and E-7. Extraction well E-1 was heavily fouled with solidified creosote material and suspected naphthalene crystals. Once the pump is cleaned, the pump will be placed back into the well but left off until the injectors around he well can heat and liquefy the crystallized material in the well. Informal tests of the material clogging the pump revealed that the material changes from a solid to a liquid phase at about 74 degrees C.

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Operations Team Meeting Minutes 26 November 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10); Ginny Dierich – USACE RPM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On leave); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The boiler is off-line and requires minor repairs to insulation and gaskets caused by a rich fuel mixture at start-up. This occurred early in the morning last Sunday. After the operator back flushed the vapor condenser, he was attempting to restart the vacuum pumps when the boiler tripped off due to low pressure on the sour gas stream. The valve in the sour gas line had been sticking all day Saturday and causes a pressure imbalance that makes it difficult to restart the boiler. After a couple of tries, the operator finally got the boiler to fire, went outside to check that the field condenser was draining properly, then re-entered the boiler building to find black smoke coming of both ends of the boiler. In addition, the boiler was rumbling, indicating a less than optimum firing. The operator immediately shut down the boiler and noticed gasket material pushed out in several areas and some soot indicating combustion gasses had leaked out around the service doors. Uncertain of the condition of the boiler, the operator wisely shut the system off until the boiler could be inspected.

The boiler inspection conducted Monday (25 Nov.) did reveal minor damage to the gaskets and the insulation inside the service door. The Combustion & Controls technician believes that this damage was consistent with firing the boiler with too rich of a fuel mixture. While the damage was by no means serious, he did recommend that it be repaired soon. Rather than re-fire the boiler immediately, the Site Manager decided to go ahead and have the repairs done now, rather than shut down the boiler later for maintenance. The technician was confident that they could complete the job by this afternoon.

Since the root cause of the boiler shut down was the sticky sour gas control valve, the technician removed the cover plate of the valve for inspection. The neoprene seal was sticking and the o-rings seals on the inner valve housing were swollen. In addition, the valve body retaining a small amount of fluid with a strong naphthalene odor. We will attempt to find viton seals for this valve immediately.

The condensate pumps have failed again, specifically, the pump that was put back into service last Friday (22 Nov.) with borrowed seals from the redundant feed water pump. The original plan was to have replacement seals on-site by Saturday, however, the order has failed to arrive and we have begun the trace the shipment. Once the replacement seals are on-site, we can install the seals quickly and bring the pumps back-on line at least temporarily. To avoid future failures, we will need to replace the EPD seals with viton to deal with chemical incompatibility problems and we are evaluating the use of self-flushing seals or some other mechanism to avoid physical damage to the seals by crystals or other particles (Dick Watts at the NW Area Office is following up on these issues).

The field condensate receiver is undergoing an engineering evaluation by District's design group (Lead is Sven Lie). While this system can be drained manually, it is a labor-intensive operation and distracts the boiler room operators. The design group is also evaluating the function of the vapor condenser to provide a recommendation for the ongoing fouling problems. The engineers were provided with temperature and flow data from the last several weeks to assist in this evaluation. While waiting for parts, the field staff is evaluating the liquid conveyance system for materials of construction and potential fouling points in anticipation of problems associated with the liquid waste stream once highly contaminated liquids begin moving to the treatment plant.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Temperatures across the Pilot Area continue to decrease since the injectors were turned-off to allow maintenance of the boiler.

Contaminant Recovery: The TOC instrument back on-line. The TOC electronic data collection is still topping out at 1000 ppm. Steve Meyerholtz (USACE) is working with the vendor and the on site personnel to resolve the problem. Manual reading will continue to guard against the lost of data until the problem is solved.

Operational Issues: Liquid extraction rates will be maintained at about 23 gpm to maintain stable liquid levels in the Pilot Area. Steam injection will be resumed as soon as the boiler and condensate pumps are repaired.

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Operations Team Meeting Minutes 27 November 2002 Attendees: Mary Jane Nearman – EPA RPM (Region 10); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On leave); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The boiler repairs were completed yesterday and the boiler was test fired without incident. Pump seals for the condensate pumps are suppose to be on-site and installed today.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be stable. Temperatures across the Pilot Area continue to decrease since the injectors were turned-off to allow maintenance of the pumps in E-1, E-7 and the boiler. Pumping from E-3 appears low yet the draw down in the well seems uniform. Mike requested that we check the well by shutting off the pump and evaluating the real time water level data for E-3 to determine if water is flowing into the well. Contaminant Recovery: The TOC instrument back on-line. The TOC electronic data collection is still topping out at 1000 ppm. Steve Meyerholtz (USACE) is working with the vendor and the on site personnel to resolve the problem. Manual reading will continue to guard against the lost of data until the problem is solved.

Operational Issues: Liquid extraction rates will be maintained at about 23 gpm to maintain stable liquid levels in the Pilot Area. The pump in E-2 was shut off to avoid fouling in the well as the site cools during the interruption in steam injection caused by the boiler maintenance shutdown. The pumps in E-1 and E-7 will be reinstalled today. The pump in E-1 will remain off, however, until temperatures at the well reach 75 degrees C to liquefy the solidified material in the well casing. Assuming that the seals for the condensate receiver pumps arrive as scheduled, the boiler will be brought back on-line with a target injection of 450-500 lbs/hr across the entire Pilot Area well field. Extraction pumping rates will be increased to 30 gpm once steam injection resumes.

Addendum to the Ops Report for 22 Nov. – Wells E-3 and E-5 were opened and the pumps lowered approximately 2 feet. This operation was conducted to correct a problem discovered last week when it became apparent that the contractor had misunderstood the specifications and used the wrong reference point during the installation of the pumps. E-3 and E-5 were lowered because the area around these wells had not become dangerously warm, which provided an opportunity to more safely open the wells. The pump inlet elevation in wells E-1 and E-7 will also be corrected since the pumps have been removed for maintenance.

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Operations Team Meeting Minutes 28 November 2002

Attendees:

Mary Jane Nearman – EPA RPM (On Leave) Ginny Dierich – USACE PM, Acting (On Leave) Travis Shaw – USACE Site Manager (On Leave) Mike Bailey – USACE Hydrogeologist (On Leave) Brenda Bachman – USACE Monitoring Coordinator (On Leave) Cliff Leeper – SCS Engineers (On Leave)

Construction Update – Construction is substantially complete. All of the construction contractors are off-site until Monday (2 December) for the Thanksgiving Day holiday.

Boiler Room Update – All necessary repairs to the boiler and condensate pumps were completed yesterday and the system was brought back up by about 1500. Operators continue to be plagued by problems with the feed water pumps tripping off.

Treatment Plant Update – The treatment plant is operating normally.

Subsurface/Thermal Monitoring Update – Due to the holiday, there was no data upload to the web site today.

Contaminant Recover Update – Due to the holiday, there was no data upload to the web site today.

Operations Update – With the system up and running again, the well field was balanced late yesterday. Steam injection was targeted at approximately 400 lbs/hr at all of the steam injection wells with 30 psi at the header. Liquid extraction was set to approximately 23 gpm from all 6 of the functioning extraction wells. The pump in E-1 was not installed as planned yesterday due to the fouling of the well. This well will be heated to about 80 degrees C in an effort to liquefy the solidified contaminant in the well that is obstructing proper pump placement.

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Operations Team Meeting Minutes 29 November 2002

Attendees:

Travis Shaw – USACE Site Manager (District Office) Mike Bailey – USACE Hydrogeologist (On Leave) Brenda Bachman – USACE Monitoring Coordinator (On Leave) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction is substantially complete. All of the construction contractors are off-site until Monday (2 December) for the Thanksgiving Day holiday.

Boiler Room Update – The feed water pumps continued to trip off yesterday. By mid-morning, the situation continued to get worse to the point that the on duty operator could not get the pumps to function for more than 20-30 seconds before having to re-set the pumps. Travis and Cliff conferred by phone and decided to shut down the boiler at 1500 to avoid damaging the pumps. Both Cliff and Travis have been attempting to contact an electrical contractor to troubleshoot the system (the Baird Weber electrician was finally reached at approximately 1100 and was responding to the site).

Treatment Plant Update – The treatment plant is operating normally.

Subsurface/Thermal Monitoring Update – The 24 hours of operation did add significant heat to the subsurface, particularly in the northern portion of the Pilot Area. Steam temperatures were noted reaching extraction wells E-2 and E-6 at an elevation of about 5 MLLW. Water levels appear stable across the formation.

Contaminant Recover Update – The on-line TOC instrument is recording a general upward trend in the liquid recovered from the Pilot Area. Since 18 November, average daily concentrations have increased from about 200 ppm to 600 ppm.

Operations Update – Hopefully, the electrical problem with the feed water pumps can be resolved today and the boiler can be re-started. Once the boiler is brought on-line, steam injection will be targeted at approximately 400 lbs/hr at all of the steam injection wells with 30 psi at the header. Liquid extraction will remain set to approximately 23 gpm from all 6 of the functioning extractions wells.

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Operations Team Meeting Minutes 2 December 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10); Kathy LeProwse – USACE PM (District office); Ginny Dierich – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On leave); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The boiler is functioning normally after some difficulty last Thursday (Thanksgiving Day) with the feed water pumps. The field condenser pump has started leaking slightly, the pumps seals will be evaluated today to determine if the problem is mechanical or chemical in nature. The temperature across the heat exchangers has finally risen to 130 degrees F, which is above the target levels for cooling water to begin flowing through that part of the system. The controls system appears to have sensed the increase temperatures and responded according to design. The temperature increase across the condenser also appears to be hot enough to maintain flow through the system since it has not been necessary to back-flush the condenser with hot water since last Friday.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to have increased slightly in response to the continuous steam injection through the weekend. Temperatures across the Pilot Area also increased since the injectors were turned-on last Wednesday (27 Nov.). Steam breakthrough is evident at extraction wells 2, 5 and 6.

Contaminant Recovery: The TOC instrument is continuing to record an upward trend in the concentration of TOC from the Pilot Area. Samples collected this morning from wells E-3 and E-7 contained some NAPL for the first time.

Operational Issues: The following operations changes will be implemented today in the following sequence:

1. Extraction well E-2 will be turned back on now that temperatures have increased enough to reduce the chance of fouling.

2. The injectors surrounding the E-1 array have been shut-off and we will attempt to set the pump into the well. Temperature data indicates that the well temperature has increased enough to dissolve the solid matrix plugging the well.

3. Once all the extraction well pumps are in operation, pumping rates will be increased to 30 gpm across the Pilot Area well field and the response monitored throughout the day.

4. Steam injection will be re-balanced to target 400-500 lbs/hr at each injector with steam moving across the entire injection well screen. Steam pressure at the header may need increased to successfully achieve this target.

5. An attempt will be made to increase the vapor recovery in the array around E-6 to mitigate high near surface temperatures.

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Operations Team Meeting Minutes 3 December 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10); Kathy LeProwse – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On leave); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally.

Boiler Room Operations: The boiler is functioning normally without any major issues. The leaky seal on the field condensate receiver pump reported yesterday was caused by a minor mechanical problem that was easily corrected.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to have increased slightly in response to the continuous steam injection through the weekend. Temperatures across the Pilot Area also increased since the injectors were turned-on last Wednesday (27 Nov.). Steam breakthrough is evident at extraction wells 1, 2, 5 and 6. Near surface temperatures in the vicinity of E-6 continue to be high. Mike has some concerns regarding the performance of E-3. Mike feels that problem may be related to mobilized NAPL in the formation cooling and interfering with the flow of fluid into the well. Contaminant Recovery: The TOC instrument is continuing to record an upward trend in the concentration of TOC from the Pilot Area. Samples collected this morning from wells E-3 and E-7 contained some NAPL.

Operational Issues: The following operations changes will be implemented today in the following sequence:

1. The injectors surrounding the E-1 array have been shut-off and we will attempt to set the pump into the well, again. The Ops team favored attempting to place the pump near the designed elevation rather than placement above the solidified NAPL plug. If the attempt fails, more aggressive cleaning strategy may need to be employed.

2. Once all the extraction well pumps are in operation, pumping rates will be increased to 30 gpm across the Pilot Area well field and the response monitored throughout the day.

3. Steam injection will be re-balanced to target 400-500 lbs/hr at each injector with steam moving across the entire injection well screen. Steam pressure at the header may need increased to successfully achieve this target.

4. An attempt will be made to further increase the vapor recovery in the array around E-6 to mitigate high near surface temperatures.

In addition, Mike and Brenda will develop a strategy by next Thursday (5 December) for the sampling of the new lower aquifer monitoring well completed this week in the vicinity of E-6.

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Operations Team Meeting Minutes 4 December 2002

Attendees: Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Cliff Leeper – SCS Engineers (On-site); Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally. The aeration basin appears to have responded to an increase in contaminant concentrations over the last 24 hours. Based on visual inspection, there has been some die-off in the basin. The overall impact to treatment efficiency will not be known until analytical results are received later this week.

Boiler Room Operations: The boiler was taken off-line last night at approximately 1930. A slug of liquid came through the vapor system causing a high fluid level trip-off of the vacuum pumps. Once the vacuum pumps shutdown, the sour gas valve to the boiler did not function causing the boiler to shut down. Since the valve was sticking, the boiler could not be re-started. A service representative from Combustion Controls is responding to the site to rebuild the valve again. This will get us back on line until the seals and o-rings fail again due to chemical attack. Hopefully, a new valve with chemical resistant components will arrive on site before the next failure. Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to fairly stable. Temperatures across the Pilot Area are decreasing slightly with the boiler shutdown. Temperature increases are evident at T-73 and T-76 indicating some heat migration out of the treatment area. The pumping rate at E-3 has increased which may indicate increased fluid flow into the well. Similarly, liquid levels have increased in E-7, again a possible indication of increased flow into the well.

Contaminant Recovery: The TOC instrument is continuing to record an upward trend in the concentration of TOC from the Pilot Area. A sudden increase in TOC (up to 3000 ppm) was measured yesterday. Samples collected this morning from wells E-3 and E-7 contained substantial NAPL.

Operational Issues: Every attempt will be made to re-start the boiler today. If the boiler is not fired, liquid extraction rates will be decreased to about 20 gpm to maintain liquid levels in the Pilot Area. If the boiler is successfully re-fired, injection rates will be maintained at 400-500 lbs/hr with 30 psi at the header. Extraction rates will be maintained at 27 gpm across the Pilot Area.

The pump in E-1 was successfully placed in the well yesterday afternoon. The pump remains off until temperatures increase enough to ensure that all the solidified contaminant mass has liquefied.

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Operations Team Meeting Minutes 5 December 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Kathy LeProwse – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site): Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (District office); Cliff Leeper – SCS Engineers (On-site); Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume.

Treatment Plant Operations: The treatment plant is operating normally. The aeration basin appears to have responded to an increase in contaminant concentrations over the last 24 hours. Based on visual inspection, there has been some die-off in the basin. This morning, the basin appears to have rebounded with indications of increased biological activity.

Boiler Room Operations: The boiler is back on line. Combustion Controls provided parts for the failing sour gas valve and a replacement valve has been ordered and should be shipped Friday (6 December). Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be decreasing slightly with the reduction in steam injection caused by the boiler shut down. In addition, temperatures across the Pilot Area are decreasing slightly with the boiler shutdown. Contaminant Recovery: TOC concentrations dropped dramatically after boiler and vacuum system shutdown last Monday. Current concentrations measured by the on-line instrument are approximately 500 ppm.

Operational Issues: Every attempt will be made to return to normal operations today. Injection rates will be maintained at 400-500 lbs/hr with 30 psi at the header. Extraction rates will be maintained at 27 gpm across the Pilot Area.

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Operations Team Meeting Minutes 6 December 2002

Attendees: Mary Jane Nearman – EPA RPM (Region 10 office); Kathy LeProwse – USACE PM (District office); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site); Dave Roberson – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Final connection of the non-contact cooling water is proceeding this week after the design engineers confirmed that the existing outfall line should be capable of accepting addition volume. The work will be completed Monday.

Treatment Plant Operations: The treatment plant is operating normally. The aeration basin appears to have rebounded after the indications of a die-off in the basin earlier in the week. Biological activity in the basin currently appears robust. Based on the samples collected Monday, the plant is now receiving a waste stream with concentrations of contaminants several orders of magnitude higher than previous weeks. Most of the treatment is taking place in the front end of the treatment process (DAF).

Boiler Room Operations: The boiler is back on line. Combustion Controls provided parts for the failing sour gas valve and a replacement valve has been ordered and should be shipped today. If the valve fails again over the weekend, parts are available to keep the system operating until the new valve is received. The new Grundfos condensate pumps will be installed today.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing slightly with the resumption in steam injection. In addition, temperatures across the Pilot Area are recovering rapidly. The heating outside the Pilot Area noticed last week before the boiler shut down is indicated again at instrument strings T-76 and T-74). Mike mentioned that as steam moves across the formation, it might become difficult to separate steam pressure from liquid pressure creating sum uncertainty in the water level measurements.

Contaminant Recovery: TOC concentrations are increasing with the resumption of steam injection. As noted above, the results from sampling in the treatment plant indicate a dramatic increase in contaminant concentrations (for example, naphthalene concentrations jumped from about 10,000-20,000 ppb to greater than 1,500,000 ppb).

Operational Issues: Every attempt will be made to continue normal operations today. Injection rates will be maintained at 400-500 lbs/hr with 30 psi at the header. Extraction rates will be maintained at 27 gpm across the Pilot Area.

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Operations Meeting Minutes 12 December 2002 SHOULD BE 9 DEC

Attendees:

Travis Shaw – USAC Site Manager (District office); Mike Bailey – USACE Hydrogeologist (District office); Brenda Bachman – USACE Monitoring Coordinator (On-site); Cliff Leeper – SCS Engineers (On-site);

Boiler Room Update – The boiler is temporarily off-line due to problems with the vacuum system and the sour gas valve. An influx of hot vapors caused a pressure differential that caused the vacuum system to automatically shut down. The boiler then shut down due to a failure of the troublesome sour gas valve. The operators are replacing the sour gas valve with the spare that is on-site (the new valve is scheduled to be on site today). The boiler should be back on-line by noon today.

Treatment Plant Update – The treatment plant did experience a slight difficulty over the weekend. The mixing chamber between the clarifier and the basin clogged causing solids to be spilled downstream of the system. It is unclear if this is related to thermal operations. The mixing chamber is a 12-inch line that is not regularly checked. Given the size of the line, Cliff feels that clogging has probably been occurring over some period of time and just happened to finally restrict flow. The operators will brush out the chamber and keep an eye on accumulation of material in this line in the future.

Sub-surface Monitoring – Mike reports fairly consistent heating except at injections wells 4,5,11 and 12. Liquid extraction in E-3 continues to improve with increased temperatures around the well. Instrument string T-18 is showing heat propagation above and below a clay confining layer indicating steam may have found a around this low permeability zone.

Contaminant Recovery – CLP data has started to arrive. The in-line TOC instrument continues to show increasing concentrations with several spikes a day above 3000 ppm.

Operations Update – The operators will verify steam flow is on target both in terms of injection pressure at individual well heads and steam flow. In addition, the operators will verify valve positions in the vacuum system. Extraction well E-1 will be tested to determine if solidified NAPL material has liquefied yet. Brenda, Cliff and Dave Roberson will work towards firming up water balance values today. This must be accomplished prior to increasing steam injection pressure to avoid inadvertently dumping excess non-contact cooling water. Otherwise, the targets of 30 psi at the header, 400-500 lbs/hr steam injection across the well field with 27-30 gpm liquid extraction will be maintained for the next 24 hours.

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Mike Bailey
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Operations Meeting Minutes 10 December 2002

Attendees:

Brenda Bachman - USACE Monitoring Coordinator and Acting Site Manager (On-site); Mike Bailey - USACE Hydrogeologist (District office); Marlowe Dawag - USACE Process Engineer (District Office); Cliff Leeper - SCS Engineers (On-site)

Boiler Room Update - The boiler is temporarily off-line due to problems with the vacuum system and the sour gas valve. Repairs to the system are expected to begin on Friday when the valve arrives. However, due to problems with the treatment plant, the boiler will not be restarted until those problems are resolved.

Treatment Plant Update - The treatment plant has not been on-line since yesterday afternoon due to uncertainty about the nature of the fines that were discharged to Puget Sound due to the clogged pipe that occurred on Sunday. It was hoped that significant settling would occur in the clarifier overnight, but minimal change was noted (from 3" clarity to 6"). The suspended solid load in the effluent was 33 mg/L yesterday, so there is no source of clean water to backflush treatment plant systems. Analytical chemistry results from yesterday's effluent are all at least 4 times below permittable discharge limitations! (Hurrah!) So we did not violate the discharge permit. (Whew! wipe brow here)

The reason for the clogged pipe is still uncertain. It may have been a long-term change as noted in yesterday's ops report, but other possibilities also exist such as: 1) the influent of contaminants is no longer compatible with the polymer, and 2) the microbe die-off reported on Dec. 4th may have overwhelmed the polymer and caused clogging. Cliff has requested jar tests to determine compatability of the polymer.

Sub-surface Monitoring - Mike reports minor decrease (roughly 10 degrees C) in temperature at most of the extraction wells, with the exception of E-1, which has continued to show marked temperature increases down to an elevation of -5 ft MLLW. Well E-1 has not been restarted as yesterday's ops report identified. The injection wells have also shown temperatures drop as a result of cessation of steam injection. The remainder of the site remains relatively unchanged. Near-surface steam temperatures are apparent at E-2, E-4, E-5, E-6, T-13, T-31, T-49, T-50, T-51, and T-52. Presumably these areas will cool off if the boiler remains off. Water levels dropped significantly (2-6 ft) across the PTA with cessation of steam injection.

Contaminant Recovery - With steam off, TOC levels have dropped. Visual evidence suggests contaminant load from the PTA is significantly lower, as water samples from E-2 and E-6 are described as clear (in contrast to recent black discharge from these wells). There is speculation that the bulk of the contaminants being removed are LNAPLs. With the decrease in overall pumping rate from 27 gpm to 18 gpm overnight and to 4.8 gpm this morning, it is believed that recharge to extraction wells has lifted the LNAPL above pump intakes.

Operations Update - Pending EPA agreement, the treatment plant operations will restart and discharge to Puget Sound will continue. It is recognized that the effluent will probably exceed turbidity discharge criteria, and the appropriate regulatory authorities will be notified by EPA. Wellfield extraction will remain at 4.8 gpm for the PTA and 0 gpm for wells outside the PTA until resolution of the problem with the treatment plant.

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Mike Bailey
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Operations Meeting Minutes 11 December 2002 Attendees:

Brenda Bachman - USACE Monitoring Coordinator and Acting Site Manager (On-site); Mike Bailey - USACE Hydrogeologist (District office); Travis Shaw - USACE Site Manager (Arizona); Cliff Leeper - SCS Engineers (On-site)

Boiler Room Update - The boiler remains off-line due to problems with the vacuum system and the sour gas valve. The new sour gas valve is expected to arrive on Friday, at which time final repairs will be completed. In the meantime, replacement parts installed earlier this week are considered acceptable for the near term. Gaskets for the vacuum system are expected today and will be installed shortly thereafter.

Treatment Plant Update - The treatment plant is operating at normal flows (approx. 40 gpm) and discharging to Puget Sound. The existing inventory (plus minimal flow from the PTA) is being treated. Estimated time to treat the existing inventory is two days. There was little, if any, improvement in clarity observed in the clarifier since yesterday. Some exceedance of turbidity standards is expected until the system has been flushed. There is an indication that microbial stock species in the aeration basin are proliferating.

Sub-surface Monitoring - Temperatures in extraction and injection wells continue to drop, while the remainder of the site remains unchanging. Typical extraction well temperatures are 5-20 degrees C lower than yesterday, with most of the change occurring in the vadose zone. Exceptions are noted at E-6 and I-6, where temperatures have decreased by as much as 60 degrees C and 40 degrees C, respectively. Temperature is a uniform 15 degrees from the bottom of E-6 to an elevation of -3 ft MLLW. The temperature response at E-6 and I-6 is probably due to cool water upwelling from the lower aquifer.

Average water level in the PTA is approximately 2.75 ft MLLW. Extraction wells E-3, E-5, and E-7 have not rebounded since pumping rates were cut back. It appears that flow to these wells may be hampered by a buildup of NAPL around the wells. Prior to system shutdown, gradually improving extraction rates had been noted at E-3, presumably a reflection of increased mobility of NAPL due to warmer temperatures.

Contaminant Recovery - With steam off, TOC levels have dropped and stabilized at roughly 500 mg/L. Visual evidence suggests some contaminant presence in water samples from E-2, E-3, E-4, and E-5, which are described as translucent golden or golden brown.

Operations Update - The boiler will be lit today after the vacuum system gaskets have been replaced, with targets of 30 psi and 400 lbs/hr at the injection wellheads. Extraction from PTA wells will be increased to approximately 18 gpm (total) or an average of 3 gpm for the six extraction wells currently operational. E-1 will remain off until temperatures have rebounded. Extraction wells outside the PTA will remain off until the inventory of water in the treatment plant is processed. Assuming the sour gas valve arrives Friday, the boiler will be shut down for several hours to make final repairs.

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SiteOpLog: **Ops Meeting Minutes - 12 December**

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Operations Team Meeting Minutes 12 December 2002

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Ginny Dierich – USACE COR (District Office) Travis Shaw – USACE Site Manager (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (On Site) Cliff Leeper – SCS Engineers (On Site) Joe Harrington – SCS Engineers (On Site)

Construction Update – Construction is substantially complete. Instruments on extraction well E-4 have been installed and outfall connection for non-contact cooling water is complete. Remaining work includes installation of the rental emergency generator (on-site), troubleshooting of the treatment plant instrumentation (pH and temperature) and commissioning and testing of the thermox (to be completed next week).

Boiler Room Update – The boiler is on-line and operating at 30 psi at the header as of late yesterday afternoon. The field condensate pump air locked early this morning. The operators will check the pump manually every 30 minutes until the pipe temperature reaches 130 degrees F to verify that fouling does not impact pump operation. The condensate receiver pump in the boiler room has also failed. The pump will be disassembled to determine the cause of the failure. In the meantime, a small peristaltic lab pump left on site during a previous project will be used to empty the receiver manually.

Treatment Plant Update – The treatment plant is operating more normally after the problems in the aeration basin cased an interruption in discharges earlier in the week. The fines are still working through the system. Cliff will obtain samples for TSS at different points in the process to evaluate the current status of fines in the multi-media filters, carbon vessels and the effluent. In addition, Cliff has requested that the polymer vendor visit the site early next week to help determine if a change in the polymer system might help reduce settling of fines in the aeration basin. Current through-put of the plant is set to handle 35 gpm from the existing extraction system, 18 gpm from the Pilot Area and 10 gpm to reduce the water inventory on the plant sump. If TSS concentrations are low enough to reduce pressure increases across the multi-media filters, total plant production will be increased to allow greater extraction from the Pilot Area and increased reduction of the GWTP water inventory.

Subsurface/Thermal Monitoring Update – Temperatures are rebounding quickly after the boiler shutdown early in the week. Heat propagation toward E3 and E5 is occurring rapidly. Extraction well E6 cooled significantly during the shut down indicating greater influx of cooler lower aquifer water in this area. The influx of cool water at E6 may require greater variation in extraction and injection rates to heat the lower portion of this well. Upward trends in water levels were measured in extraction wells E2, E3, E5, E6 and E7. Extraction rates will need to be increased to stabilize water levels. The DTS system is still dropping off occasionally due to software problems. A permanent fix may require an extended shutdown. Since the periodic failures do not result is significant data losses, this may be a situation that has to be tolerated for now.

Contaminant Recover Update – The on-line TOC instrument is recording a general upward trend in the liquid recovered from the Pilot Area with spikes to 8500 ppm. The instrument will be recalibrated to achieve a maximum reporting limit of 20,000 ppm. No contractor supplied chemical data is available today.

Operations Update – Pending minor repairs to the vapor system (gasket and filter replacement), the boiler will be run at 30 psi with 400-500 lbs/hr injected across the Pilot Area. Current liquid extraction will be increased from 18 gpm to a target of 22 gpm. Extraction well E1 will evaluated for fouling and will be restarted if possible. Water balance reporting issues need to be resolved prior to stepping up injection pressures.

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SiteOpLog: **Ops Meeting Minutes - 13 Decemnber**

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Operations Team Meeting Minutes 13 December 2002

Attendees:

Travis Shaw – USACE Site Manager (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today.

Boiler Room Update – The boiler is on-line and operating with the new sour gas valve in place. The planned shutdown for today was moved up to yesterday afternoon to install the new chemical resistant valve. The field condensate pump remains in manual operations mode. Heat exchanger HX-3 was tested today and operated smoothly, however, some non-contact cooling water was discharged to the outfall due to low boiler feed water demand.

Treatment Plant Update – The treatment plant is operating more normally with continued reduction in fines in the later portion of the plant. Another round of TSS samples will be collected and analyzed to document reductions in fines throughout the plant. The plant through put is holding at about 70 gpm partitioned between the Pilot Area (22 gpm), existing extraction system (35 gpm) and reducing treatment plant water inventory (10 gpm).

Subsurface/Thermal Monitoring Update – Temperatures are rebounding quickly after the boiler shutdown early in the week. Steam breakthrough is evident in the vadose zone at well E2, E4, E5 and E6. Water levels are rebounding rapidly across the Pilot Area in response to continued steam injection and increased rainfall over the last 24 hours.

Contaminant Recover Update – The on-line TOC instrument is recording a general upward trend. No contractor supplied chemical data is available today.

Operations Update – Liquid extraction will be increased to approximately 29 gpm by stepping up pumping rates at wells E2, E4 and E5. Steam injection will continue at 30 psi with 400-500 lbs/hr across the well field except at well I9 and I12, which will not accept the targeted steam flow rate. The operators will collected and calculated total feed water to the boiler building at the water softener, temperature data across HX-3 and non-contact cooling water temperatures during a test operation of HX-3 over the weekend. The goal is to track operations of HX-3 set to a target of 100 degrees F at the outlet in an effort to reduce condensate levels between the liquid ring vacuum pumps and the boiler.

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SiteOpLog: **DTS Data Processing**

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12/16/02 08:27 | | DTS Data Processing

g3ectlma
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DTS Loop 2 is down. Loop 2 carries the data for the west side of the study area. Will process data for 16 December without the Loop 2 information.

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SiteOpLog: **Ops Meeting Minutes - 16 December**

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! 12/16/02 15:05 | | Ops Meeting Minutes - 16 December

Mike Bailey
Member
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Operations Team Meeting Minutes 16 December 2002 Attendees:

Travis Shaw – USACE Site Manager (EPA Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Cliff Leeper – SCS Engineers (On Site) Mike Bailey - USACE Hydrogeologist (On Site) Kathy LeProwse - USACE Project Manager (Home) Mary Jane Nearman - EPA Project Manager (EPA) Dave Roberson (SCS) Joe (SCS)

Boiler Room Update – The boiler is off-line. Gaskets in the heat exchanger are believed to have failed. The vendor is being contacted to provide replacements gaskets as well as to discuss chemical incompatibility concerns.

Treatment Plant Update – The treatment plant experienced a slug of contaminants over the weekend that apparently resulted in complete (or nearly so) die-off of microbes in the aeration basin. Some evidence of microbial activity was noted this morning. Discharge from the PTA was reduced to 18 gpm, while discharge from the rest of the wellfield was maintained at 35 gpm.

Subsurface/Thermal Monitoring Update – The IFix (thermocouple) and DTS systems both experienced problems that resulted in some loss of data over the weekend. Both systems are currently operating, although one DTS fiber optic loop is not acquiring data. As expected, there has been some loss of heat at injection and extraction points, although temperatures are stable across much of the PTA. Water levels are stable.

Contaminant Recovery Update – With the boiler off-line, TOC levels have dropped dramatically.

Operations Update – The boiler will remain off-line until the heat exchanger has been fixed and the aeration basin has recovered. The treatment plant will be placed in a closed-loop recycle mode and the aeration basin will be inoculated with microbes.

Further Update (1500 hrs) - The operators are monitoring DO levels in the aeration basin. DO is currently at 1.4 mg/L, and levels of 2 mg/L are necessary for survival of the microbes. Inoculation with a fresh batch of microbes is delayed until DO has increased. The treatment plant is operating as a closed loop.

Discharge from the wellfields is going to 402. To reduce the contaminant load on 402, it was decided to shut off extraction wells in the PTA. For the most part, current water levels (not counting extraction wells) in the PTA run between 1.5 and 5 ft MLLW. Lower aquifer wells (measured by CL and MMB) show water levels of 10-12 ft MLLW, so concerns about head reversal do not seem serious at the moment.

Maintenance manuals have been obtained for the heat exchanger. Chemical resistant gaskets (teflon, for example) are available. OMI is evaluating in-house vs. contracting options to disassemble the heat exchanger.

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Operations Team Meeting Minutes 17 December 2002

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 office); Kathy LeProwse – USACE PM (On Site); Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (On Site); Brenda Bachman – USACE Monitoring Coordinator (On-site); Marlowe Dawag – USACE Process Engineer (On Site); Cliff Leeper – SCS Engineers (On-site); Dave Roberson – SCS Engineers (SCS Offices); Joe Harrington (SCS Offices)

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Testing, commissioning and training of the thermal oxidizer will occur at the end of the week. The thermox and propane fuel system installation is complete. b) Chemical injection system training will also occur at the end of the week. The problems with the pH sensors installed in the GWTP appear to have been resolved.

Treatment Plant Operations: The treatment plant is operating in a closed loop mode without discharge to the outfall. This action was taken to allow the aeration basin to recover from the apparent die off experienced over the weekend. Indications are that the basin has begun to recover with improvement in DO, increased foam on the surface of the basin (indicating microbial activity) and a reduction in the suspended solids in the clarifier. With an increase in DO, the basin will be inoculated to speed recovery. The polymer vendor is on site conducting jar tests to help determine if a change in the polymer system might help reduce suspended solids in the basin. Until the suspended solids issue improves, the operators are concerned about increasing flows through the plant above 40-45 gpm. Water inventory at the treatment plant is high and needs to be reduced soon to allow continued operations (38,000 gallons in T-401 normally set at 10,000-15,000 gallons; 50,000 gallons in T-402 normally set at 30,000 gallons).

Boiler Room Operations: The boiler is back off line. The vapor heat exchanger (HX-3) is down with apparent seal failures. Liquid extraction from the Pilot Area is off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. The condensate receiver pump between the vacuum pumps and the boiler has failed due to unknown reasons (chemical incompatibility issues are suspected). Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing slightly due to precipitation and the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling with the cessation of steam injection. Water levels outside the Pilot Area appear to be fairly stable. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area. Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area will be reduced to 25 gpm. The current remaining plant capacity will be used to reduce the water inventory in T-402 at a rate of 20 gpm. Reduction from T-401 (with a higher contaminant load) will be initiated once analytical data collected on Monday is reported by the laboratory. This will allow the field team to more accurately track loading on the carbon vessels until treatment improves in the aeration basin. Polymer evaluations will be completed by tomorrow. If the polymer system can be optimized, the GWTP through put may be increased to more quickly reduce the water inventory.

Engineering evaluations will be initiated to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

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Operations Team Meeting Minutes 18 December 2002

Attendees: Travis Shaw – USACE Site Manager (On-site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (In Training); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Testing, commissioning and training of the thermal oxidizer will occur at the end of the week. The thermox and propane fuel system installation is complete. b) Chemical injection system training will also occur at the end of the week. The problems with the pH sensors installed in the GWTP appear to have been resolved.

Treatment Plant Operations: The treatment plant is operating at a total 45 gpm with 25 gpm coming into the system from the Former Process Area and 20 gpm dedicated to water inventory reduction. Since yesterday, the inventory in T-402 has been reduced by 17,500 gallons. Suspended solids in the clarifier remain unchanged. DO levels have dropped slightly and foam is evident on the surface of the basin indicating renewed microbial activity. Once liquid levels in T-402 have reached the normal operating level (100 inches), the inventory in T-401 will be introduced to the system.

Boiler Room Operations: The boiler is back off line. The vapor heat exchanger (HX-3) is down. A leak test was conducted today and indicates widespread failure of the gaskets between plates of the heat exchanger. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. The condensate receiver pump between the vacuum pumps and the boiler has failed due to unknown reasons (chemical incompatibility issues are suspected). Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing slightly due to precipitation and the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling with the cessation of steam injection. Water levels outside the Pilot Area appear to be fairly stable and are being measured today to provide updated information.

Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area. Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area remains at 25 gpm. The current remaining plant capacity will be used to reduce the water inventory in T-402 at a rate of 20 gpm. Reduction from T-401 (with a higher contaminant load) will be initiated once the laboratory reports analytical data collected on Monday and levels in T-401 reach 100 inches.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory

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Operations Team Meeting Minutes 19 December 2002

Attendees:

Mary Jane Nearman - EPA RPM (District Office); Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (District Office); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Testing, commissioning and training of the thermal oxidizer will occur at the end of the week. The thermox and propane fuel system installation is complete. b) Chemical injection system training will also occur at the end of the week. The problems with the pH sensors installed in the GWTP appear to have been resolved.

Treatment Plant Operations: The treatment plant is operating at a total 45 gpm with 35 gpm coming into the system from the Former Process Area and 10 gpm dedicated to water inventory reduction. Suspended solids in the clarifier remain unchanged. DO levels have increased slightly and foam is evident on the surface of the basin indicating renewed microbial activity. Once liquid levels in T-402 have reached the normal operating level (100 inches), the inventory in T-401 will be introduced to the system.

Boiler Room Operations: The boiler off line. The vapor heat exchanger (HX-3) is down. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. The condensate receiver pump between the vacuum pumps and the boiler has failed due to unknown reasons (chemical incompatibility issues are suspected).

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing slightly due to precipitation and the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling with the cessation of steam injection. Water levels outside the Pilot Area appear to be fairly stable and are being measured today to provide updated information. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area was increased to 35 gpm to provide buffering capacity when highly contaminated liquid from T-401 is introduced into the system. Reduction from T-401 (with a higher contaminant load) will be initiated once the laboratory reports analytical data collected on Wed. and levels in T-402 reach 100 inches.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory.

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Operations Team Meeting Minutes 20 December 2002

Attendees: Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete. Outstanding issues and status include: a) Testing, commissioning and training of the thermal oxidizer is complete. b) Chemical injection system training is complete.

Treatment Plant Operations: The treatment plant is operating at a total 26 gpm with 35 gpm coming into the system from the Former Process Area. The immediate goal is to obtain optimum levels in T-402 (150 inches) to allow flexibility in buffering highly contaminated flows from T-401. Suspended solids in the clarifier have improved slightly. DO levels have increased slightly and foam is evident on the surface of the basin indicating renewed microbial activity. Inventory reduction from T-401 will begin Monday.

Boiler Room Operations: The boiler off line. The vapor heat exchanger (HX-3) is down. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. The condensate receiver pump between the vacuum pumps and the boiler has failed due to unknown reasons (chemical incompatibility issues are suspected).

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing very slightly due to the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling across the vadose zone with the cessation of steam injection. Mike anticipates only a 1 degree C per day reduction in temperature based on a review of previous operations data. Water levels outside the Pilot Area appear to be fairly stable and are being measured today to provide updated information.

Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area was increased to 35 gpm to provide buffering capacity when highly contaminated liquid from T-401 is introduced into the system. Reduction from T-401 (with a higher contaminant load) will be initiated once the laboratory reports analytical data collected on Wed. and levels in T-402 reach 100 inches.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure.

This list will be used to stock a more complete critical parts inventory.

The boiler will remain off line until the heat exchanger issues are resolved. Water levels will continue to be monitored but extraction out of the Pilot Area will not be initiated until water levels increase enough to threaten hydraulic control of the area. Liquid extraction from the Pilot Area is being avoided to reduce cooling during the shutdown.

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Operations Team Meeting Minutes 23 December 2002

Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (On Site); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete with only minor modifications to complete.

Treatment Plant Operations: The treatment plant is operating at a total 26 gpm with 35 gpm coming into the system from the Former Process Area. The immediate goal is to obtain optimum levels in T-402 (150 inches) to allow flexibility in buffering highly contaminated flows from T-401. Suspended solids in the clarifier have improved dramatically (secchi disk tests have improved from 10 inches to 3 feet). DO levels have increased slightly and good foam is evident on the surface of the basin indicating renewed microbial activity. Qualitative observations from the aeration basin indicate renewed ciliate presence and activity. Inventory reduction from T-401 will begin Monday.

Boiler Room Operations: The boiler off line. The vapor heat exchanger (HX-3) is down. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. The condensate receiver pump between the vacuum pumps and the boiler has failed due to chemical incompatibility.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing very slightly due to the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling across the vadose zone with the cessation of steam injection. Mike anticipates only a 1 degree C per day reduction in temperature based on a review of previous operations data. Water levels outside the Pilot Area appear to be fairly stable and are being monitored to provide updated information.

Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area was increased to 35 gpm to provide buffering capacity when highly contaminated liquid from T-401 is introduced into the system. Reduction from T-401 (with a higher contaminant load) will be initiated slowly to prevent shocking the aeration basin.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory. Repair activity is ongoing to resolve seal failures on both the vacuum pumps and the boiler building condensate receivers.

The boiler will remain off line until the heat exchanger issues are resolved. Limited firing of the boiler will occur through the shut down period to allow circulation of boiler feed water-conditioning chemicals. Steam generated during these limited firings will be used to heat water in the DA tank to allow hot water flushing of pipe runs and product lines to avoid fouling. Any excess steam will be vented to the blow down tank or the muffled pipe run.

Water levels will continue to be monitored but extraction out of the Pilot Area will not be initiated until water levels increase enough to threaten hydraulic control of the area. Liquid extraction from the Pilot Area is being avoided to reduce cooling during the shutdown. If water levels within the Pilot Area reach 10 feet MLLW, liquid extraction will be reinitiated.

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Operations Team Meeting Minutes 24 December 2002

Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-Site);

Construction Update: The new systems are substantially complete with only minor modifications to complete.

Treatment Plant Operations: The treatment plant is operating at a total 26 gpm with 35 gpm coming into the system from the Former Process Area. The immediate goal is to obtain optimum levels in T-402 (150 inches) to allow flexibility in buffering highly contaminated flows from T-401. Suspended solids in the clarifier have improved dramatically (secchi disk tests have improved from 10 inches to 3 feet). DO levels have increased slightly and good foam is evident on the surface of the basin indicating renewed microbial activity. Qualitative observations from the aeration basin indicate renewed ciliate presence and activity. Inventory reduction from T-401 will begin this week. The back wash pump (P-206) failed and was successfully repaired with parts stockpiled on-site.

Boiler Room Operations: The boiler off line. The vapor heat exchanger (HX-3) is down. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seals of the vacuum pumps are leaking on one of the pumps and the filter gaskets on both pumps have failed due to chemical incompatibility. A Work Authorization Directive (WAD #2) was issued yesterday to have SCS evaluate and repair the vacuum pumps. The condensate receiver pump between the vacuum pumps and the boiler has failed due to chemical incompatibility. The SCS field staff is researching pump replacement options.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing very slightly due to the reduction in liquid extraction. In addition, temperatures across the Pilot Area are cooling across the vadose zone with the cessation of steam injection.
Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area was increased to 35 gpm to provide buffering capacity when highly contaminated liquid from T-401 is introduced into the system. Reduction from T-401 (with a higher contaminant load) will be initiated slowly to prevent shocking the aeration basin.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory. Repair activity is ongoing to resolve seal failures on both the vacuum pumps and the boiler building condensate receivers.

The boiler will remain off line until the heat exchanger issues are resolved. Limited firing of the boiler will occur through the shut down period to allow circulation of boiler feed water-conditioning chemicals. Steam generated during these limited firings will be used to heat water in the DA tank to allow hot water flushing of pipe runs and product lines to avoid fouling. Any excess steam will be vented to the blow down tank or the muffled pip run. Water levels will continue to be monitored but extraction out of the Pilot Area will not be initiated until water levels increase enough to threaten hydraulic control of the area. Liquid extraction from the Pilot Area is being avoided to reduce cooling during the shutdown. If water levels within the Pilot Area reach 10 feet MLLW, liquid extraction will be reinitiated.

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SiteOpLog: **Ops Meeting Minutes - 26 December**

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bbachman
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Operations Team Meeting Minutes 26 December 2002 Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Leave); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-Site);

Construction Update: No activities today.

Treatment Plant Operations: The treatment plant is still operating at a total of 26 gpm with 35 gpm coming into the system from the Former Process Area. Began reducing inventory from T-401 today. DO levels ar at 7.1 and good foam is still evident on the surface of the basin. Jar tests indicate that the existing polymer used in the basin is acceptable but mixing was increased to mitigate the polymer coagulation problem.

Boiler Room Operations: The boiler continues to remain off line. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation continue to increase slightly. Temperatures across the Pilot Area are continuing to cooling across the vadose zone with the cessation of steam injection. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Continuing to operate as reported on Dec. 24th.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

SCS field staff is working to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory. Repair activity is ongoing to resolve seal failures on both the vacuum pumps and the boiler building condensate receivers.

The boiler will remain off line until the heat exchanger issues are resolved. Limited firing of the boiler will occur through the shut down period to allow circulation of boiler feed water-conditioning chemicals. Steam generated during these limited firings will be used to heat water in the DA tank to allow hot water flushing of pipe runs and product lines to avoid fouling. Any excess steam will be vented to the blow down tank or the muffled pip run. Water levels will continue to be monitored but extraction out of the Pilot Area will not be initiated until water levels increase enough to threaten hydraulic control of the area. Liquid extraction from the Pilot Area is being avoided to reduce cooling during the shutdown. If water levels within the Pilot Area reach 10 feet MLLW, liquid extraction will be reinitiated.

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SiteOpLog: **Operations Team Meeting Minutes 27 December 2002**

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! 12/27/02 14:35 | | Operations Team Meeting Minutes 27 December 2002

bbachman
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Attendees: Kathy LeProwse – USACE PM (District Office); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (On-Site); Cliff Leeper – SCS Engineers (On-Site); Mary Jane Nearman (EPA)

Construction Update: No activities today.

Treatment Plant Operations: The treatment plant is still operating at a total of 26 gpm with 35 gpm coming into the system from the Former Process Area. Continuing to reduce inventory from T-401 today. DO levels will be measured every hour to prevent excessive contaminant load to the basin.

Boiler Room Operations: Limited firing of the boiler will occur today to allow circulation of boiler feed water-conditioning chemicals. Steam generated during these limited firings will be used to heat water in the DA tank to allow hot water flushing of pipe runs and product lines to avoid fouling. Any excess steam will be vented to the blow down tank or the muffled pipe run. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation decreased approximately 0.3 to 0.5 feet since yesterday. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Continuing to operate as reported on Dec. 24th.

Compressed Air Solutions was on site this morning and removed the 'failed' LRVP seal. The seal did not appear to be chemically degraded but did appear to have a tear in it. We took several pictures of the seal prior to shipment to the manufacturer.

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SiteOpLog: Ops Team Meeting Minutes 30 Dec 2002

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! 12/30/02 12:57 | | Ops Team Meeting Minutes 30 Dec 2002

bbachman
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Attendees: Kathy LeProwse – USACE PM (District Office); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (On-Site); Cliff Leeper – SCS Engineers (On-Site); Mary Jane Nearman (EPA) Construction Update: No activities today.

Treatment Plant Operations: The treatment plant is still operating at a total of 26 gpm with 35 gpm coming into the system from the Former Process Area. Continuing to reduce inventory from T-401 at a rate of 4000-4500 gal per day with sump water additions over the next several days. It will require approximately 12-13 days to reduce T-401 inventory to appropriate levels.

Boiler Room Operations: Limited firing of the boiler occurred on Friday to allow circulation of boiler feed water-conditioning chemicals. Steam was not generated during these limited firings because the muffle pipe was fully opened prior to firing. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear stable except at E-07 with a level of 11.5 ft. This well may be exhibiting a lag in water mounding seen in other wells last week due the tightness of the formation in that area. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Continuing to operate as reported on Dec. 24th.

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SiteOpLog: **Ops Meeting Minutes - 2 January**

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Operations Team Meeting Minutes 2 January 2003

Attendees: Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete with only minor modifications to complete.

Treatment Plant Operations: The treatment plant is operating at a total 50 gpm with 35 gpm coming into the system from the Former Process Area. The remainder of the plant's capacity has been dedicated to reducing the inventory of T-401. Conditions in the aeration basin appear good (good foam, low turbidity in the clarifier, abundant protists in sludge).

Boiler Room Operations: The boiler off line. The vapor heat exchanger (HX-3) is down. Liquid extraction from the Pilot Area remains off line to reduce contaminant loads to the GWTP. Mechanical seal on the Liquid Ring Vacuum Pump was replaced and forwarded to the manufacturer to evaluate the mode of failure. Since the site power may be interrupted tomorrow to finish installation of the emergency generator, the boiler will be operated today (rather than tomorrow as scheduled) to circulate boiler feed chemicals and produce hot water for flushing potentially fouled conveyance lines.

Thermal Monitoring/Subsurface Conditions: Water levels across the formation appear to be increasing to the reduction in liquid extraction from the Pilot Area and increased precipitation. In addition, temperatures across the Pilot Area are cooling across the vadose zone with the cessation of steam injection. Average temperatures across the Pilot Area have decreased approximately 13 degrees C since the system was taken off line 14 December. Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area. Operational Issues: Water inventory in the GWTP needs to be reduced to continue operation. Extraction from the Former Process Area was increased to 35 gpm to provide buffering capacity when highly contaminated liquid from T-401 is introduced into the system. Reduction from T-401 (with a higher contaminant load) will be initiated slowly to prevent shocking the aeration basin.

Engineering evaluations continue to address problems with the vapor system. These evaluations include reassessing the HX-3 problems and options for separating the high contaminant loading from the condensate receivers into a separate waste stream. In addition, a pre-treatment option will be developed for the extracted liquids from the Pilot Area if a chemical evaluation determines that the contaminant load from the Pilot Area is likely to interfere with continued aeration basin efficiency.

While the boiler is off line, field staff has been directed to complete the previously requested evaluation of the boiler room facility to identify other plant components that may contain parts fabricated of materials susceptible to chemical degradation. In addition, the operators have been directed to identify key components that will critically impact plant operations in the event of failure. This list will be used to stock a more complete critical parts inventory. Repair activity is ongoing to resolve seal failures on both the vacuum pumps and the boiler building condensate receivers.

The boiler will remain off line until the heat exchanger issues are resolved. Limited firing of the boiler will occur through the shut down period to allow circulation of boiler feed water-conditioning chemicals. Steam generated during these limited firings will be used to heat water in the DA tank to allow hot water flushing of pipe runs and product lines to avoid fouling. Any excess steam will be vented to the blow down tank or the muffled pipe run.

Water levels will continue to be monitored and groundwater extraction out of the Pilot Area will be re-started today to reduce high water levels. Pumping out of the Pilot Area will only be conducted during daylight hours to prevent an inadvertent overflow of the product tank. Targeted rates of extraction are 10 gpm out of T-401, 10-12 gpm out of the Pilot Area 30-35 gpm out of the Former Process Area.

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Operations Team Meeting Minutes 3 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office); Kathy LeProwse – USACE PM (On Leave); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (On Leave); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete with only minor modifications to complete.

Treatment Plant Operations: The treatment plant is operating at a total 35 gpm with 35 gpm coming into the system from the Former Process Area. The remainder of the plant's capacity has been dedicated to reducing the inventory of T-401. Conditions in the aeration basin appear good (good foam, low turbidity in the clarifier, abundant protists in sludge). The system is running on emergency power due to widespread power failures in Kitsap County.

Boiler Room Operations: The boiler is off line. The emergency generator hook-up is continuing as scheduled despite the power failure.

Thermal Monitoring/Subsurface Conditions: No data is available due to the power failure.

Contaminant Recovery: TOC concentrations from the Pilot Area are not being reported due to the interruption in pumping from the Pilot Area.

Operational Issues: Once power is restored, pumping out of the Pilot Area will resume during daylight hours to prevent an inadvertent overflow of the product tank. Targeted rates of extraction are 10 gpm out of T-401, 10-12 gpm out of the Pilot Area 30-35 gpm out of the Former Process Area.

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Operations Team Meeting Minutes 6 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Kathy LeProwse – USACE PM (On Site) Travis Shaw – USACE Site Manager (On Site) Mike Bailey – USACE Hydrogeologist (On Site) Brenda Bachman – USACE Monitoring Coordinator (On Site) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today.

Boiler Room Update – The boiler off line pending engineering evaluations to repair the vapor treatment system.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is 50 gpm with 20 gpm dedicated to reducing the inventory in T-401 (T-401 received an influx of water from the sump due to heavy rain over the past week).

Subsurface/Thermal Monitoring Update – Water levels are high with in the Pilot Area and need to be reduced.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction will targeted to approximately 79 gpm partitioned between the Pilot Area (12gpm), the well field outside the Pilot Area (47 gpm) and inventory reduction in T-401 (20 gpm).

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Operations Team Meeting Minutes 7 January 2003

Attendees:

Kathy LeProwse – USACE PM (District Office) Travis Shaw – USACE Site Manager (District Office) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today.

Boiler Room Update – The boiler off line pending engineering evaluations to repair the vapor treatment system.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is 80 gpm with 20 gpm dedicated to reducing the inventory in T-401 (T-401 received an influx of water from the sump due to heavy rain over the past week).

Subsurface/Thermal Monitoring Update – Water levels are high with in the Pilot Area and need to be reduced.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction will targeted to approximately 80 gpm partitioned between the Pilot Area (25 gpm), the well field outside the Pilot Area (35 gpm) and inventory reduction in T-401 (20 gpm). Chemical Oxygen Demand (COD) will be used to evaluate potential negative impacts to the aeration basin due to increased contaminant flows from the Pilot Area. Samples collected at the plant manifold with a COD in excess of 500 will trigger a reduction in pumping from the Pilot Area.

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Operations Team Meeting Minutes 8 January 2003

Attendees:

Travis Shaw – USACE Site Manager (District Office) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today.

Boiler Room Update – The boiler off line pending engineering evaluations to repair the vapor treatment system.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. The treatment rate was approximately 80 gpm yesterday with 20 gpm from T-401, 26 gpm from the Pilot Area and 35 gpm from the Former Process Area. Pumping from the Pilot Area was suspended late yesterday afternoon as planned but not before COD data indicated that the 500 mg/L critical COD value established yesterday had been exceeded. Tank levels in T-401 have been reduced to normal operating levels.

Subsurface/Thermal Monitoring Update – Water levels are high with in the Pilot Area and need to be reduced.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Since the inventory in T-401 is back within normal operating levels, flow through the plant will be returned to the normal operating path with influent from both the Pilot Area and the Former Process Area equalizing in T-401 before being pumped to the DAF. Extraction rates from the Pilot Area will be targeted at 26 gpm and 35 gpm from the Former Process Area. Samples will be collected at T-401 and the Manifold prior to restarting the Pilot Area wells to obtain some measure of the contaminant levels in the system. Once the Pilot Area wells are re-started, an additional TOC sample will be collected and run manually to obtain and indication of the increase in contamination introduced into the plant by the Pilot Area effluent. The field staff will measure water levels outside the Pilot Area today to allow an evaluation of hydraulic control site wide and help determine if the current pumping strategy is sufficient.

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Operations Team Meeting Minutes 9 January 2003

Attendees: Mary Jane Nearman – EPA RPM (District Office); Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (On Site); Cliff Leeper – SCS Engineers (On-site); Joe Harrington - SCS Engineers (SCS Office);

Construction Update: The new systems are substantially complete with only minor modifications to complete. Chemical Feed System (caustic/acid injection) is being commissioned today.

Treatment Plant Operations: The treatment plant is operating at a total 61 gpm with 35 gpm coming into the system from the Former Process Area and 26 gpm out of the Pilot Area. Aeration basin conditions are good (good foam, DO above 5 mg/L, visibility in the clarifier at 2.5 feet).

Boiler Room Operations: The boiler is off line. The boiler room staff has completed the critical parts/critical repair triage and repairs activity has been initiated in preparation to restarting thermal operations.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are still high but progress is slowly being made reducing these levels. All measurements from the Pilot Area indicate water levels are now below 10 feet MLLW.

Contaminant Recovery: No report today.

Operational Issues: In an effort to reduce water levels in the Pilot Area, liquid extraction out of the Pilot Area will be increased to 35 gpm during daylight hours. Extraction from the Former Process Area wells will remain at 35 gpm. The concentration of contaminants will be monitored by collecting samples at the GWTP manifold and running them manually on the on-site TOC instrument.

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Operations Team Meeting Minutes 10 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office); Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total 70 gpm with 35 gpm coming into the system from the Former Process Area and 35 gpm out of the Pilot Area. Aeration basin conditions are good (good foam, DO above 5 mg/L, visibility in the clarifier at 2.5 feet). Boiler Room Operations: The boiler is off line. An attempt to fire the boiler failed this morning due to fouling of the burner. The burner was cleaned and boiler fired successfully. The boiler room staff has completed the critical parts/critical repair triage and repairs activity has been initiated in preparation to restarting thermal operations.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are still high but progress is slowly being made reducing these levels. All measurements from the Pilot Area indicate water levels are now below 10 feet MLLW. The pump in extraction well EW-3 was removed yesterday and found to be heavily fouled with crystallized NAPL. The pump will be cleaned and placed back into the well.

Contaminant Recovery: No report today.

Operational Issues: Liquid extraction from the Pilot Area will shift to 24-hour operation beginning Saturday at about 35 gpm in an effort to reduce water levels to approximately 8 feet MLLW by Monday morning. Assuming that this target is met, steam injection will be restarted at low fire with targeted flows into each injection well of 200-400 lbs/hr. Liquid extraction will be balanced to match injection plus approximately 10 gpm to recover natural groundwater infiltration. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site.

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Operations Team Meeting Minutes 13 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site); Joe Harrington SCS Engineers (SCS Offices);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total about 55 gpm with 35 gpm coming into the system from Former Process Area (FPA) and 22 gpm from the Pilot Area (PA). The GWTP had been operation at 70 gpm for most of the weekend with the flows split evenly between the FPA and the PA. Declining dissolved oxygen levels in the aeration basin during Saturday and Sunday lead to an interruption in extraction from the PA at about 2300 Sunday night. Liquid extraction from the PA was restarted this morning after monitoring indicated a slight rebound in DO levels. TOC and COD had remained fairly stable at 400 mg/L TOC and 800-900 mg/L COD at the manifold. Current operations are 23 gpm from the PA and 35 gpm from the FPA.

Boiler Room Operations: The boiler is off line but ready to begin low fire steam injection.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are still high but progress was made in reducing water levels over the weekend with a more aggressive pumping schedule (35 gpm over 24 hours). Average water levels within the PA are approximately 8.1 feet MLLW.

Contaminant Recovery: No report today.

Operational Issues: Liquid extraction from the Pilot Area shifted to 24-hour operation beginning Saturday at about 35 gpm in an effort to reduce water levels to approximately 8 feet MLLW by Monday morning. Liquid extraction rates from the PA will be adjusted to approximately 20-25 gpm to match liquid equivalent of injected steam plus 10 gpm to withdraw natural groundwater infiltration. Steam injection will be restarted at low fire with targeted flows into each injection well of 200-400 lbs/hr. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site. The GWTP DO levels will also be monitored closely at the manifold, downstream of the DAF, at the outlet of T-402 and in the aeration basin. A decrease in basin DO levels will be mitigated through increasing air injection into the basin. The operators are also exploring methods for adding diffusers to the basin to optimize gas transfer. Based on DO monitoring, additional flow regimes will also be explored to maintain adequate oxygen levels in the aeration basin during this period of low fire steam injection.

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Operations Team Meeting Minutes 14 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total about 55 gpm with 35 gpm coming into the system from Former Process Area (FPA) and 22 gpm from the Pilot Area (PA). Conditions in the aeration basin appear good (good foam formation, DO at 4.0 mg/L, 1.5 feet of visibility in the clarifier). Evaluations of DO within the plant revealed that DO levels entering the plant are fairly depressed (1.0 mg/L), increase on the downstream side of the DAF (4.0 mg/L), decrease again after passing through T-402 (1.0 mg/L) and are increased by the aeration in the basin (4-6 mg/L). Brief experimentation with the blowers providing air to the basin revealed that an increase in DO levels can be achieved by fully opening all air supply valves into the basin and bring both blowers on-line simultaneously. A 2 mg/L increase in basin DO levels was observed after 30 minutes at the current 55 gpm flow rate. Carbon change out was completed today with a fresh carbon now in standby in the vessel.

Boiler Room Operations: The boiler is operating and on-line. Injection pressure at the header is 15 psi at just below 300 degrees F for an approximate liquid equivalent of 8-10 gpm.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are still fairly high but stable at about 8.7 MLLW. Liquid extraction rates will be held constant for the next 24 hours. Dryer weather may reduce groundwater infiltration to allow water levels to decrease without alteration to the pumping rates. In attempting to manage to avoid surface releases, the area around T-55 needs to be watched carefully. Mike reports the thermocouple at 3.9 feet MLLW is reading 107 degrees C.

Contaminant Recovery: No report today.

Operational Issues: Steam injection was restarted at low fire yesterday afternoon with targeted flows into each injection well of 200-400 lbs/hr. As of this morning, flow rates into the injection wells was balanced at between 190-210 lbs/hr with the exception of IW-9. Based on feed water flow rates, liquid equivalent of injected water is approximately 8-10 gpm. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site. The GWTP DO levels will also be monitored closely at the manifold, downstream of the DAF, at the outlet of T-402 and in the aeration basin. A decrease in basin DO levels will be mitigated through increasing air injection into the basin.

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Operations Team Meeting Minutes 15 January 2003

Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (On site); Kathryn Carpenter – USACE Chemist (On Site); Cliff Leeper – SCS Engineers (On-site); Dave Roberson – SCS Engineers (On Site);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total about 59 gpm with 35 gpm coming into the system from Former Process Area (FPA) and 24 gpm from the Pilot Area (PA). Conditions in the aeration basin appear good (good foam formation, DO at 4.0 mg/L, 1.5 feet of visibility in the clarifier).

Boiler Room Operations: The boiler is operating and on-line. Injection pressure at the header is 15 psi at just below 250 degrees F for an approximate liquid equivalent of 5-8 gpm. The feed water valve from the DA tank appears to be sticking; Cliff will follow-up with the vendor to determine if a service call is necessary. Unfortunately, the vendor for the TOC drain pump parts has changed the delivery schedule for replacement parts. The TOC instrument may not be on-line for automated operation until later in the month, rather than by the end of the week. Manual operation of the TOC instrument will continue until the pump is repaired.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are still fairly high but stable. Liquid extraction rates will be held constant for the next 24 hours. Dryer weather may reduce groundwater infiltration to allow water levels to decrease without alteration to the pumping rates. In attempting to manage to avoid surface releases, the area around T-55 needs to be watched carefully. Mike reports the thermocouple at 3.9 feet MLLW is still reading at steam temperatures. Other high temperature readings showing increases to around 100 degrees C include T-1, T-11, T-49 and T-51.

Mike voiced some concern regarding the pumping rates posted to the wed site based on the lack of response to pumping in the extraction wells. However, the pumping rates collected electronically are also being verified manually by timing pumps strokes and appear to be in agreement. Cliff will check the actual output of E-2 in an effort to begin troubleshooting this disparity.

Contaminant Recovery: No report today.

Operational Issues: Steam injection is continuing at low fire with targeted flows into each injection well of 200-400 lbs/hr. As of this morning, flow rates into the injection wells was balanced at between 190-210 lbs/hr with the exception of IW-9. Based on feed water flow rates, liquid equivalent of injected water is approximately 5-8 gpm. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site. The GWTP DO levels will also be monitored closely at the manifold, downstream of the DAF, at the outlet of T-402 and in the aeration basin. A decrease in basin DO levels will be mitigated through increasing air injection into the basin. Injection well I-11 will be throttled back to reduce near surface heating in the vicinity of T-55. Temperatures at T-49 and T-55 will be monitored closely for indications of imminent steam breakthrough at E-6.

* Note: The pump in E-3 was re-installed yesterday. The pump will remain off until temperatures in the vicinity increase to avoid fouling of the pump with crystallized product already in the well.

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Operations Team Meeting Minutes 16 January 2003

Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (District Office); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Kathryn Carpenter – USACE Chemist (District Office); Marlowe Dawag (District Office); Cliff Leeper – SCS Engineers (On-site);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total about 69 gpm with 35 gpm coming into the system from Former Process Area (FPA) and 24 gpm from the Pilot Area (PA). The remainder of flow in the plant is being dedicated to balancing levels in the treatment plant equalization tanks. Conditions in the aeration basin appear good (good foam formation, 1.3 feet of visibility in the clarifier). DO levels in the basin have continued to fluctuate but have been mitigated by increasing air flow into the basin by putting the second blower on-line for 30 minutes when DO drops below 2 mg/L. This adjustment was required 3 times over the last 24 hours. Qualitatively, biological activity appears to be depressed. Ciliates and other protests are apparent but appear to behaving sluggishly.

Boiler Room Operations: The boiler is operating and on-line. Injection pressure at the header is 15 psi at just below 250 degrees F for an approximate liquid equivalent of 5-8 gpm. The feed water valve from the DA tank appears to be sticking; Cliff will follow-up with the vendor to determine if a service call is necessary.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are decreasing. Liquid extraction rates will be held constant for the next 24 hours. Dryer weather may reduce groundwater infiltration to allow water levels to decrease without alteration to the pumping rates. Steam override is apparent at instrument strings T-3, T-7, T-37, T-50 and T-63. The arrays around E-1, E-6 and E-7 are warming more rapidly.

Mike voiced some concern regarding the pumping rates posted to the wed site based on the lack of response to pumping in the extraction wells. However, the pumping rates collected electronically are also being verified manually by timing pumps strokes and appear to be in agreement. Cliff verified that pump in E-2 is pumping at the rate actually indicated by the manual rate measurements. Continued problems with the stroke counters may require a warranty claim with the construction contractor to replace the new stroke counters with the old style counters that appeared to be more reliable.

Contaminant Recovery: No report today.

Operational Issues: Steam injection is continuing at low fire with targeted flows into each injection well of 200-400 lbs/hr. As of this morning, flow rates into the injection wells was balanced at between 190-210 lbs/hr with the exception of IW-9 (30 lbs/hr). Based on feed water flow rates, liquid equivalent of injected water is approximately 5-8 gpm. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site. The GWTP DO levels will also be monitored closely at the manifold, downstream of the DAF, at the outlet of T-402 and in the aeration basin. A decrease in basin DO levels will be mitigated through increasing air injection into the basin. Basin DO levels will be checked hourly during the day shift and every 2 hours on the night shift. The action level for bumping the second blower will be 2 mg/L. Injection well I-11 was throttled back about 90 lbs/hr to reduce near surface heating in the vicinity of T-55. Temperatures at T-49 and T-55 will be monitored closely for indications of imminent steam breakthrough at E-6.

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Operations Team Meeting Minutes 17 January 2003

Attendees:

Kathy LeProwse – USACE PM (District Office); Travis Shaw – USACE Site Manager (On Site); Mike Bailey – USACE Hydrogeologist (District Office); Brenda Bachman – USACE Monitoring Coordinator (District Office); Kathryn Carpenter – USACE Chemist (District Office); Marlowe Dawag (District Office); Cliff Leeper – SCS Engineers (On-site); Joe Harrington – SCS Engineers (SCS Office);

Construction Update: The new systems are substantially complete pending modifications required to repair the vacuum system.

Treatment Plant Operations: The treatment plant is operating at a total about 60 gpm with 35 gpm coming into the system from Former Process Area (FPA) and 24 gpm from the Pilot Area (PA). Conditions in the aeration basin appear good (good foam formation, 1.2 feet of visibility in the clarifier). DO levels in the basin have continued to fluctuate but have been mitigated by increasing air flow into the basin by putting the second blower on-line for 30 minutes when DO drops below 2 mg/L. This adjustment was required 4 times over the last 24 hours. Qualitatively, biological activity appears to be depressed. Ciliates and other protests are apparent but appear to behaving sluggishly. Brenda, Kathryn and Marlowe are working on an amendment to the FSP that may temporarily increase sampling in the GWTP in an effort to obtain data to more fully troubleshoot the issues regarding aeration basin performance. This plan should be completed by early next week.

Boiler Room Operations: The boiler is operating and on-line. Injection pressure at the header is 15 psi at just below 250 degrees F for an approximate liquid equivalent of 5-8 gpm. The feed water valve from the DA tank was evaluated by the vendor and confirmed that the valve seat was sticking. This may be a warranty issue pending completion of the vendor's evaluation.

Thermal Monitoring/Subsurface Conditions: Water levels in the Pilot Area are decreasing. Liquid extraction rates will be decreased today to better balance extraction rates with injection. Based on current extraction rates, flows from E-2 and E-6 will be reduced to approximately 4 gpm. Increased temperatures are apparent around E-1 and E-2. In an effort to decrease the potential for steam breakthrough over the weekend, Injection rates will be reduced in injection wells I-1,I-3, I-4 and I-5. These wells were selected based on an evaluation of the vertical well profiles from the instrument strings around E-1 and E-2. These profiles indicated that steam override was occurring at instrument strings on the west side of the PA (T-1, T-2, T-3, T-4, T-7, T-8 and T-11) but not on the eastern side of E-2 (T-9, T-10 and T-12).

Contaminant Recovery: No report today.

Operational Issues: Steam injection is continuing at low fire with targeted flows into each injection well of 200 lbs/hr. As of this morning, flow rates into the injection wells was balanced at between 190-210 lbs/hr with the exception of IW-9 (30 lbs/hr). Based on feed water flow rates, liquid equivalent of injected water is approximately 5-8 gpm. The goal will be to hold water levels constant within the Pilot Area while beginning to re-warm the site. Based at the discussion of potential stream breakthrough above, steam injection will be reduced to approximately 100 lbs/hr at I-1, I-3, I-4 and I-5. Liquid extraction will be reduced to about 16 gpm by reducing pumping rates at E-2 and E-6.

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Operations Team Meeting Minutes 21 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Kathy LeProwse – USACE PM (On Site) Travis Shaw – USACE Site Manager (On Site) Rich Fink – USACE Resident Engineer (On Cell) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Kathryn Carpenter - USACE Chemist (District Office) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the design is complete.

Boiler Room Update – The boiler is operating on low fire with 15 psi at the header. Injection at the injection wells is targeted 200 lbs/hr except at I-1, I-3, I-4, I-5, which are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 50 gpm with 16-17 gpm from the Pilot Area (PA) and 35 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable and ranging between 5.5-6.0 mg/L. Visibility in the clarifier has also been stable at 1 foot 2 inches as measured with a secchi disk. Foam on the basin is abundant and protist activity is vigorous.

Subsurface/Thermal Monitoring Update – Water levels is the PA are stable at approximately 7 feet MLLW in the formation. Heating in the vicinity or E-2, E-3 and E-4 is increasing though steam breakthrough does not appear imminent. Pumping from E-7 appears to be low despite high water levels in the casing (6.6 feet MLLW). The exhaust from the pump may be fouled and needs to be checked.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will continue to be targeted at about 16 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4 and I-5 which are shut back to 100 lbs/hr to avoid steam break through at the extraction well or the surface. Given the stability of DO measurements, DO sampling in the aeration basin will be cut back to every 4-hours rather that ever 2 hours. The exhaust port on well E-7 will be evaluated and cleaned if necessary to allow proper operation of the pump.

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Operations Team Meeting Minutes 22 January 2003

Attendees:

Travis Shaw – USACE Site Manager (On Site) Rich Fink – USACE Resident Engineer (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (On Site) Marlowe Dawag – USACE Process Engineer (On Site) Cliff Leeper – SCS Engineers (On Site) Joe Harrington – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the design is complete.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted 200 lbs/hr except at I-1, I-3, I-4, I-5, which are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden. The product tank has been fouling consistently the last couple of days and may need to be drained to allow a visual inspection of the cone screen in the tank. This may result in a temporary (1 hour) interruption in liquid extraction from the Pilot Area.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 50 gpm with 16-17 gpm from the Pilot Area (PA) and 35 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable and ranging between 5.5-6.0 mg/L. Visibility in the clarifier has also been stable at 1 foot 2 inches as measured with a secchi disk. Foam on the basin is abundant and protist activity is vigorous.

Subsurface/Thermal Monitoring Update – Water levels is the PA are stable at approximately 7 feet MLLW in the formation. No significant change in heating was observed over the last 24 hours. Pumping from E-7 appears to be low despite high water levels in the casing (6.6 feet MLLW). The exhaust from the pump was fouled yesterday and will need to be checked again today based on water levels and pump performance data.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will continue to be targeted at about 16 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4 and I-5 which are shut back to 100 lbs/hr to avoid steam break through at the extraction well or the surface. The exhaust port on well E-7 will be evaluated and cleaned if necessary to allow proper operation of the pump. Once the exhaust is cleaned, the pump will be set to a targeted 1 gpm flow rate.

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Operations Team Meeting Minutes 23 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (District Office) Kathy LeProwse – USACE PM (District Office) Travis Shaw – USACE Site Manager (District Office) Rich Fink – USACE Resident Engineer (District Office) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Marlowe Dawag – USACE Process Engineer (On Site) Kathryn Carpenter – USACE Chemist (District Office) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the design is complete.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted 200 lbs/hr except at I-1, I-3, I-4, I-5, which are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden. The product tank has been fouling and was backwashed again yesterday. This is now required approximately every 24 hours. The visual inspection of the tank planned for yesterday was not conduct due to the lack of proper confined space ventilation equipment.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 50 gpm with 16-17 gpm from the Pilot Area (PA) and 35 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable and ranging between 5.5-6.0 mg/L. Visibility in the clarifier has also been stable at 1 foot 2 inches as measured with a secchi disk. Foam on the basin is abundant and protist activity is vigorous.

Subsurface/Thermal Monitoring Update – Water levels is the PA are stable at approximately 7 feet MLLW in the formation. No significant change in heating was observed over the last 24 hours.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will continue to be targeted at about 16 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4 and I-5 which are shut back to 100 lbs/hr to avoid steam break through at the extraction well or the surface. The exhaust port on well E-7 will be evaluated and cleaned if necessary to allow proper operation of the pump. Once the exhaust is cleaned, the pump will be set to a targeted 1 gpm flow rate.

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Operations Team Meeting Minutes 24 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Travis Shaw – USACE Site Manager (On Site) Rich Fink – USACE Resident Engineer (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Keith – SCS Engineers (On Site) Joe Harrington – SCS Engineers (SCS Office)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the design is complete.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted 200 lbs/hr except at I-1, I-3, I-4, I-5, which are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 55 gpm with 19 gpm from the Pilot Area (PA) and 35 gpm from the Former Process Area (FPA). Pumping rates from E-4 above targets resulting in the increased flows from yesterday. DO in the aeration basin has been stable and ranging between 5.5-6.0 mg/L. Visibility in the clarifier has also been stable at 1 foot 2 inches as measured with a secchi disk. Foam on the basin is abundant and protist activity is vigorous. Installation of the diffusers has been more difficult than expected, but the operators hope to make progress over the weekend. Once diffuser installation begins, DO measurement in the basin will be increased to every 2 hours during the day shift and ever 4 hours during the night shift.

Subsurface/Thermal Monitoring Update – Water levels is the PA are stable at approximately 7 feet MLLW in the formation. Heating on the north and northwest sides of the E-4 array is evident at instrument strings T-25, T-30 and T-31. This may be a result of steam override from the vicinity of I-5. Pumping at E-7 continues to be erratic due to fouling of the exhaust valve. The pumping rate from E-4 increased for no apparent reason and will need to be reset to approximately 4 gpm.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will continue to be targeted at about 16 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4 and I-5 which are shut back to 100 lbs/hr to avoid steam break through at the extraction well or the surface. The exhaust port on well E-7 will be evaluated and cleaned if necessary to allow proper operation of the pump. Once the exhaust is cleaned, the pump will be set to a targeted 1 gpm flow rate to establish a liquid level in the well casing of about 4 feet MLLW. The pumping rate from E-4 will be re-set to approximately 4 gpm. If the operators are successful in installing diffusers in the basin, DO sample frequency will increase to every 2 hours during the day shift and every 4 hours during the night shift.

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Operations Team Meeting Minutes 27 January 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Kathy LeProwse – USACE Project Manager (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington – SCS Engineers (SCS Office)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the modification is complete.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted at 200 lbs/hr except at I-1, I-3, I-4, I-5, and I-11 that are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden. This injection rate yields approximately 5.2 gpm.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 56 gpm with 18.5 gpm from the Pilot Area (PA) and 37.5 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable and ranging between 3.0-4.0 mg/L over the weekend. However, at noon on Sunday, the DO dropped to 2.0. The second blower was turned on for 45 minutes. Visibility in the clarifier has also been stable at 1 foot as measured with a secchi disk. Foam on the basin is abundant and protist activity is vigorous. (The protist activity of today is approximately 60 – 70% of the activity level prior to the basin upset on 12/14/02.) Installation of the diffusers has been more difficult than expected and no progress was made over the weekend. Once diffuser installation begins, DO measurement in the basin will be increased to every 2 hours during the day shift and ever 4 hours during the night shift.

Subsurface/Thermal Monitoring Update – Water levels in the PA are increasing about 6 – 12 inches since Friday at approximately 8.4 feet MLLW in the formation. Mike recommended we increase the extraction target to 25 to 26 gpm to bring the water levels back down. Temperatures are elevated at T-17 (95 C in the vadose zone); T-52 (100 C in the vadose zone, which jumped from 35 C last week); and T-31 (100 C in the cap at the highest thermocouple). There is no concern at this time for steam override at E-3 and E-6 based on the temperature data. Pumping at E-7 continues to be erratic due to fouling of the exhaust valve. The temperature at E-7 dropped 20 C since last week. Since the maintenance issue is problematic, we agreed to shut off the extraction at E-7 today for the next 2 – 3 days and to watch the temperature change. (E-7 was pumping at 0.8gpm prior to the shut down.) Requested Brenda make a table comparing chemistry data with field observations to find a correlation between the two.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will be increased to a target of about 25 to 26 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4, I-5 and I-11 which are shut back to 100 lbs/hr to avoid steam break through at the extraction well or the surface, and E-7 will be shut down completely and watched over the next 2 to 3 days. The operators will keep trying to install the diffusers today. (Call Brenda to let her know if any diffusers are installed successfully today.) If the operators are successful in installing diffusers in the basin, DO sample frequency will increase to every 2 hours during the day shift and every 4 hours during the night shift. Starting tomorrow, the operators will take a manual TOC reading at SP-1 at least once a day. Later this week, the operators will put some digester solids through the filter press.

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Attendees:

Kathy LeProwse – USACE Project Manager (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington – SCS Engineers (SCS Office)

Construction Update – Construction crews are not on-site today. Construction activity to repair the vacuum system will begin once the modification is complete. It was determined that the condensate line and the main liquid line will be kept as separate streams to have the capability of collecting the condensate for separate disposal for both understanding the quantity/composition and as a means to "insulate" (for the lack of a better word) the treatment plant from potentially higher concentrations. In addition, the heat exchanger is currently being resized.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted at 200 lbs/hr except at I-1, I-3, I-4, I-5, and I-11 that are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden. I-1 has been reduced to 50 lbs/hr to control heat migration toward E-02. The current injection rate provides approximately 5.3-5.8 gpm to the pilot area.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 56 gpm with 22 gpm from the Pilot Area (PA) and 37.5 gpm from the Former Process Area (FPA). Twelve diffusers were installed yesterday and approximately 12 more will be installed today. DO in the aeration basin has been stable at approximately 5.0. We are working on setting up a DO profile in the aeration basin to determine the effect of the diffusers on circulation. We hope to be able to cut back air flow during 'normal' loads so that we have additional air input capability if needed during antipated higher basin loading times. Operators will begin decreasing total TP inventory this week in preparation to shut down the basin system next week to troubleshoot the clarifier pump (approx 1 day). Pilot system extraction will continue but will be inventoried until the aeration basin system (mainly the clarifier) is back on-line. FPA extraction may be decreased during this time to provide volume for pilot area extraction.

Subsurface/Thermal Monitoring Update – Water levels in the PA are increasing have remained somewhat stable except at E-07 which has increased due the pump being turned off yesterday. E-07 will remain off-line until the vapor extraction system is back on-line and we can increase injection at I-11. The PA extraction target of 25 to 26 gpm set yesterday will continue. E-03 has been turned on and set to pump at 3gpm. It began pumping at approximately 11:30am today. Elevated temperatures at E-02 indicate breakthrough may occur soon and injection rate at I-1 has been decreased to 50 lbs/hr. Temperatures at E-01 are not high enough to resume pumping but once they are, it will be too hot for required well maintenance. Mike will pursue this issue with Dave Becker from the USACE Center of Expertise. All other injection wells will remain at the previously targeted rates.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA remain at a target of 25 to 26 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-1, I-3, I-4, I-5 which are shut back to 100 lbs/hr to avoid steam break through at the extraction wells or the surface. I-11 will be decreased to injection of 50 lbs/hr. E-03 will resume pumping today at 3 gpm. Brenda, Marlowe and Kathryn will define DO profile for aeration basin. Inventory in TP will be reduced this week to clean out clarifier next week without shutting down the PA extraction.

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Operations Team Meeting Minutes January 30, 2003

Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Rich Fink – USACE Resident Engineer (On Site) Kathy LeProwse – USACE Project Manager (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Cliff Leeper– SCS Engineers (On Site) Katherine Carpenter- USACE Data Management (District Office) Eva Davis – EPA Laboratory (Oklahoma) Marie Lacey – EPA (Region 9 Office) Liena Wolfe – USACE Project Manager (Ft. Lewis)

Construction Update – Pease Construction was on-site looking at the vapor system.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted 200 lbs/hr except at I-1, I-3, I-4, I-5, I-11 which are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr at 0.5 psi per foot of overburden.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 65 gpm with 24.5 gpm from the Pilot Area (PA) and 39.5 gpm from the Former Process Area (FPA). Pumping rates from E-4 above targets resulting in the increased flows from yesterday. DO in the aeration basin has been unstable and ranging between 0.5-5.7 mg/L. Visibility in the clarifier has been stable at 1 foot 6 inches as measured with a secchi disk. Installation of 24 diffusers has been completed. DO measurement in the basin has been increased to every 2 hours during the day shift and ever 4 hours during the night shift. Have begun pressing solids from the digester yesterday will take 5 – 6 days to complete.

Subsurface/Thermal Monitoring Update – Water levels is the PA are stable at approximately 7 feet MLLW in the formation. Temperatures are stable in all extraction wells and no concern of breakthrough.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Liquid extraction from the PA will continue to be targeted at about 16 gpm with the current injection rates maintained at 200 lbs/hr at all wells except I-3, I-4, I-5 and I-11 which are shut back to 100 lbs/hr and I-01 are shut back to 50 to avoid steam break through at the extraction well or the surface. The well E-7 is shut down. DO profiles are being completed today in the aeration basin.

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02/03/03 11:01 | | Ops Team Meeting Minutes 02 February 2003

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Operations Team Meeting Minutes 02 February, 2003 Attendees:

Mary Jane Nearman – EPA RPM (Region 10 Office) Kathy LeProwse – USACE Project Manager (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Marlowe Dawag – USACE Process Engineer (District Office) Cliff Leeper– SCS Engineers (On Site) Katherine Carpenter- USACE Data Management (District Office) Mike Bailey- USACE Subsurface Coordinator (District Office)

Construction Update – No construction activities today.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection is continuing at previously set rates. Extraction from the pilot area is 22.39 gpm.

Treatment Plant Update – The treatment plant is operating normally with 99% treatment across the aeration basin. Current treatment rate is approximately 53 gpm with 22.4 gpm from the Pilot Area (PA) and 37.4 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable at approximately 5.0 mg/L. The second blower is now being used as the primary blower which seems to have a positive effect likely due to increased efficiency. Visibility in the clarifier is stable but the lift pump is clogged and will be cleaned out on Wednesday. Installation of additional diffusers will be done on Tuesday and Thursday this week. Continuing to press solids from the digester in anticipation of higher need in the near future. Polymer test showed 22% reduction of PCP. No PAH results yet.

Subsurface/Thermal Monitoring Update – Average water levels in the PA are stable at approximately 7 feet MLLW in the formation. Temperatures at E-06 and E-07 are increasing and we will continue to watch these to avoid steam breakthrough. Target extraction rates are low in E-05 and E-03 and will be increased if possible.

Contaminant Recover Update – No contaminant recovery or chemistry to report today. TOC spikes are occuring on a periodic basis that appear to be correlated with pumping rates in E-03. We will evaluate CLP data in an attempt to determine if E-03 provides greater contaminant concentrations and is responsible for the TOC spikes.

Operations Update – Injection and extraction will continue as previously identified. Well E-07 will be turned on today at 1 stroke per minute. The exhaust port will be cleaned regularly to keep it running if possible.

[Edited by bbachman on 02/06/03 01:45 PM]

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02/04/03 16:01 | | Ops Team Meeting Minutes 4 February 2003

g3pmemkl
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Operations Team Meeting Minutes 4 February 2003

Attendees: Kathy LeProwse – USACE Project Manager (On Site) Mike Bailey – USACE Hydrogeologist (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (At home) Cliff Leeper – SCS Engineers (On Site)

Construction Update – Construction crews are on-site today. Construction activity to repair the vacuum system outside the boiler building in the well field will begin today.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Injection at the injection wells is targeted at 200 lbs/hr except at I-1 at 50 lbs/hr, and I-3, I-4, I-5, and I-11 that are set to approximately 100 lbs/hr. Injection well I-9 continues to be a low performing well accepting only 30 lbs/hr. This injection rate yields approximately 5.2 gpm. Extraction from the PA is at 24.91 gpm today. Well E07 is totally plugged this morning and is off line. The TOC instrument has been indicating spikes and needed to be checked. The plexiglass well at the front end of the sampler was growing crystals. The staff cleaned the well of crystals and turned the TOC instrument on again. The TOC will be taken off line sometime this week and thoroughly cleaned. Kathryn will be doing a QA review of the TOC data from the beginning and will mark bad data in the dataset.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate is approximately 63 gpm with 24.9 gpm from the Pilot Area (PA) and 37.1 gpm from the Former Process Area (FPA). DO in the aeration basin has been stable and ranging between 2.4 -3.0 mg/L. Only one blower is running. Visibility in the clarifier has also been stable at 2 foot as measured with a secchi disk. Cliff intends to repair the RAS pumps in the clarifier starting Wednesday morning. OMI has met the requirements for the confined space entry at the basin. The flow meter at T401 is not working and will be investigated later this week. Microbial action is good today. They finished pressing solids and the digester will be brought back on line today with 2 ft. solids left in the digester. Plan to add more diffusers on Thursday and Friday.

Subsurface/Thermal Monitoring Update – No DTS data is available today. Water levels in the PA are at approximately 7 feet MLLW in the formation, with a slight downward trend. Subsurface temperatures are in the same pattern as yesterday. E5 is still warming but at a slower rate. It is warming in the vicinity of E3.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction will continue as previously identified. The TOC instrument well will be cleaned and put back on line. Additional cleaning of the TOC will occur later this week.

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! 02/05/03 13:47 | | Ops Team Meeting Minutes 5 February 2003

bbachman
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marolowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington - SCS Engineers (On phone)

Construction Update – Pease has isolated and flushed the vapor system line outside the building. Continuing to work on new vapor system design today.

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header and 5.2 gpm. Injection rates in all wells remains the same except that I-2, I-6, and I-8 be reduced to 100 lbs/hr to control breakthrough at E-02 and E-06. Extraction from the PA is at 22.19 gpm over last 24 hours. Well E07 is still off line. Well E-05 has decreased pumping (see below). Well E-03 is pumping product and water. The TOC is running without crystal buildup. However, it has been identified that some TOC spikes may be correlated with product tank cleaning. Cliff will provide information to identify this.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Current treatment rate has been approximately 60 gpm with 22.19gpm from the Pilot Area (PA) and 37.1 gpm from the Former Process Area (FPA). Flow from T-402 has been shut down to work on the clarifier. Visibility in the clarifier has also been stable at 1.9 ft. OMI will repair the RAS pumps in the clarifier today and the water level has been decreased for this purpose. DO in the aeration basin has been stable and ranging between 2.4 -5.0 mg/l with one blower running. The flow meter at T401 is not working and will be investigated later this week. Microbial action is good today. Plan to begin adding more diffusers on Thursday or Friday.

Subsurface/Thermal Monitoring Update – Water levels in the PA remain stable. Pumping performance has decreased in E-03, 5, 7. This may be due to increased NAPL movement or lack of water in the formation. Postulate that we may be concentrating NAPL in the extraction well area. Presumably, increased heat will increase NAPL mobilization and therefore pump performance. Lack of performance in E-07 may be due to slow recharge rate.

Maximum temperatures in extraction wells as follows: E-01= 57C(vadose), E-02= 100C (vadose and water), E-03= 87C (vadose), E-04=89C (vadose), E-05=95C (vadose), E-06= 100C (vadose), E-07= 100C (water).

Potential breakthrough at E-02 and E-6 soon.

Contaminant Recover Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction will continue as previously identified except that I-2, I-6 and I-8 will be decreased to 100 lbs/hr to control potential breakthrough at E-02 and E-06.

Cliff has suggested adding some form of heat for the exhaust port area at E-07 and possibly E-01. This needs further discussion and if it is done, will need integration with new vapor system design as the work will need to be done concurrently with vapor system updates when the pilot area is off-line.

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02/07/03 12:07 | | Ops Team Meeting Minutes 06 February 2003

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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marolowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA)

Construction Update – Continuing to work on new vapor system design today.

Total Injection: 7.5 gpm Total Extraction: 57.38 FPA Extraction: 35.15 gpm PA Extraction: 22.23 gpm T-402 Flow: 55.3 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The TOC will be taken off-line today for cleaning. Brenda and Steve will pursue TOC anomolous data issues. Feed water pumps tripped off this morning due to colder than normal temperatures.

Pilot Area - Extraction wells E-01 and E-07 are still off-line. QED is on site and will provide information regarding pump control and stroke counters. Sven is also on site today.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Air supply to the clarifier pump was checked yesterday and appears to be fine, however, the pump failed again after running for 1 hr. The liquid line will be flushed today. DO in the aeration basin has been stable and ranging between 4.0-5.0 mg/l with one blower running.

Subsurface/Thermal Monitoring Update – Water levels in the PA are still decreasing. We will decrease extraction in wells E-02, -04, -06 by 1 gpm each. Temperatures are stable in all wells except E-01 which in increasing but is still low.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction will continue as previously identified.

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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marolowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA) Mary K. LeProwse (District Office)

Construction Update – No construction activities today.

Total Water Usage: 7.4 gpm Total Injection: 4.7gpm Total Extraction: 56.23 gpm FPA Extraction: 36.38 gpm PA Extraction: 19.85 gpm T-402 Flow: 44.7 gpm

Boiler Room Update – The boiler was taken off-line yesterday for approximately 1 hr to clean burner due to low firing rate. The boiler is continuing to operate on low fire with 15 psi at the header. Feed water pumps tripped off twice today. This is a warranty issue that Rick is pursuing with Pease. The TOC was cleaned yesterday but needs additional work due to product buildup in the copper tube feed line. Cliff will provide a memo with suggestions for ops team review.

Pilot Area - Steam breakthrough is occurring at the interlocks just north of E-01. QED is scheduled to provide a review of their field visit by COB today.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. The air supply appears to be a weak/degraded area in the air line above the aeration basin. A portion of the pipe will need to be replaced today. DO in the aeration basin has been stable and ranging between 4.5-5.0 mg/l with one blower running. Reduction across the DAF is very bad. Flow meter on T-401 will be serviced today to determine problem. The crew will continue adding diffusers when possible. An additional 16, 55-gal drums were filled with pressed digester solids.

Subsurface/Thermal Monitoring Update – Water levels in the PA are stable. Temperatures are stable in all wells except E-01 which is still increasing without pumping. Temperature strings near this well do not show an increase.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction will continue as previously identified.

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! 02/11/03 09:36 | | OPS Team Meeting Minutes 10 February 2003

g3pmemkl
New Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA) Kathy LeProwse (On Site)

Construction Update – Tim Gibson is on site today for Pease by himself. He is planning out the work on the vapor system changes on the exterior of the building. He will be working on the chemical feed system into the dearator and will need the boiler shut down for 60 to 90 minutes. The contractor was directed to shut the boiler down.

Total Water Usage: 5.79 gpm Total Injection: 4.7gpm Extraction: 33 gpm FPA; Extraction: 18.74 gpm PA; Extraction T-402 Flow: 44 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Three issues occurred over the week end. 1) One of the liquid heat exchangers plugged with naphthalene (probably on Sunday at 1400-1500 hours); it was back flushed with hot water and is operating now. 2) A feedwater flow control valve that automatically senses water level in the boiler failed; we can go around the valve in manual mode; same valve that was repaired by Pease 10 days ago; Cliff will call Proctor and Rich will call Pease. 3) The pump that provides water from the deep well trips out regularly between 0730 and 0930, weekends are the worst. Kathy needs to talk with Sven about this.

Pilot Area - Steam breakthrough is still occurring at the interlocks just north of E-01. Breakthrough is not occurring anywhere else at this time. EW3 quit pumping on Sunday at 1500 hours. Cliff will troubleshoot this well today.

Treatment Plant Update – Cliff's crew cleaned the flow meter on T401. It plugged up again on Sunday. All flow control devices, pitot tubes, and the pump fouled with naphthalene crystals. Plan is to route around T401 and clean everything with hot water. RAS pump in the south clarifier is still not working. The crew will troubleshoot this pipeline this week. No more diffusers have been installed but they will get back on that as soon as they can. The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable and ranges between 4.0-6.0 mg/l. There is good microbial activity and foam today. Clarity in the basin is 18 inches. Cliff was requested to take TSS measurements today.

Subsurface/Thermal Monitoring Update – Water levels in the PA are stable at 7.5 to 7.75 ft MLLW, except at EW3, where the level is rising. DTS is down. Area around EW5 is hot in the collector layer. Mike believes the spiking in the TOC is related to EW3. When EW3 shut down yesterday, the readings from the TOC meter stabilized around 580. Naphthalene crystals formed in the sampling jar at EW3 on Friday.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction will continue as previously identified.

[Edited by g3pmemkl on 02/11/03 01:09 PM]

[Edited by g3pmemkl on 02/11/03 01:10 PM]

[Edited by g3pmemkl on 02/11/03 01:11 PM]

[Edited by g3pmemkl on 02/11/03 01:12 PM]

[Edited by g3pmemkl on 02/11/03 01:13 PM]

[Edited by g3pmemkl on 02/11/03 01:16 PM]

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SiteOpLog: **OPS Team Meeting Minutes 11 February 2003**

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02/11/03 12:04 | | OPS Team Meeting Minutes 11 February 2003

g3pmemkl
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA) Kathy LeProwse (Home)

Construction Update – Tim Gibson is on site today for Pease by himself. He is planning out the work on the vapor system changes on the exterior of the building. There were no issues with the boiler shut down on Monday.

Total Water Usage: 5.7 gpm Total Injection: 4.7gpm Extraction: 36.77 gpm FPA; Extraction: 18.52 gpm PA; Extraction T-402 Flow: 44.4 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. Proctor tried to troubleshoot the feedwater flow control valve over the phone, which was unsuccessful. They will have to send someone out. The pump that provides water from the deep well is still tripping out regularly between 0730 and 0930. Cliff has notified Pease. They will investigate.

Pilot Area - Steam breakthrough is still occurring at the interlocks just north of E-02. Breakthrough is not occurring anywhere else at this time. EW3 is not pumping now. Cliff will try to get it back online today.

Treatment Plant Update – Cliff's crew cleaned the flow meter, pitot tubes and pump on T401. They were plugged with the naphthalene wax, but are working today. RAS pump in the south clarifier is still not working. The crew will troubleshoot this pipeline this week. There is not enough air to run the pump or it is physically clogged somewhere they can't see. The pipeline most likely needs to be replaced and it should be done at the same time as the blower improvements are made. Kathy needs to talk to Sven. No more diffusers have been installed but they will get back on that as soon as they can. The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable and ranges between 4.9 - 6.9 mg/l with one blower. There is good microbial activity and foam today. Clarity in the basin is 18 inches. Cliff will get the results of the TSS measurements today to Kathryn.

Subsurface/Thermal Monitoring Update – Water levels in the PA are dropping. The data for EW2 for Saturday and Sunday indicates an extraction rate of 2 gpm. However, on Friday and Monday, the extraction rate was 5 gpm. Need Cliff to check if there was a data entry error. Area around EW1 is at steam temperature in the vadose zone. The temperature at EW7 is at boiling water temperature at the bottom of the well. This one is ok because it is under water. Mike suggested we reduce the injection rate at I3, I4, I5, I6, and I11 to 50 lbs/hr in lieu of 100 lbs/hr and that we reduce the extraction rates at EW2 and EW6 by 2 gpm each to compensate for that reduction in injection rates and the decrease in water levels.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Reduce injection rates on I3, I4, I5, I6, and I11 to 50 lbs/hr. Reduce extraction rates on EW2 and EW6 by 2 gpm each. Try to get EW3 back online today at 2 gpm. Continue investigation of the problem with the south RAS pump. Get the TSS measurements to Kathryn today. Check if there was an data entry error on EW2 extraction rate over the weekend. Mike and Steve are to look at the daily average for TOC by this Friday to see if there is a problem with the data. Kathryn is to look at the old data to see is there is a trend for naphthalene in the Pilot Area. Kathy is to get with Rich and Sven to develop a timeline for repairs to EW7 and E1.

[Edited by g3pmemkl on 02/11/03 02:41 PM]

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02/12/03 10:46 | | Operations Team Meeting 12 February 2003

bbachman
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathy LeProwse (District Office)

Construction Update – Pease is continuing work on the vapor system.

Total Water Usage: 5.46 gpm from ion meter Total Injection: not reported today Extraction: 36.6 gpm FPA; Extraction: 16.22 gpm PA; Extraction T-402 Flow: not reported today

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The feedwater pump is still tripping out regularly between 0730 and 0930. Cliff has notified Pease. They will investigate.

Pilot Area - Water levels are still slowly decreasing. No other problems reported. E-03 is pumping again with the exhaust vented to the atmosphere.

Treatment Plant Update – RAS pump in the south clarifier is still not working. The crew will continue to work on this today. The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable and ranges between 5.0- 6.0 mg/l with one blower. There is good microbial activity and foam today. The clarifier is pumped out to work on the pump. Flow from T-401 is not reported because flow valve is inoperable. Continuing to waste solids. Meter?

Subsurface/Thermal Monitoring Update – Water levels in the PA are continuing to decrease. Decrease extraction in E-02 and E-04 to 2.5-3 gpm and decrease E-06 to no less than 3 gpm. Total extraction target of 12-14 gpm from pilot area. Injection rates will change as follows: I-4 will be increased to 100 lbs/hr and I-16 will be decreased to 100 lbs/hr.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Change injection rate in I-4 and I-16 to 100 lbs/hr each. Reduce extraction rates on EW2 and EW4 to 2.5-3 gpm each. Mike and Steve reviewed TOC data and found the problem. The team will discuss it at Thursday's meeting.

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! 02/13/03 10:26 | | Operations Team Meeting 13 February 2003

bbachman
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathy LeProwse (District Office) Mary Jane Nearman (EPA)

Construction Update – Pease is continuing work on the vapor system.

Total Water Usage: 4.26 gpm from ion meter Total Injection: not reported today Extraction: 37.86gpm FPA; Extraction: 12.88 gpm PA; Extraction T-402 Flow: 58.5 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The feedwater pump is still tripping out regularly between 0730 and 0930. Product tank and liquid heat exchangers clogged last night and were flushed. The TOC machine clogged with napthalene crystals and is being cleaned again today. Automatic feed water pump on boiler is being maintained manually until it is replaced by Pease.

Pilot Area - Water levels are still slowly decreasing and are now approximately 5.5 ft. No other problems reported. QED reviewed problems with stroke counters and suggested adding air regulators to the pumps. This has been forwarded to Pease.

Treatment Plant Update – RAS pump was looked at but no problems were found. Problem may be the strength of the blowers. This will part of the package provided by Marlowe. The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable and is approximately 5.0 mg/l with one blower. There is good microbial activity and foam today. Flow from T-401 is not reported because flow valve is inoperable. Continuing to waste solids. Flow from T-402 into aeration basin is 58.5 gpm. The lead carbon will be backflushed in the next few days.

Subsurface/Thermal Monitoring Update – Water levels in the PA are continuing to decrease and are approximately 5.5 ft. Total extraction is 12.88 gpm from pilot area.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operations Update – Injection and extraction rates will remain constant.

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! 02/18/03 11:17 | | Ops Team Meeting 18 February 2003

bbachman
Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Brenda Bachman – USACE Monitoring Coordinator Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathy LeProwse (District Office)

Construction Update – Pease is continuing work on the vapor system. The well field was unexpectedly shut down for approximately 45 minutes yesterday while vapor system work occurred. There were no impacts.

Total Water Usage: 3.85 gpm from ion meter; Total Injection: not reported today; FPA Extraction: 37.4 gpm; PA Extraction 15.36 gpm; T-402 Flow: 44.7 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The TOC skidmore pump clogged with napthalene and was cleaned this weekend. The TOC was offline for several hours on Sunday while cleaning occurred.

Pilot Area - Water levels are stable. No problems reported. Injection remains at previously set targets. Well E-03 is pumping at a reduced rate (0.16 gpm) probably due to clogged exhaust port. This will be cleaned today in an attempt to keep the pump running. Extraction rate will remain the same.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable. There is good microbial activity and foam today. Flow from T-401 is not reported because flow valve is still inoperable. Flow from T-402 into aeration basin is 44.7 gpm. The lag carbon will be changed this week.

Subsurface/Thermal Monitoring Update – Water levels are stable. Total extraction is 15.36 gpm from pilot area.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operational Activities – Injection and extraction rates will remain constant. E-03 exhaust port will be cleaned.

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SiteOpLog: TOC Issues

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! 02/19/03 08:14 | | TOC Issues

Cliff Leeper
Member
37 Posts

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The TOC meter stopped working this morning due to a swollen plastic fitting that is being attacked by chemical degredation in the waste stream. The fitting was swollen to twice it normal size and had become soft and pliable. It is a standard PVC fitting. We are attempting to replace it with a metal fitting. This event manifested itself at 4:45 this morning. I will update the web as to when we get the system back on line.

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! 02/19/03 13:29 | | Ops Team Meeting 19 February 2003

Mike Bailey
Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA)

Construction Update – Pease is continuing work on the vapor system. Combustion Controls is on-site troubleshooting problems with the feed water pumps.

Total Water Usage: 3.9 gpm from ion meter; Total Injection: unchanged; FPA Extraction: 37.6 gpm; PA Extraction 22.4 gpm; T-402 Flow: 42.9 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The TOC instrument is off-line. At approximately 0445 hrs, the boiler operator noticed that the instrument was not reporting valid results. Although blockages in the line feeding the instrument have caused this problem in the past, the current problem was the result of a PVC fitting losing structural integrity (soft to touch), presumably as a result of prolonged contact with the waste stream. OMI is troubleshooting the problem with the vendor, and the instrument is expected to be back on-line today, with temporary fixes.

Pilot Area – With the exception of E-3 and E-5, water levels are stable. Overnight rebound in water level in E-3 was believed to be the result of naphthalene fouling in the exhaust line. However, no evidence of naphthalene was found. The problem was apparently due to air- or vapor-lock in the exhaust line. When the exhaust tube was disconnected, allowing discharge to atmosphere, the pump started operating normally. Rebound in E-5 to non-pumping water levels was noted yesterday. On inspection, the pump was found to be discharging at approximately 9.1 gpm, compared to a rate of less than 4 gpm in the previous 24 hr period. Rebound in water levels, combined with increased pumping rates, suggests that flow to the well has dramatically improved, possibly from continued warming in and around E-5. Injection remains at previously set targets. Extraction rate will be allowed to stay at the current, higher rate of 22.4 gpm.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, in the range of 5-6 mg/L. There is good microbial activity and foam today. To maintain DO levels, the second blower is being bumped every 4 hrs. A pump at 401 is being rebuilt. Flow from T-401 is not reported because flow valve is still inoperable. Flow from T-402 into aeration basin is 42.9 gpm. The lag carbon has been moved to lead, and new carbon has been placed in the lag position. TOC out of 401 was noted at 298 mg/L for 18 Feb, which compares to an average of approximately 970 mg/L in the period before the TOC instrument failed.

Subsurface/Thermal Monitoring Update – Except as noted at E-3 and E-5, water levels are stable. Comparison of temperatures today with those of 14 Dec reveals: average site temperature (simple average of all sensor data) has increased 5 C (from 66 to 71 C); excluding the injection wells, average temperature has increased from 63 to 70 C; and all extraction wells except E-1 have shown a 5-25 C increase at the bottom of the well. However, the last 24 hrs brought a decrease of 10-15 C in E-1 and 5-10 C in E-5. The decrease in E-1 may be the result of reduced injection in the area last week and lack of groundwater flow to E-1. The decrease in E-5 is presumably due to the greatly increased flow of groundwater to the well. Total extraction is 22.4 gpm from pilot area, up roughly 7 gpm from yesterday. The increase in extraction reflects improved performance of E-3 and E-5. Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operational Activities – To counteract temperature losses near E-1, injection rates will be increased at I-3 and I-4 by 50 lb/hr, with the new targets being 100 (I-3) and 150 lb/hr (I-4).

Extraction rates will remain constant. E-3 will be monitored to forestall problems leading to a drop in extraction rate.

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SiteOpLog: **Ops Team Meeting 20 February 2003**

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! 02/21/03 06:58 | | Ops Team Meeting 20 February 2003

Mike Bailey
Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Mary Jane Nearman (EPA)

Construction Update – Pease is continuing work on the vapor system. Yesterday HX-3 and its support were removed from the boiler building. Extensive naphthalene buildup and seal degradation were observed when the heat exchanger was opened. Pease will not be on site next week; they are waiting for additional guidance on modifications to the boiler plant and plumbing. Combustion Controls took readings yesterday in an attempt to diagnose the problem with the feed water pumps. Awaiting a report back from them on a resolution.

Total Water Usage: 4.5 gpm from ion meter; Total Injection: 4.3 gpm; FPA Extraction: 36.5 gpm; PA Extraction 22.4 gpm; T-402 Flow: 28 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The TOC instrument was put back on-line yesterday afternoon using temporary fixes. Replacement parts of same material (PVC) have been shipped.

Pilot Area – Injection was increased yesterday at I-3 and I-4 to 117 and 153 lb/hr, respectively. Steam was noted coming out of the vent pipe on E-3. Extraction remains unchanged from yesterday at 22.4 gpm.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, in the range of 5-6 mg/L. There is good microbial activity and foam today. To maintain DO levels, the second blower is being bumped every 4 hrs. The motor failed on a backwash pump (P206). Failure was anticipated, and a spare motor is on hand. However, the mount is extremely corroded/rusted and may be difficult to rehabilitate. Pump is hoped to be back on-line today. Flow from T-401 is not reported because flow valve is still inoperable. Flow from T-402 into aeration basin is 28 gpm, and inventory is building for the time being. DAF thickener pumps and valves are being fouled with naphthalene. The DAF will be taken off-line next week for approximately 8 hrs to clean the fouled components.

Subsurface/Thermal Monitoring Update – Water levels are stable. With the exception of E-1 and E-3, temperatures are fairly stable. A 5-30 C increase at E-1 (max temp 90C in the vadose zone) and 5-25 C increase at E-3 (at steam temp, also in vadose zone) are a response to increased injection rates at I-3 and I-4 yesterday.

Contaminant Recovery Update – No contaminant recovery or chemistry to report today.

Operational Activities – Although the desired effect was achieved at E-1 by increasing injection rates at I-3 and I-4, there was also a response at E-3 that led to minor steam breakthrough at the well. Injection rates will be decreased at I-3 and I-4 by 50 lb/hr, with the new targets being approximately 50 (I-3) and 10 lb/hr (I-4). Extraction rates will remain constant.

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SiteOpLog: Ops Team Meeting 21 February 2003

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! 02/21/03 11:13 | | Ops Team Meeting 21 February 2003

Mike Bailey
Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathy LeProwse – USACE Project Manager Mary Jane Nearman (EPA) Construction Update – Pease is continuing work on the vapor system. Pease will not be on site next week; they are waiting for additional guidance on modifications to the boiler plant and plumbing.

Total Water Usage: 3.7 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 37.8 gpm; PA Extraction 20.3 gpm; T-402 Flow: 40.7 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The auto flow control valve was replaced and is now functioning on auto mode. Part of the TOC system is being replumbed temporarily with polyethylene tubing, with an eventual goal of replacing the tubing with Teflon. The boiler was shutdown for approximately an hour yesterday afternoon to perform routine maintenance.

Pilot Area – A decrease in extraction rate at E-3 (from 3.7 to 1.7 gpm) was noted. Cause is uncertain at this point, but it will be investigated. No steam was noted coming out of the vent pipe on E-3 (in contrast to yesterday), however, the vent pipe was capped this morning as planned. Extraction is down from yesterday to 20.3 gpm, with the difference essentially due to the dropoff in performance of E-3. Injection rates are unchanged, except at I-3 and I-4, which were reduced to 63 and 115 lb/hr, respectively. Total injection equates to 4.1 gpm liquid equivalent.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. To maintain DO levels, the second blower is being bumped every 4 hrs. Clarity was reported as 1.5 ft. The backwash pump (P206) was replaced successfully yesterday and is currently on-line. Flow from T-401 is not reported because flow valve is still inoperable. Flow from T-402 into aeration basin is 40.7 gpm. TOC out of 401 was 394 mg/L on 19 Feb and 378 on 20 Feb. Chemistry results indicate no exceedances out of the lag carbon.

Subsurface/Thermal Monitoring Update – Water levels are stable. With the exception of E-1 and E-3, temperatures are fairly stable. A 5 C increase at E-1 (max temp 93 C in the vadose zone) and 3 C increase at E-3 (max 103 C, also in vadose zone) are noted, despite a reduction in injection rates at I-3 and I-4 yesterday. Given that no steam was observed coming out of the vent pipe on E-3, it was recommended to let things ride over the weekend and evaluate on Monday.

Contaminant Recovery Update – Based on average TOC over the last 24 hrs (1100 mg/L) and an extraction rate of 22 gpm, contaminant removal equates to 290 lbs or roughly 35 gal of creosote. That compares to a daily removal rate of less than 6 gal from the Former Process Area.

Operational Activities – Injection and extraction rates will remain constant. Drop in performance of E-3 will be investigated. Keith will be instructed to change dilution factor in the TOC instrument by a factor of 2 to better capture spikes in TOC readings. This change will be coordinated with Kathryn and Steve.

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! 02/24/03 11:57 | | Ops Team Mtg 24 Feb 2002

bbachman
Member
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Attendees: Mike Bailey – USACE Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Kathryn Carpenter – USACE Project Chemist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathy LeProwse – USACE Project Manager Brenda Bachman-Monitoring Coordinator (District Office)

Construction Update – no construction activities today.

Total Water Usage: 4.0 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 37.1 gpm; PA Extraction 20.6 gpm; T-402 Flow: not reported today

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. No issues occurred over the weekend, however, the feed water control pumps tripped this morning. Consequently, the boiler was shut down for two hours this morning from 7:30-9:30am. Electricians should be on site today to replace the pumps. Cliff will keep us updated. Part of the TOC system was replumbed temporarily with polyethylene tubing, with an eventual goal of replacing the tubing with Teflon. The waxy substance that is plugging the TOC drain, liquid HX and skidmore pump will be analyzed this week. TOC values are approximately 1000 ppm. A decrease in non-contact cooling water usage over the last 24 hours was noted. Fuel will be delivered on Friday.

Pilot Area – A total of 20.6 gpm is being extracted from the pilot area. Injection rates are unchanged. Total injection equates to 4.1 gpm liquid equivalent.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. To maintain DO levels, the second blower is being bumped every 4 hrs. Clarity was reported as 1.5 ft. Flow from T-401 is not reported because flow valve is still inoperable. It was cleaned yesterday due to buildup of waxy substance. The DAFT pump efficiency also decreased due to waxy buildup.

Subsurface/Thermal Monitoring Update – Water levels are stable. Temperatures are also fairly stable. A temperature increase in the aquitard has been noted, especially at E-03 and E-05.

Contaminant Recovery Update – Based on average TOC over the last 24 hrs (1100 mg/L) and an extraction rate of 22 gpm, contaminant removal equates to 235 lbs or roughly 28 gal of creosote from the Pilot Area and 185 lbs and 22 gpm of creosote from the combined flow. That compares to a previous daily removal rate of less than 6 gal from the Former Process Area. Increased accuracy in these values will occur when the flow meter into the treatment plant is installed.

Operational Activities – Injection and extraction rates will remain constant. Brenda and Cliff will work on getting additional information posted to the website.

[Edited by bbachman on 02/24/03 03:21 PM]

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SiteOpLog: Operations Team Meeting 25 February 2003

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02/25/03 12:36 | | Operations Team Meeting 25 February 2003

bbachman
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Attendees: Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Brenda Bachman- Monitoring Coordinator (District Office)

Construction Update – no construction activities today.

Total Water Usage: 4.0 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 38 gpm; PA Extraction 19.9 gpm; T-402 Flow: 44 gpm

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The feed water control pumps tripped again this morning. Consequently, the boiler was shut down again this morning until 9:30am. Waiting for Pease electricians to replace the pumps. Cliff will keep us updated. The TOC values are approximately 1025 ppm. The TOC sampling arm was clogged until 11:30am today.

Pilot Area – A total of 19.9 gpm is being extracted from the pilot area. Injection rates are unchanged. Total injection equates to 4.1 gpm liquid equivalent.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1.5 ft. Flow from T-401 is 44 gpm. The multi-media filters appear to be clogging and OMI will work on this non-critical issue in the next 30 days.

Subsurface/Thermal Monitoring Update – Water levels are stable with a slight increase in E-03. Temperatures are also fairly stable. A temperature increase in the aquitard has been noted, especially at E-03 and E-05.

Contaminant Recovery Update – Based on average TOC over the last 24 hrs (1025 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 246 lbs or roughly 30 gal of creosote from the Pilot Area

Operational Activities – Injection and extraction rates will remain constant. The Extraction Rate Summary Table has been posted to the website.

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SiteOpLog: Operations Team Meeting 26 February 2003

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! 02/26/03 10:57 | | Operations Team Meeting 26 February 2003

bbachman
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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Brenda Bachman- Monitoring Coordinator (District Office) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS

Construction Update – no construction activities today.

Total Water Usage: 4.0 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 37.6 gpm; PA Extraction 20.2 gpm; T-402 Flow: 40 gpm Contaminant Recovery: 37 gal/day (310 lbs/day)

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. The feed water control pumps tripped again this morning, however, the boiler was not shut down today. Pease electricians have not yet arrived to replace the pumps. Cliff will check in with Pease today. The TOC values are approximately 1293 ppm. The TOC was down today until approximately 10:30am due to disintegration of a PVC drain part. Brenda will discuss engineering overhaul of TOC with Steve Meyerholtz.

Pilot Area – A total of 20.2 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. Total injection equates to 4.1 gpm liquid equivalent. Kathryn will check in with Bruce Woods regarding CLP data delivery times so that we know wellhead concentrations on a more regular time schedule.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1.5 ft. Flow from T-401 is 40 gpm. T-401 was bypassed last night due to clogging of flow valve with waxy substance. DAF impellers and several pumps may also be affected. There are increased floating solids on the clarifier possibly because the skimmers cannot keep up with solids production.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable. Decreased performance in E-03 has been noted but the reason is unknown. It does not match changes in water level. Mike assumes that something may be impeding the flow of water to the pump. No action at this time, E-03 will be watched over the next few days.

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC over the last 24 hrs (1293 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 310 lbs or roughly 37 gal/day of creosote from the Pilot Area. Approximately 3000 gallons of product has been removed to date.

Operational Activities – Injection and extraction rates will remain constant.

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SiteOpLog: Ops Team Meeting 27 Feb 2003

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! 02/27/03 11:19 | | Ops Team Meeting 27 Feb 2003

Mike Bailey
Member
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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS Mary Jane Nearman - EPA Gorm Heron - Steamtech

Construction Update – no construction activities today. Pease is waiting for parts to deal with the problem with the feed water pumps.

Total Water Usage: 4.9 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 37.6 gpm; PA Extraction 20.2 gpm; T-402 Flow: 40 gpm Contaminant Recovery: 34 gal/day (283 lbs/day)

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. No problems noted today with the feed water pumps. The TOC values are approximately 1179 ppm. The retrofit to the TOC system is working. The Skidmore pump had to be flushed due to waxy buildup on the impellers. Back pressure on HX-2 was noted, and when the heat exchanger was flushed, liquid started dripping out of the unit. Apparently the seals have failed because of material incompatibility issues. Currently, liquids are flowing through HX-1.

Pilot Area – A total of 20.4 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. Total injection equates to 4.1 gpm liquid equivalent.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1.5 ft. Flow to the aeration basin is 40 gpm. The flow control valve has been rebuilt, and T-401 is no longer being bypassed.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable. Pumping rate in E-3 has stabilized at approximately 1.3 gpm. A lengthy discussion ensued about energy balance. The website does not currently report energy balance, although the intent is to make those calculations available on a daily basis. Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC over the last 24 hrs (1179 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 283 lbs or roughly 34 gal/day of creosote from the Pilot Area.

Operational Activities – There was a preliminary discussion about increasing extraction rates in an attempt to dewater the aquifer and allow steam penetration to deeper parts of the aquifer. A plan is to be developed for implementation when the treatment plant is in better shape. Injection and extraction rates will remain constant for the time being.

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SiteOpLog: **Operations Team Meeting 28 February 2003**

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03/03/03 16:56 | | Operations Team Meeting 28 February 2003

bbachman
Member
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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Mary Jane Nearman - EPA

Construction Update – no construction activities today.

Total Water Usage: 4.5 gpm from ion meter; Total Injection: 4.1 gpm; FPA Extraction: 37.7 gpm; PA Extraction 20.1 gpm; T-402 Flow: 40 gpm Contaminant Recovery: 31 gal/day (258 lbs/day)

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. No problems noted today with the feed water pumps. Some of the TOC values are suspect due to data transfer problems or data collection problems but are good enough to estimate contaminant recovery (see below).

Pilot Area – A total of 20.1 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. Total injection equates to 4.1 gpm liquid equivalent.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1 ft 10 inches. Flow to the aeration basin is 40 gpm.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable.

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC over the last 24 hrs and an extraction rate of 20 gpm, contaminant removal equates to 258 lbs or roughly 31 gal/day of creosote from the Pilot Area.

Operational Activities – Injection and extraction rates will remain constant.

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03/03/03 17:08 | | Operations Team Meeting 3 March 2003

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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Brenda Bachman (District Office) Kathryn Carpenter (District Office) Marlowe Dawag (District Office)

Construction Update – no construction activities today.

Total Water Usage: 4.5 gpm from ion meter; Total Injection: 4.2 gpm; FPA Extraction: 37.6 gpm; PA Extraction 20.1 gpm; T-402 Flow: 40 gpm Contaminant Recovery: 26 gal/day (217 lbs/day)

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. No problems noted today with the feed water pumps. Some of the TOC values are suspect due to data transfer problems or data collection problems but are good enough to estimate contaminant recovery (see below). At 11 pm last night, TOC decreased to 12 mg/L for approximately 2 hours indicating that the sampler was clogged. Visual observation by the boiler operator, confirm that a thick, black, oily looking fluid was being pumped through the system at approximately the same time. Based on this observation, we would have expected to have TOC spikes but did not probably due to a clogged sampling port. Data after 1 am this morning appears normal.

Pilot Area – A total of 20.1 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. Total injection equates to 4.2 gpm liquid equivalent.

Treatment Plant Update – Pumping efficiency from T-401 is decreased and the pumps are being cleaned again. Otherwise, the treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1 ft 10 inches. Flow to the aeration basin is 40 gpm.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable. E-03 and E-05 are recieving an incursion (higher temps from specific directions). We will be watching for breakthrough in these areas.

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC (904 mg/L) over the last 24 hrs and an extraction rate of 20 gpm, contaminant removal equates to 217 lbs or roughly 26 gal/day of creosote from the Pilot Area.

Operational Activities – Injection and extraction rates will remain constant.

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SiteOpLog: Operations Team Meeting Minutes 04 March 2003

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! 03/04/03 10:11 | | Operations Team Meeting Minutes 04 March 2003

bbachman
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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Brenda Bachman (District Office) Kathryn Carpenter (District Office) Marlowe Dawag (District Office)

Construction Update – no construction activities today.

Total Water Usage: 4.5 gpm from ion meter; Total Injection: 4.2 gpm; FPA Extraction: 37.1 gpm; PA Extraction 20.2 gpm; T-402 Flow: 35.3 gpm Contaminant Recovery: 3.6 gal/day (197 lbs/day)

Boiler Room Update – The boiler is continuing to operate on low fire with 15 psi at the header. No problems noted today. TOC clogged again this morning and evidently one measurement was missed at approximately 8:45am. Visual observation continue to indicate that product is in the waste stream.

Pilot Area – A total of 20.2 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. Total injection equates to 4.2 gpm liquid equivalent.

Treatment Plant Update – Pumping efficiency from T-401 is decreased due to clogging of flow meter. Otherwise, the treatment plant is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with an average of approximately 6 mg/L. There is good microbial activity and foam today. Clarity was reported as 1 ft 11 inches. Flow to the aeration basin is 35.3 gpm.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable. E-03 is currently vented to the atmosphere and Kathy will check on the status of SCS Health and Safety air monitoring to assure that we are not emitting harmful vapors.

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC (821 mg/L) over the last 24 hrs and an extraction rate of 20 gpm, contaminant removal equates to 197 lbs or roughly 23.6 gal/day of creosote from the Pilot Area.

Operational Activities – Injection and extraction rates will remain constant.

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SiteOpLog: Operations Team Meeting 5 March 2003

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! 03/06/03 16:02 | | Operations Team Meeting 5 March 2003

bbachman
Member
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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Brenda Bachman (District Office) Kathryn Carpenter (District Office) Marlowe Dawag (District Office) Mick Easterly (District Office)

Construction Update – no construction activities today.

Total Water Usage: Reported values are approximate based on recent 24 hour values. 4.5 gpm from ion meter; Total Injection: 4.2 gpm; FPA Extraction: 37.1 gpm; PA Extraction 20.2 gpm; T-402 Flow: 35.3 gpm Contaminant Recovery: not reported

The pilot extraction system was taken off line at approximately 8pm on March 4 due to a plugged liquid line. The plug occurred immediately prior to the treatment plant at the intersection where the pilot area and former process area liquid lines merge. The two inch line was plugged and was effectively only a 3/4 inch line reducing flow into the treatment plant. Two of the FPA lines were also shut down automatically due to high pressure. One pump had shut down yesterday. The DAFT is being drained while the system is down to examine the recycle pump. As per photos sent by email, the DAFT pump system is also loaded with contaminants and nearly clogged. The piping system will be cleaned with a jet rod. A second line is being installed temporarily to bypass the DAFT so that the entire extraction system can be brought back on line by COB today.

WE WILL HAVE A 10 AM CALL TOMORROW, FRIDAY MARCH 7TH.

[Edited by bbachman on 03/06/03 06:03 PM]

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SiteOpLog: Operations Team Meeting 7 March 2003

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03/07/03 13:41 | | Operations Team Meeting 7 March 2003

Mike Bailey
Member
59 Posts

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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS Mary Jane Nearman - EPA Gorm Heron – Steamtech Mick Easterly – Hydrogeologist (District Office)

Construction Update – no construction activities today.

Total Water Usage: 3.5 gpm from ion meter; Total Injection: not reported, but no changes were made to settings; FPA Extraction: 31.9 gpm; PA Extraction 20.4 gpm; T-402 Flow: 37.5 gpm Contaminant Recovery: 15 gal (125 lbs) for 12+ hrs since startup

Boiler Room Update – The boiler was relit yesterday at approximately 1730 hrs and continues to operate on low fire with 15 psi at the header. No problems noted today with the feed water pumps. Operators report a rough TOC average of 850 mg/L, but note that the values are jumpy. At the recommendation of Shimadzu (on-site yesterday) and Steve Meyerholtz (and discussed in an in-house team meeting on Wednesday), the TOC sampling interval was changed to 30 min. Under some sampling conditions, the TOC analyzer was taking longer than normal to complete its analysis. It is believed less frequent sampling will correct the problem. Shimadzu is going to fabricate stainless steel components for the sampler that should eliminate material incompatibility problems. The liquid-liquid heat exchangers are being bypassed; current effluent from the PA is approximately 110 degrees F. Visual observations continue to indicate that product is in the waste stream in the form of globules. During shutdown the deaerator tank was drained and opened for inspection. Corrosion was noted inside the tank, and that info is being passed on to Pease for action.

Pilot Area – A total of 20.4 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. A steam leak was noted at the manifold at E-3 that is believed to be from a crack where a nipple is attached.

Treatment Plant Update – The treatment plant was put back online at approximately 1600-1630 hrs yesterday and is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with values of 6-7 mg/L reported. There is good microbial activity and foam today. Clarity was reported as 1' 8". Flow to the aeration basin is 37.5 gpm. A shunt was installed around the blocked line to the DAF. After lines were cleaned of contaminant blockage, no further problems with FPA extraction pumps have been noted. T-401 is currently offline.

Subsurface/Thermal Monitoring Update – Water levels since startup have settled around an average of 5.3 ft MLLW. Temperatures at extraction wells have nearly recovered; otherwise temperatures are stable.

TPH DATA

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC over the last 12+ hrs (1000 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 125 lbs or roughly 15 gal of product from the Pilot Area. A discussion about the nature of contaminants being removed resulted in the identification of a data gap. It was recommended that TPH be added to routine wellfield sampling to get a better handle on the amount of diesel range oil (solvent that keeps creosote liquid) being removed. Problems experienced in lines to the treatment plant may be the result of current operational mode (low fire; no vapor extraction). This diagnosis could be evaluated with TPH data.

Operational Activities – Injection and extraction will cease for approximately two hours today to allow the steam leak (noted above) to be repaired and to allow for routine maintenance (oil and filter change) to the air compressor that supplies air to the extraction well pumps.

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SiteOpLog: Operations Meeting Minutes 10 March 2003

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! 03/10/03 10:41 | | Operations Meeting Minutes 10 March 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS Mary Jane Nearman - EPA Brenda Bachman- Monitoring Coordinator (District Office)

Construction Update – no construction activities today.

Total Water Usage: 3.7 gpm from ion meter including regeneration of the deairator tank; Total Injection: 4.1 gpm; FPA Extraction: 37.4 gpm; PA Extraction 21.9 gpm; T-402 Flow: 57.8 gpm Contaminant Recovery: not reported.

Boiler Room Update – The boiler continues to operate on low fire with 15 psi at the header. Operators report a rough TOC average of 500 mg/L. Based on statistical precision analysis, the TOC sampling frequency will be changed to 60 min. This should provide a precision of approximately 77 mg/L at a 20 gpm pumping rate. Shimadzu is going to fabricate stainless steel components for the sampler that should eliminate material incompatibility problems. Brenda will let Steve know of this decision.

Pilot Area – A total of 21.9 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. E-03 ceased pumping on Saturday night for unknown reasons and was not noticed until Monday morning. The exhaust port was opened and closed and it began pumping again. TOC spike of approximately 5200 mg/L was noted when E-03 was brought back on line. The PA wellfield was shut down for approximately 2hrs on Friday to repair a broken pipe and provide maintenance on one of the hammerhead pumps.

Treatment Plant Update – The treatment is operating normally with apparent good treatment across the aeration basin. DO in the aeration basin has been stable, with values of 5.5 mg/L reported. There is good microbial activity and foam today. Clarity was reported as 1' 6". Flow to the aeration basin is 57.8 gpm. T-401 is currently offline.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable except at E-01 where temp has decreased by 10-20 degrees in the vadose zone. We will continue to watch temps to determine if there is a problem (such as leaking through the vapor cap or release of steam) that is causing the temp decrease. We will also attempt to determine whether the temperature decrease is a critical issue for operations.

Contaminant Recovery Update (rough estimate)– Based on an assumed average TOC over the last 12+ hrs (536 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 129 lbs or roughly 15 gal of product from the Pilot Area.

Operational Activities – Injection and extraction remain the same as previously set.

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SiteOpLog: **Operations Team Meeting 13 March 2003** ([Expand] [RevSort])

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!

03/13/03 10:50 | | Operations Team Meeting 13 March 2003

bbachman
Member
32 Posts

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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Marlowe Dawag - Process Engineer (District Office) Cliff Leeper – SCS Engineers (On Site) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office)

Construction Update – no construction activities today.

Total Water Usage: 3.7 gpm from ion meter ; Total Injection: 4.2 gpm; FPA Extraction: 35.1 gpm; PA Extraction 20.3 gpm; T-402 Flow: 57.8 gpm Contaminant Recovery: 233 lbs/ 28 gal of creosote.

Boiler Room Update – The boiler continues to operate on low fire with 15 psi at the header. Operators report a TOC average of 900 mg/L based on hourly readings.

Pilot Area – A total of 20.3 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. E-03 is pumping fine.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 1' 9". The multi-media filters appear to be clogged and will need media change out. A plan will be developed by OMI for the change out. This will occur after the polymer and organoclay tests. Flow to the aeration basin is 57.8 gpm. T-401 is currently online. However, the DAFT recycle pump is clogging again and efficiency is decreasing. The DAFT will be taken off line for pump cleaning and part replacement. Custom fittings for DAFT have not yet arrived. The polymer and organoclay tests will occur after DAFT pump cleaning and part replacement. If we cannot begin the test until mid-week next week, we will delay until Monday, March 24th.

Subsurface/Thermal Monitoring Update – Water levels and temperatures are stable except at E-01 where temp has decreased by 10-20 degrees in the vadose zone. We will continue to watch temps to determine if there is a problem (such as leaking through the vapor cap or release of steam) that is causing the temp decrease. We will also attempt to determine whether the temperature decrease is a critical issue for operations.

Contaminant Recovery Update- Based on average TOC over the last 24 hrs (970 mg/L) from only six (6) readings, and an extraction rate of 20 gpm, contaminant removal equates to 233 lbs or roughly 28 gal of product from the Pilot Area. The reason for only six reading is unknown at this time but may be due to the problem with IFix. Mike will check on this with Dave Gustafsen.

Operational Activities – Injection and extraction remain the same as previously set.

!

03/13/03 11:53 | | Update/correction to TOC value

Mike Bailey
Member
59 Posts

Ignore User

Problems with TOC data collection were due to a bug in a new program that was installed. The bug has been fixed.

An average of 868 mg/L was reported from boiler operator hourly readings. That translates to approximately 208 lbs/day TOC or 25 gallons of creosote (at a rate of 20 gpm).

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SiteOpLog: Operations Team Meeting Minutes 17 March 2003 ([Expand] [RevSort])

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03/17/03 10:24 | | Operations Team Meeting Minutes 17 March 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Kathryn Carpenter- Chemist (District Office) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Mary Jane Nearman- Project Manager (EPA)

Construction Update – no construction activities today.

Total Water Usage: 3.6 gpm from ion meter ; Total Injection: 4.1 gpm; FPA Extraction: 36.7 gpm; PA Extraction 21.9 gpm; T-402 Flow: 55.3 gpm Contaminant Recovery: 160 lbs/ 19 gal of creosote per day.

Boiler Room Update – The boiler continues to operate on low fire with 15 psi at the header. Operators report a TOC average of 665 mg/L based on hourly readings.

Pilot Area – A total of 21.94 gpm is being extracted from the pilot area. Injection and extraction rates are unchanged. E-03 shut down Sunday evening at approximately 8:30pm and was turned on again this morning at 8am. There was a spike in TOC (3700 mg/L) when it was turned on. However, during our meeting, Mike mentioned that it was again off-line. Cliff will check on this. Cliff reports low temp liquid line reading at E-05 but there is no apparent association or explanation from other measurements. Liquid levels in the joint observation wells are normal.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 1' 6". The multi-media filters will be changed during the week of April 1. Flow to the aeration basin is 55.3 gpm. Custom fittings for DAFT arrived today and will be changed later this week. The polymer and organoclay tests will begin Monday, March 24th. There was a slight decrease in DO (avg 3-4 mg/L) due to solids buildup in aeration basin. Solids pressing will begin today to be ready for tests next week.

Subsurface/Thermal Monitoring Update – Water levels increased by approximately 1 ft over the weekend. Surface temperatures have rebounded. Extraction well temperatures (E01, E02, E06) have also rebounded.

Contaminant Recovery Update- Based on average TOC over the last 24 hrs (665 mg/L) and an extraction rate of 20 gpm, contaminant removal equates to 160 lbs or roughly 19 gal of product from the Pilot Area.

Operational Activities – Injection and extraction remain the same as previously set.

03/17/03 11:44 | | Temp and performance at E-5

Mike Bailey
Member
59 Posts

Ignore User

Cliff updated me on his findings at E-5. Apparently the well is pumping at a rate well below 11 gpm. Cliff is going to do a bucket test to establish actual rate. He touched the liquid discharge line with his hand and confirmed that hot water is not discharging from the well. He suspects that the cool discharge line temps are due to little or no flow from E-5. We believe that the pump may be getting insufficient air pressure to evacuate the pump cavity. If we cannot increase performance at E-5, we'll have to make up the difference by increasing E-2, E-4, and E-6. Stay tuned.

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SiteOpLog: **Site Shut Down**

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! 03/17/03 14:32 | | Site Shut Down

Cliff Leeper
Member
37 Posts

Ignore User

At appox 12:55 this afternoon we shut both the former process area and the pilot well feild off to effect repairs on the DAFT unit. The impellor on the recycle pump had packed with NAPL wax to the point where it was no longer functional. We have drained the DAFT and hope to be back on line early this evening. I will update you as to we get back on line.

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SiteOpLog: Site shut down

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! 03/18/03 16:52 | | Site shut down

Cliff Leeper
Member
37 Posts

Ignore User

At 1615 this afternoon we noted a oil leak on one of the recirculating oil lines on the Texas Air Compressor. The leak got worse as we monitored it for half an hour. This is the compressor that supplies combustion air for tbe boiler. It was determined we could risk damage to this equipment if we continued to run it. Currently the boiler is off line until we can repair this leak. I will keep all updated as to status. I have notified Rich Fink of this problem.

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SiteOpLog: **Status Report 3-20-03**

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! 03/20/03 15:45 | | Status Report 3-20-03

Cliff Leeper
Member
37 Posts

Ignore User

The TOC machine was put back on line today after retro fitting a new drain for unit. We pulled Extraction well E-5 this afternoon and discovered a two inch slit in the discharge tubing. The pump was recycling back into the well casing with very little liquid volume being pump during strokes. We cut off 20.5 inches of tubing and reattached the hose. I have no explaination for the failure of the hose however the liquid temperature returned to normal levels shortly after we resumed pumping operations, 130 F.

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SiteOpLog: Operation Team Meeting Minutes 20 March 2003

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! 03/20/03 16:23 | | Operation Team Meeting Minutes 20 March 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Mark Varljen- SCS Engineers Gorm Heron- Steamtech

Construction Update – no construction activities today.

Total Water Usage: 3.2 gpm from ion meter ; Total Injection: 4.1 gpm; FPA Extraction: 37.6 gpm; PA Extraction not reported today; T-402 Flow: 51.6 gpm Contaminant Recovery: approximately 104 lbs/ 12.5 gal of creosote per day.

Boiler Room Update – The boiler was turned off due to a leak in the in the hose that supplies air to the boiler compressor. The boiler was returned to operations on Wednesday morning on 10:14am. At 5:30pm on Wednesday, the TOC drain failed due to a disintegration of a PVC part. I was turned on Today at approximately 1 pm when the drain was fixed. Operators report a TOC average of 789 mg/L based on 10 hours of readings. The "new" sampling and drain portion of the TOC machine was replaced 2.5 weeks ago. The flow control valve on failed for the third time. It will be replaced with a valve from a different manufacturer. In addition, the gate valve has failed and will also be replaced. The water level is being controlled with a third valve at this time. Fuel will be delivered on Monday.

Pilot Area – Injection and extraction rates are unchanged. However, E-03 is operating sporadically. E-05 pump was pulled and a split in the discharge line was found. The pump was replaced approximately 2 feet higher in the well than the original depth. Upon re-start the temperatures in the well returned to normal (~100). Extraction rates in wells 2, 4, and 6 were increased by 3 pgpm each to compensate for lack of performance in E-05 but will be readjusted to previously set rates since E-05 was fixed. The extraction rate reported for E-04 (8.4 gpm) is incorrect and will be corrected.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin (99.99% PAH and 99.96% PCP). Clarity was reported as 1' 6". The multi-media filters will be changed during the week of April 1. Flow to the aeration basin is 51.6 gpm. Flow from FPA was routed to T-401 while custom fittings for DAFT were installed today. The polymer and organoclay tests will begin Monday, March 24th. Solids pressing continues to be ready for tests next week.

Subsurface/Thermal Monitoring Update – Water levels decreased by several ft when the boiler was shut down but rebounded upon start of injection and are approximately 6.8 ft and trending upward. Surface temperatures are stable.

Contaminant Recovery Update- Based on average TOC over the last 11 hrs (790 mg/L) and an extraction rate of 10.9 gpm, contaminant removal equates to 104 lbs or roughly 12.5 gal of product from the Pilot Area.

Operational Activities – Injection and extraction remain the same as previously set.

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SiteOpLog: **Boiler Status 3-23-03**

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! 03/23/03 14:05 | | Boiler Status 3-23-03

Cliff Leeper
Member
37 Posts

Ignore User

This morning at 7:05 the boiler tripped off with a low water alarm. The boiler operator reset the system and attempted to light off. During the attempt the boiler began to pant and belch black smoke from the stack. A review of proceedures and checks was completed and the system again elicited the same panting and black smoke. This type of problem is most likely an air to fuel ratio problem. We are currently off line and a boiler repair technician will be here tommorrow morning to trouble shoot the system. I will update all as to issues as they manifest themselves.

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SiteOpLog: Operations Team Meeting 24 March 2003

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! 03/24/03 13:09 | | Operations Team Meeting 24 March 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Kathryn Carpenter- Project Chemist (District Office) Marlowe Dawag- Process engineer (District Office) Mary Jane Nearman- EPA Project Manager Construction Update – Pease is on site working on the boiler with CHO.

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 38.6 gpm; PA Extraction: 18.4 gpm; T-402 Flow: 58.9 gpm Contaminant Recovery: 137.6 lbs/day, 16.5 gal/day creosote.

Boiler Room Update – No injection for past 24 hours due to boiler shut down at 7am on Sunday from a low water trip due to improper fuel/air ratio. The boiler will remain off-line until fixed. TOC average = 639 mg/L . Fuel was delivered this morning (9600 gal).

Pilot Area – No injection. Extraction rates are unchanged and total extraction = 18 gpm. The extraction rate reported for E-04 (8.4 gpm) remains incorrect on the website as reported last week and will be corrected.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 1' 6". The multi-media filters will be changed this week if possible due to continued high pressure after backwashing. This will not affect the polymer test. Flow to the aeration basin is 58.9 gpm. The polymer tests will begin today Monday, March 24th. Organoclay test will be done later in the week. Kathy LeProwse is working on this.

Subsurface/Thermal Monitoring Update – Water levels decreased by several ft due to boiler shut down. Average water level is 5.7 ft. Water level in E-03 has increased and Cliff will do a bucket test to assure pumping rate and post data to the website log. Surface temperatures are relatively stable.

Contaminant Recovery: TOC=637 mg/L, extraction rate=18 gpm 137.6 lbs/day, 16.5 gal/day creosote

Other Issues: Evidently, the information recieved from pump vendors about pump volume per stroke is inaccurate due to varying conditions under which the pump operates. Therefore, the method of using stroke counters to assure pumping rates is also inaccurate. Cliff will do a bucket test once a week on each well to provide specific well data. Weekly data will be posted to the Thermal Flow Rate section of the operation log. It will be determined if there is a constant variation within each well that can be used to calculate accurate flow rates or if another method is required to provide accurate extraction rate data.

[Edited by bbachman on 03/24/03 03:10 PM]

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SiteOpLog: **Updates 2/25/03**

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! 03/25/03 17:17 | | Updates 2/25/03

Cliff Leeper
Member
37 Posts

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Currently the boiler is off line until we get resolution for the air/ fuel problem that began Sunday morning. We started the boiler yesterday at 1630 (appox) and ran throughout the night in manual override for the electronic systems. This resulted in a very erratic steaming pressure on the header. It was decided this morning to suspend steaming ops until the boiler factory rep could come out and resolve the oil/air problem. He is scheduled to come out tommorrow and continue trouble shooting the system . I will keep all appraised as to out come and resolutions.

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SiteOpLog: Operations Team Meeting March 31 2003

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! 03/31/03 15:38 | | Operations Team Meeting March 31 2003

bbachman
Member
32 Posts

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Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Kathryn Carpenter- Project Chemist (District Office) Mary Jane Nearman- EPA Project Manager

Construction Update – Pease and Sons is on site working on the boiler and de-air tank with CHO. New chillers are being installed to safely collect water samples. A boiler inspection will occur tomorrow.

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 40.3 gpm; PA Extraction: 16.4 gpm; T-402 Flow: 41.0 gpm Contaminant Recovery: 108.5 lbs/day, 13.0 gal/day creosote.

Boiler Room Update – The boiler is off-line until fixed. TOC average = 565 mg/L .

Pilot Area – No injection. Total extraction = 16.4 gpm. Extraction rates will be decreased as follows to maintain water levels: E2, E5, E6=2 gpm; E4=2.5 gpm; E3 remains at 1.6 gpm.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 1' 6". The multi-media filters were changed last Thursday and are operating well. Flow to the aeration basin is 40.0 gpm. The second round of polymer tests will begin today Monday, March 31.

Subsurface/Thermal Monitoring Update – Water levels decreased by approximatley 1 foot since last week. Mike requested decreased pumping rates as noted above. Average pilot area temperatures have decreased by approximately 1.5 degrees C over the last seven days.

Contaminant Recovery: TOC=565 mg/L, extraction rate=16 gpm 108.5 lbs/day, 13.0 gal/day creosote.

Other Issues: Changed data collection and analyses: Liquid extraction data for CLP analysis will be collected at wells E-3 and E-4 on Mondays.

[Edited by bbachman on 04/01/03 10:17 AM]

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SiteOpLog: Operations Team Meeting Minutes 4 April 2003

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! 04/03/03 10:38 | | Operations Team Meeting Minutes 4 April 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Kathy LeProwse- USACE Project Manager Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Kathryn Carpenter- Project Chemist (District Office) Mary Jane Nearman- EPA Project Manager

Construction Update – Pease and Sons continues to work on the boiler and de-air tank with CHO. New chillers were installed on the de-air tank to safely collect water samples. The boiler inspection occurred on Tuesday and no appreciable damage was found to it or the de-air tank.

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 38.6 gpm; PA Extraction: 9.28 gpm; T-402 Flow: 41.5 gpm Contaminant Recovery: 72 lbs/day, 8.6 gal/day creosote.

Boiler Room Update – The boiler is off-line until the fuel/air mixture problem is solved. TOC average = 601 mg/L .

Pilot Area – No injection. Total extraction = 9.2 gpm. Extraction rates remain the same as last week.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 2' 2". Flow to the aeration basin is 41.5 gpm. The second round of polymer tests are continuing.

Subsurface/Thermal Monitoring Update – Water levels are stable at 4.1ft. Average pilot area temperatures are 72.5C and have decreased by approximately 2.5-3.0 degrees C since the boiler was shut down.

Contaminant Recovery: TOC=601 mg/L, extraction rate=10 gpm 72lbs/day, 8.6 gal/day creosote.

Other Issues: Cliff requested a plan of action for the shut-down period.

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SiteOpLog: **Boiler Status** ([Expand] [RevSort])

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! 04/04/03 12:52 | | Boiler Status

JoeSCS
New Member
4 Posts

Ignore User

The boiler was brought on-line yesterday, 4/3/03, at 16:52 by Combustion Controls.

The boiler was shut down today, 4/4/03, at 10:35 to allow CH2O, the boiler chemical treatment system vendor, to install and adjust the chemical injection equipment.

The boiler operator on duty attempted to bring the boiler on-line at about 11:00, after CH20 work their completed. He was unsuccessful after three light off attempts.

Combustion Controls has been requested to visit the site today to bring the boiler on line. When the boiler is brought on line, the time will be posted.

! 04/04/03 16:13 | | Boiler fuel igniter failure

JoeSCS
New Member
4 Posts

Ignore User

Combustion Controls arrived the site in the afternoon to repair the boiler. They inspected the burner box and discovered the fuel igniter was inoperative.

Combustion Controls took the igniter to their shop for repairs. The igniter repair time period is currently unknown.

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SiteOpLog: Operations Team Meeting Minutes 7 April 2003

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! 04/07/03 10:50 | | Operations Team Meeting Minutes 7 April 2003

bbachman
Member
32 Posts

Ignore User

Attendees: Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Brenda Bachman- Monitoring Coordinator (District Office) Kathryn Carpenter- Project Chemist (District Office) Marlowe Dawag- Process Engineer (District Office) Mary Jane Nearman- EPA Project Manager

Construction Update – no construction today.

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 38.21 gpm; PA Extraction: 12.37 gpm; T-402 Flow: 48.7 gpm Contaminant Recovery: 63 lbs/day, 7.6 gal/day creosote.

Boiler Room Update – The boiler is off-line until a high spark ignition module is replaced. TOC average = 440 mg/L .

Pilot Area – No injection. Total extraction = 12.37 gpm. Extraction rates remain the same as last week. Bucket test occurred 4 days last week and results have been posted. e-05 was off-line late last week for unknown reasons but appears to be working again today.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. Clarity was reported as 2'. Flow to the aeration basin is 48.7gpm. Polymer tests were concluded and results are expected late this week. The lag carbon unit may experience breakthrough of anthracene soon. Solids continue to be pressed daily.

Subsurface/Thermal Monitoring Update – Water levels are stable at 4.3 ft MLLW. Average pilot area temperatures are 71 C.

Contaminant Recovery: TOC=440 mg/L, extraction rate=12 gpm 63 lbs/day, 7.6 gal/day creosote.

Other Issues: Cliff requested a plan of action for the shut-down period. This will be discussed today at 2pm on a conference call. Marlowe may be requested to sign manifests for disposal.

[Edited by bbachman on 04/07/03 12:51 PM]

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SiteOpLog: **Ops Team Meeting Minutes - 10 Apr 03**

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! 04/10/03 11:15 | | Ops Team Meeting Minutes - 10 Apr 03

Mike Bailey
Member
59 Posts

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Attendees: Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Kathy LeProwse – Project Manager (District Office) Mary Jane Nearman- EPA Project Manager

Construction Update – no construction today.

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 39.23 gpm; PA Extraction: 9.57 gpm; T-402 Flow: 46.2 gpm Contaminant Recovery: 47 lbs/day, 5.6 gal/day creosote.

Boiler Room Update – The boiler is off-line until a high spark ignition module is replaced. Part was expected yesterday, but did not arrive. TOC average = 405 mg/L.

Pilot Area – No injection. Total extraction = 9.57 gpm. E-3 has continued to experience fouling in the air exhaust line. Additional bucket tests indicate that the typical discharge volume per stroke of a pump is 0.6 gallons.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO is in the range of 6-7 mg/L. Clarity was reported as 2'4". Volumes in 401 and 402 are at target levels. Flow to the aeration basin is 46.2 gpm. The lag carbon unit may experience breakthrough of anthracene soon. Estimate that carbon switch-out will be necessary within two weeks. Solids continue to be pressed daily. Estimated time to get ahead of solids inventory is two months. Maintenance continues on 108 separator and the drops on the aeration basin air diffusion system.

Subsurface/Thermal Monitoring Update – Water levels are stable at 4.1 ft MLLW. Average pilot area temperatures are 70.2 C. Average temperature drop per day is approximately 0.3 C, but it varies from 0 to 0.7 C.

Contaminant Recovery: TOC=405 mg/L, extraction rate=9.5 gpm 47 lbs/day, 5.6 gal/day creosote.

Operational Activities - Decision was made to discontinue extraction at E-3. Continuing maintenance problems associated with the exhaust line are taking more time to correct than is warranted, given the low pumping rate of the well. After problems with the boiler are identified and corrected, it is not anticipated that the boiler will be operated continuously prior to shutdown next week. Polymer injection will continue until the supply on-site for the polymer test is used up.

Other Issues - Draft RAMP amendment will be distributed by COB 11 Apr.

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SiteOpLog: Ops Meeting Minutes - 14 Apr 03

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! 04/16/03 11:45 | | Ops Meeting Minutes - 14 Apr 03

Mike Bailey
Member
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Attendees: Mike Bailey- Hydrogeologist (District Office) Cliff Leeper – SCS Engineers (On Site) Joe Harrington- SCS Kathy LeProwse – Project Manager (District Office) Mary Jane Nearman- EPA Project Manager Dave Roberson – SCS Kathryn Carpenter – Project Chemist (District Office) Marlowe Dawag – Process Engineer (District Office)

Until further notice, this will be the last posting to the Ops Log. During the retrofit period, regular meetings of the Ops Team are not scheduled.

Construction Update – Combustion Controls on-site to repair welds on the boiler. Weld failures believed to be the result of boiler "panting."

Total Water Usage: not reported today; Total Injection: 0.0 gpm; FPA Extraction: 37.82 gpm; PA Extraction: 8.56 gpm; T-402 Flow: 43.6 gpm Contaminant Recovery: 34 lbs/day, 4 gal/day creosote.

Boiler Room Update – The boiler is off-line and will remain off-line during the retrofit period unless needed to conduct tests. HESI arrived and was installed last week. The boiler was put through its paces last week and performed well. TOC average = 327 mg/L.

Pilot Area – No injection. Total extraction = 8.56 gpm. Pumping is limited to wells E-2, E-4, E-5, and E-6.

Treatment Plant Update – The treatment plant is operating normally with apparent good treatment across the aeration basin. DO is in the range of 6-7 mg/L. Clarity was reported as 2'. Volumes in 401 and 402 are at target levels. Flow to the aeration basin is 43.6 gpm. Increased discharge pressure noted at EW-4, which is probably due to an occlusion in the effluent line prior to the DAF.

Subsurface/Thermal Monitoring Update – Water levels are stable at 4.0 ft MLLW. Average pilot area temperatures are 68.5 C.

Contaminant Recovery: TOC=405 mg/L, extraction rate=8.6 gpm 34 lbs/day, 4 gal/day creosote.

Operational Activities: Polymer injection will continue until the supply on-site for the polymer test is used up. The well-fields will be turned off to clean out suspected blockage in the effluent line(s). Anticipated downtime is 4-6 hours.

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DQIssues: E-5 pumping rates are suspect from 18 Feb to 20 Ma

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03/24/03 08:14 | | E-5 pumping rates are suspect from 18 Feb to 20 Mar 03

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The following is a reconstruction of events associated with extraction well E-5 between 18 Feb and 21 Mar.

18 Feb an increase in extraction rate from 4.1 gpm to 6.9 gpm was noted

19 Feb water elevation at E-5 rebounded to 5.3 ft MLLW from –8.2 ft MLLW on previous day-----a discharge rate of 9.1 gpm was confirmed (bucket test) on the well-----effluent temperature dropped from 140 deg F to roughly 120 deg F

17 Mar an increase in extraction rate from 9.5 gpm to 10.8 gpm was noted-----effluent temperature dropped from 120 deg F to less than 60 deg F-----water elevation at 6.4 ft MLLW

20 Mar water elevation at 6.4 ft MLLW-----pump was pulled, and a 2 inch slit was discovered in the discharge line-----damaged tube was cut out, remainder was spliced, and pump was reinserted

21 Mar initial discharge rate of 4.9 gpm reported; declined to 4.2 gpm later in day-----water elevation at –5.2 ft MLLW-----effluent temperature greater than 150 deg F

The weight of evidence suggests that on 18 Feb a hole developed in the discharge line for E-5. As a consequence, some water was being recirculated into the well. The pump responded to the apparently greater flow of water into the well by an increase in extraction rate from roughly 4 to 9 gpm. However, more water was being recirculated than was being discharged to the effluent line at the surface, and water levels in the well rebounded to over 5 ft MLLW. It is believed that some water continued to be discharged from the well, because temperatures in the effluent line hovered around 120 deg F until 17 Mar. On 17 Mar, temperatures in the effluent line dropped to less than 60 deg F, and a bucket test revealed an actual pumping rate of roughly 1 gpm. The stroke counter on the well indicated a pumping rate of 10.8 gpm. When the slit in the discharge tube was discovered, it became apparent that more than 9 gpm was being recirculated into the well. The only information inconsistent with this interpretation is the 9.1 gpm discharge rate determined by bucket test on 19 Feb.

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Appendix G – PAH Precipitation and Encrustation Evaluation

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Appendix G – PAH Precipitation and Encrustation Evaluation

G.1 Introduction

The expected inter-phase differentiation of NAPL components was discussed in Section 4.1. During preparation of the Design Analysis, it was understood that aliphatic compounds would be the most volatile fraction of the creosote mixture, and these compounds would be recovered primarily in the vapor phase. Highly soluble compounds that are solid at ambient conditions, such as naphthalene and other LPAHs, would be concentrated in the aqueous phase. Table G-1 shows predicted component-group concentrations at 100 º C and atmospheric pressure, in the oil, aqueous, and gas phases.

G.1.1 Precipitation from the Aqueous Phase

The NAPL concentrations in Table F-1 represent the average of samples taken throughout the FPA prior to the pilot study. The data show the average composition of the creosote mixture to be 83% LPAH (35% naphthalene), with an LPAH/aliphatic ratio of 6.4. The theoretical LPAH/aliphatic ratio is only 2.1 for the gas phase in equilibrium with NAPL, due to the higher volatility of the aliphatic group. The ratio is much higher, 24.9, for the aqueous phase in equilibrium with NAPL, due to the higher solubility of the LPAH group. Since the SEE process should result in combined recovery of all three phases, the recovered product was expected to be a liquid mixture similar to the original NAPL in the subsurface.

Steam-injection was maintained at low rates during the 5-month pilot study due to repeated equipment failures and concerns about the capacity of older equipment in the treatment plant (i.e. the outfall discharge pipe). The result was a treatment process resembling slow hot-water circulation. The average steam injection and pumping rates were 13% and 25% of design rates, respectively. The vapor-extraction system was in operation for a total of 1 month, with no more than 3 days continuous operation. Groundwater velocities were probably too low to hydraulically mobilize significant NAPL, and vapor flow was not sufficient for significant mobilization of aliphatic hydrocarbons. Aqueous-phase recovery consisted primarily of LPAH compounds, including naphthalene, which are solid at ambient conditions. For these reasons, the recovered product was not a creosote-like liquid mixture, as anticipated in design; instead it was primarily dissolved LPAH, which precipitated and crystallized in wells, pipes and in the treatment system.

G.1.2 Precipitation from the Vapor Phase

LPAH encrustation, primarily naphthalene crystals, also occurred in the vapor-extraction system, and was seen to precipitate from steam plumes discharging from pump-exhaust ports and open wells. These observations are consistent with data shown in Figure G-1 for predicted naphthalene concentrations in the gas phase. Naphthalene is classified as a semi-volatile compound, and will partition into the gas phase from NAPL according to Raoult's Law, and from naphthalene-saturated water according to Henry's Law. The data in Figure G-1 suggest that gas in the presence of water containing dissolved creosote components can contain even higher naphthalene concentrations than gas associated with creosote alone. The implication is that the problem of solids precipitation in the vapor extraction system was exacerbated by operating the pilot study as a hot-water-circulation process rather than a balanced SEE operation.

G.2 Importance of Vapor-Phase Transport

As described in Section 4, progressive downsizing of the vapor extraction system occurred during system design changes. The design criteria called for well head vacuum at 0.5 atm, cooling capacity of 30% of injected enthalpy, and a maximum non-condensable gas flow of 1,350 acfm. The original design criteria could have been optimistic, since design modeling indicated that the peak-extracted enthalpy could approach 100% of the injected enthalpy. In contrast to the design criteria, the as-built system was thought to be capable of 0.25-atm vacuum at the well heads, a cooling capacity of 10% of injected enthalpy, and non-condensable gas flow at 450 acfm. It is likely that the 0.25-atm well head vacuum would have been insufficient to extract any vapor during pressure-cycle shut-in periods, based on model results. As a means to reduce construction costs, the as-built vapor extraction capacity of the system was significantly lower than the original design capacity. In retrospect, the reduction in capacity should have been more thoughtfully implemented considering the original system design basis and the projected vapor flow and transport.

The data shown in Table G-1 can be extended to pressures lower than one atmosphere, and combined with the multiphase-extraction rates assumed during pilot study design (Section 4.1) to predict ideal contaminant mass-removal rates for each phase (Figure G-2). Figure G-2 illustrates the critical importance of vapor-phase transport for thermal treatment of creosote: theoretical mass-removal rates for the vapor and NAPL phases are equal at 0.25 atm, and vapor-phase removal is higher at vacuum levels above 0.25 atm. Predicted mass-removal in the aqueous phase is minor compared to the other phases.

Both gas-phase and aqueous-phase removal shown in Figure G-2 are assumed to be at equilibrium with the NAPL phase, and may be over-estimated relative to actual field conditions. On the other hand, the projected NAPL-removal rate includes considerable vapor-transported product that condenses in the cooling and treatment system, and in and around the extraction wells. These data indicate that a primary objective for thermal remediation of creosote should be aggressive steam flushing throughout the treatment area, and that hot-water circulation without significant hydraulic mobilization of NAPL is not an effective process.

Table G-1 Predicted Multiphase Component Concentrations

Phase	**Concentration of Component Group (g/g)**[1]			**LPAH/aliphatic ratio**
	LPAH	**HPAH**	**Aliphatic**	
NAPL[2]	0.8277	0.042976	0.12900	6.42
Gas[3]	0.0535	0.000333	0.02591	2.06
Aqueous	0.0108	0.000002	0.00044	24.86

Notes:

1. All values are estimated for 100 deg. C and atmospheric pressure, with all phases in equilibrium.
2. Mass fractions are based on an average of all NAPL samples taken to date.
3. Gas phase is assumed to be primarily air.

Figure G-1. Theoretical Naphthalene Concentrations in Gas Phase

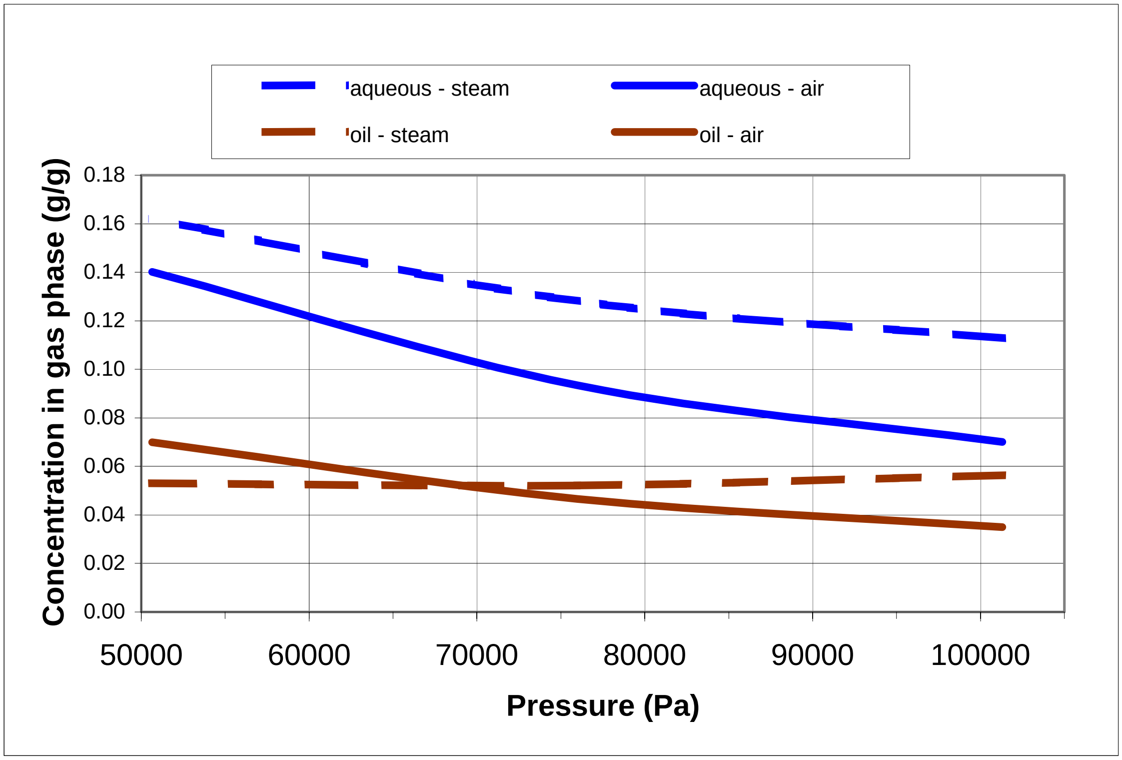
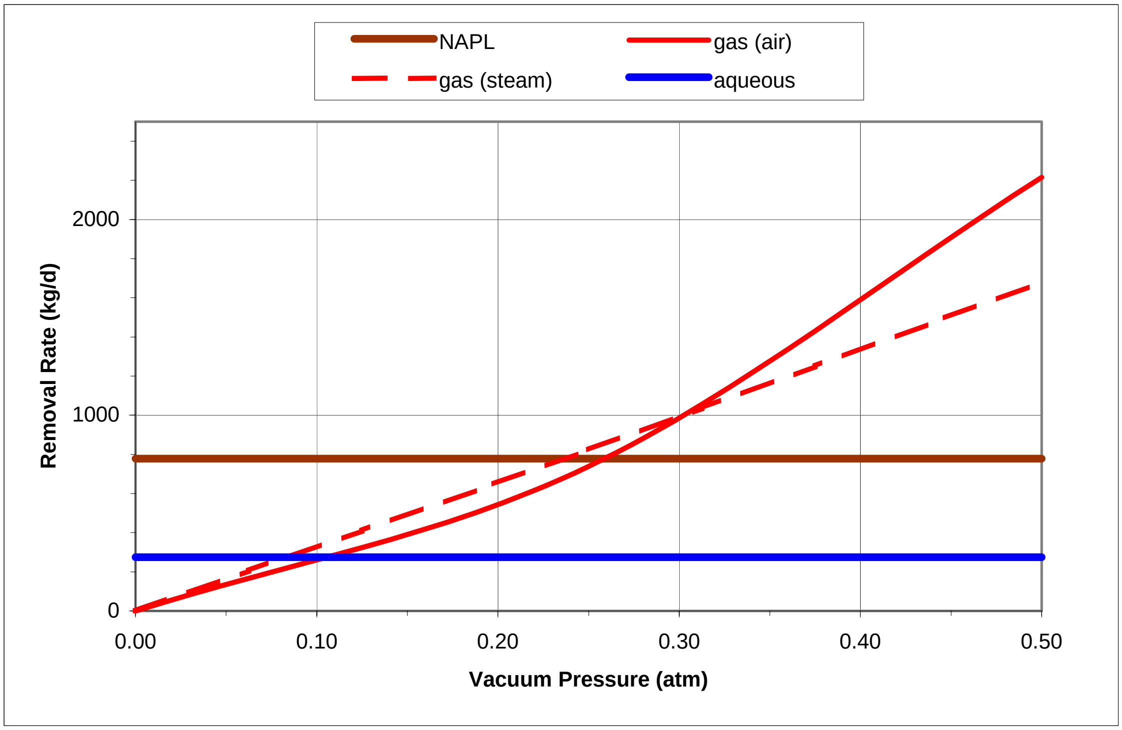


Figure G-2. Theoretical Contaminant Mass Removal Rates



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Appendix H - Calculation Methods for Process Streams

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Appendix H – Calculation Methods for Process Streams

Note: Discrepancies exist between some fundamental assumptions (pilot area, pilot volume, soil porosity) used in Appendix H and those used in the body of the text of this report, as well as in previous design documents. There was not an opportunity to correct the differences prior to publication of this report.

H.1 Mass Balance Estimation Methods

The water mass balance is calculated as follows:

$M_{in,steam} = M_{out,\ liquid} + M_{out,vapor} - M_{net\ extraction}$

The steam injection rate was estimated for each of the 16 injection wells

$$M_{in,steam} = \Sigma\ (m_{in,\ steam} \text{ x } \Delta t)$$

where $m_{in,\ steam}$ is the flow rate, and t is time. Each value of m was calculated based on a valve setting, the pressure drop across the valve, and the temperature of the steam. Average values for each day of injection were used.

Since the data from the steam regulator valves was not recorded for the entire period of steam injection, two additional lines of data were used to document the actual steam injection rates from early October to May:

1. The diesel usage was converted to an equivalent steam production rate, assuming a boiler efficiency of 85%, and a diesel energy content of 140,000 BTU/gal.
2. The water used by the boiler was converted to equivalent steam injection rates, assuming negligible blow-down volumes.

The mass removal in the liquid for is a simple summation of the measurements from each of the seven extraction pumps:

$$M_{out,\ liquid} = \Sigma\ (m_{liquid} \text{ x } \Delta t)$$

Where the values for m_{liquid} were derived from a pump stroke counter installed for each pump.

The mass removal in the form of vapor (steam, water vapor) ideally is calculated by the liquid production rate in the condenser:

$$M_{out,vapor} = \Sigma\ (m_{condensate} \text{ x } \Delta t)$$

Where $m_{condensate}$ is the flow rate of condensate. However, the flow meter that should have quantified this stream was never installed. Instead, we estimated condensate rates based on observed temperatures, and experience from other steam sites (Alameda Point, Young-Rainey STAR Center Area A).

The net extraction was estimated based on the water balance equation presented in the beginning of this section. Similarly, net water extraction rates were estimated by the difference of the measured flows:

$$m_{net\ extraction} = m_{liquid} + m_{vapor} - m_{in,steam}$$

Due to the absence of a flow meter for the produced condensate, M_{vapor} and m_{vapor} had to be estimated.

H.2 Energy Balance Estimation Methods

Cumulative energy (E) is calculated as a summation of enthalpy fluxes (Q):

$$E = \Sigma (Q \times \Delta t)$$

An estimated energy balance will be maintained for the site.

$$E_{in,\ steam} = E_{out} + E_{storage} + E_{loss}$$

The energy fluxes are related for each time step as follows:

$$Q_{in,\ steam} = Q_{out} + Q_{storage} + Q_{loss}$$

Where Q denotes enthalpy flux (in BTU/hr). Energy increments are estimated as follows:

$$Q_{in,\ steam} = \Delta m_{in,steam} \times \Delta H_{steam\text{-}ambient}$$

Where m is mass of steam. This calculation was done for each of the 16 injection wells, and average daily values were used for the steam flow rates. The enthalpy of the steam was calculated from steam tables, using a steam pressure of 20 psig, and an ambient temperature of 15 ^oC:

$$\Delta H_{steam\text{-}ambient} = (1{,}167 - 25)\ BTU/lb = 1{,}142\ BTU/lb$$

The following energy fluxes were calculated for each of the seven extraction wells:

$$Q_{liq} = \Delta m_{water} \times c_{p,\ water} \times (T - T_0)$$

Ideally, for the extracted fluid stream, the energy flux in vapor and steam should be estimated based on treatment system data:

$$Q_{non\ cond.\ gas} = \Delta m_{air} \times c_{p,\ air} \times (T - T_0)$$

$$Q_{steam\ out} = \Delta m_{condensate} \times \Delta H_{steam\text{-}ambient}$$

Where m is mass, H is specific enthalpy (in BTU/lb), c_p is heat capacity (in BTU/lb/F), and T is temperature. Since very limited and unreliable vapor flow data is available for periods other than November 26, 2002 through December 16, 2002, an assumed average flow rate of 100 scfm was chosen based on the average rate observed during this period for the vacuum system. After December 16, when the vapor extraction system was turned off, zeroes were inserted. The calculation shows that the actual vapor flow rate has a very small effect on and energy balance, due to the low heat capacity of air. Similarly, the rate of condensate production was estimated based on observed temperatures and experience from other sites.

The total energy removal from the pilot test volume was estimated as follows:

$$Q_{out,\ total} = Q_{liq} + Q_{non\ cond.\ gas} + Q_{steam\ out} + Q_{heat\ loss}$$

The actual heat loss cannot be calculated using accurate measures. An estimate can be made based on thermal profiles at the bottom and top of the treatment cell, and along the sheet-pile wall, using the following calculations:

$$Q_{heat\ loss} = A \times K_T \times dT/dz$$

Where A is the surface area through which energy is conducted, K_T is the thermal conductivity of the subsurface material (saturated sand/clay near the aquitard, partially saturated sand near the vapor cap), and dT/dz is the temperature gradient. No heat loss was calculated for the southern boundary, since inflow of water due to the net extraction would carry the conducted energy back into the pilot test area.

For the loss through the vapor cap, the temperature difference between the two uppermost temperature sensors were used to calculate the gradient dT/dz. The area of the heated zone was estimated at 27,500 ft^2, which is slightly larger than the foot print of the wells due to the steam migration south of the pilot test wells. For the heat loss through the bottom of the site, the temperature gradient was estimated based on the bottom two sensors in the monitoring locations, and the steam wells. The heat loss through the sheet-pile wall was estimated based on average temperatures on the inside of the sheet pile wall (using daily values for all the sensors), and assuming that near ambient temperatures exists five ft away from these sensors. This is a relatively rough assumption, but no data exists for an improved estimate.

Thermal conductivities of 2.5 W/mK were used for the heat loss calculations through the bottom and sides, which is based on saturated soils. It was assumed that saturated conditions exist along the boundaries of the site, due to steam condensing as it cools. For the vapor cap heat loss, a value of 1.5 W/mK was used, corresponding to partially saturated soil.

The temperatures achieved and measured using the temperature sensors were compared to the temperatures estimated based on the calculated energy balance. The stored energy is related to the pilot test heat capacity, and the measured average temperature as follows:

$$E_{storage} = C_{p,site} \times (T_{avg} - T_0) + m_{steam} \times \Delta H_{steam\text{-}ambient}$$

Where $C_{p,site}$ is the overall heat capacity of the pilot test area, estimated from the volume, saturation, and specific heat capacity of the soil and water:

$$C_{p,site} = V_{soil} \times c_{p,\ soil} \times V_{water} \times c_{p,\ water}$$

The steam energy stored as a vapor at any given time is relatively small, and was neglected in the calculations. For comparison with the measured temperatures, the energy balance was used to estimate the average temperature ($T_{energybal}$)of the pilot test volume:

$$T_{energybal} = T_0 + E_{storage}/C_{p,site} = T_0 + (E_{in,\ steam} - E_{out} - E_{loss})/ C_{p,site}$$

Where T_0 is set as the average background temperature (57 ^oF = 13.9 ^oC).

H.3 Pore Volume Calculation Methods

The number of pore volumes of steam injected has been used as a measure at other sites, and during laboratory scale treatability studies. For this pilot test, the pilot test pore volume was estimated as follows:

$$pv_{pilot\ test} = \epsilon * V_{pilot\ test}$$

Where ϵ is the average porosity, and V is the volume. For the injected volume, a direct calculation from the steam flow rate measurements and the energy balance is made, yielding the amount of water that entered the site as steam:

$$V_{steam} = M_{in,steam} * \rho_{water} = \rho_{water} * \Sigma (m_{in,\ steam} \times \Delta t)$$

Where ρ_{water} is the density of water.

The number of pore volumes injected is then derived from

$$pv_{steam} = V_{steam} / pv_{pilot\ test}$$

The vadose zone is included in this estimate, since the steam is intended to heat both the saturated and vadose zones.

Appendix I – Pilot Study Data Summary (CD-ROM ONLY)

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Appendix J – Installation Report for Well 02CD-MW01

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CENWS-EC-TB-GE 26 September 2002
BAILEY/6682

MEMORANDUM FOR RECORD

SUBJECT: Recommendation for Additional Monitoring Well at the Wyckoff Superfund Site, Bainbridge Island, Washington

1. Recent acquisition of continuous water level data in extraction well E-6 has reinforced interpretations and conclusions presented in a report titled “Well E4 Pumping Test Summary” by Mick Easterly, dated 16 Nov 01. In that report strong tidal influence was noted for wells E-5 and E-6. The report concluded that the aquitard between the upper and lower aquifers may be thin or absent near E-6 and that vertical hydraulic control should be a goal during remediation operations. Data collected recently from well E-6, in particular, have exhibited clear influence from tides. The effect is not nearly as apparent for E-5.

2. Under current conditions, the upper aquifer beneath the site in general and the Pilot Area specifically has been isolated from water level fluctuations in Eagle Harbor by the presence of two sheet pile walls. Consequently, tidal effects should be minimal to nonexistent in the upper aquifer. The presence of tidally influenced fluctuations in E-6 implies hydraulic connection with the lower aquifer. The connection is apparently limited in areal extent, because other wells in the Pilot Area exhibit minimal cyclic fluctuations.

3. The closest boring (for monitoring well 99CD-MW04) that penetrates through the glacial till aquitard beneath the upper aquifer is approximately 80 feet to the northwest of E-6. The aquitard at that location consists of roughly 20 feet of till with sand interbeds. The occurrence of sand interbeds provides one mechanism for hydraulic connection between the upper and lower aquifers, depending on the degree of interfingering of the interbeds. In the absence of direct evidence at E-6, it is impossible to know the actual nature of the connection between the two aquifers.

4. To evaluate existing conditions in the aquitard and lower aquifer near E-6, it is recommended that one monitoring well be installed in the lower aquifer to a maximum depth of approximately 70 feet below ground surface. Due to imminent commencement of thermal remediation activities in the Pilot Area, the well will have to be located outside the sheet pile wall. The chosen location should be as close to the sheet pile wall as practical, taking into account safety concerns resulting from the proximity to high pressure steam conveyance lines. It is further recommended that continuous soil sampling (by split-spoon or other equivalent methods) start at 28 feet below ground surface, which should be 5 feet above the glacial till aquitard.

5. The action recommended in this memorandum is considered necessary to document the presence or absence of site contaminants (including non-aqueous phase liquids) in the aquitard and lower aquifer in light of observations that suggest some degree of hydraulic communication between the upper and lower aquifers near E-6. One of the goals of the Pilot project is avoid exacerbating contaminant conditions in the aquitard or lower aquifer. This can be accomplished

only by fully understanding current conditions near E-6 and by periodically monitoring to ensure that existing conditions are not made worse during Pilot operations.

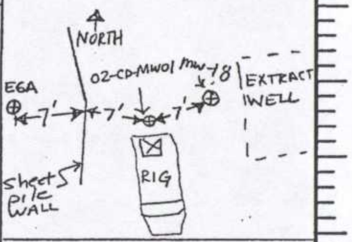
6. If you have any questions about this memorandum, please feel free to contact the undersigned at 206-764-6682.

Michael M. Bailey
Geologist

Hole No. 02-CD-MW01

DRILLING LOG	**DIVISION** NWD	**INSTALLATION** SEATTLE DISTRICT	**SHEET** 1 **OF** 2 **SHEETS**

1. PROJECT: WYCKOFF SUPERFUND SITE MW INSTALLATION
2. LOCATION (Coordinates or Station): EAGLE HARBOR, WA
3. DRILLING AGENCY: TACOMA PUMP AND DRILL
4. HOLE NO. (As shown on drawing title and file number): 02-CD-MW01
5. NAME OF DRILLER: Jim Vignal
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: —
8. DEPTH DRILLED INTO ROCK: N/A
9. TOTAL DEPTH OF HOLE: 63.0'
10. SIZE AND TYPE OF BIT: 10" mother Hubbard
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Bucyrus-Erie 22W
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4 JARS; UNDISTURBED N/A
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 11/14/02; COMPLETED 11/25/02
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Jeff Powers & S. Hess

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0		0-28' NOT SAMPLED @~5' APPEAR TO ENCOUNTER NAPL CUTTINGS w/ WATER HAVE SHEEN & STRONG ODOR ~10' DRILL PENETRATION BECOMES EASIER ~17-20' "SPONGY," DIFFICULT DRILLING (TIMBER?)			DRILL 0-28' WITHOUT SAMPLING BEGIN DRILLING 11/14/02 @1225 HRS
	28.0 29.0		dK grn-gray silty SAND (SM), soft to med. dense, wet, fine to med grained Sand, shell frags. & sm. wood frags @29.7', odor but no visible evidence of NAPL. [5GY 4/1] 28.0-30.0'	1.0' (50%)	NO SAMPLE (NS)	LOCATION: 
	30.0 31.0		dK greenish-gray silty SAND, SAME AS Above, saturated 30.0-31.4	1.0' (50%)	NS	
			gray-brn sandy GRAVEL (GP), med. dense, saturated, little fines, less shell frags. sl. odor 31.4-32.0 2" gravel stuck in shoe		J-1	11/14/02 1650 HRS STOP DRILLING; AT 20' BGS
	32.0		olive gray to gray-brn SILT (ML), very dense, TILL, moist to wet, occasional median grav ½" but up to 2", rounded, within silt matrix, sl. odor 32.0-33.0' [5Y 4/1]	0.7/1.0 (70%)	J-2	11/15/02 0800 BEGIN DRILLING 11/15/02 1600 HRS STOP DRILL
	33.0		Accidentally drilled 33.0-34.0 WITHOUT OBTAINING SAMPLE	0	NS	BLOW COUNTS: 300# HAMMER, 30" DROP
	34.0		olive gray SILT, w/occ. fine to med gravel, Very dense, TILL (similar to above) sl. odor. 34.0-34.9'	0.6/0.9 67%	NS	28-30' 10-15-18-20 30-32' 12-15-75-75 32-33 50-100 34-34.9 45-100/4.5"
	35.0		sandy Gravel w/silt (GP), dark gray, wet, slight odor, very dense 35.0-35.5'	0.5/0.5 100%	NS	▽ @ 11.0 BGS on 11/18/02 start drilling @1010hrs
	36.0		Sand w/silt (SP), gray, moist-wet, very dense, sheen, odor 36.0'-36.4'	0.4/0.4 100%	NS	Blow counts 35-35.5 100/5.5" 36-36.4 100/4"
	37.0		Silt w/sand & gravel (ML), damp-moist, very stiff, odor	0.7/1.1 85%	NS	37.0-38.2' 25-80-100/2" 38-39 25-90/6"
	38.0		same as above	1/1 100%	NS	39.0-40.2' 35-70-100/2'
	39.0		same as above	0.8/1.1	NS	Stop drilling @ 1300hrs break for lunch switching over to 6"
	40.0		lt. olive gray-brn sandy SILT (ML), TILL, occ. coarse sand grains & fine rounded gravel, v. dense, wet, no odor, no visible evidence of NAPL 40.0-41.0'	1.0/1.0' 100%	NS	2' bentonite chip seal 38-40'; bail water from hole, casing reduction from 10" to 6" @ 40' bgs
	41.0		Same as above except a few thin sand "stringers," trc. clay 41.0-42.0'	0.8/1.0' 80%	NS	Blow counts cont'd
	42.0		NO SAMPLE, LOST SPOON SHOE & SAMPLE DOWN HOLE; SPOON DRIVEN AS IF IN SAME DENSE SILTY TILL MAT'L 42.0-43.0'	0/1.0' 0%	NS	40-41' 50-150 41-42' 50-150 42-43' 85-150
	43.0		gray-brn sandy SILT, TILL, v. dense, wet, w/occ. rnded gravel to 1.5" diam 43.0-43.9	1.0/1.5' 67%	NS	43-44.5' 40-40-100 45-45.8' 25-150/4"
	44.0		gray-brn silty SAND (SP), soft to med. dense, med. grained, well sorted (slough??) 43.9-44.5			46-47 50-150 47-47.3 150/4" 48-49.25 80-75-100/3"
	45.0		See Next pg. for Description →			49.5-50.5 90-150 50.5-51.9 25-100-150/5"

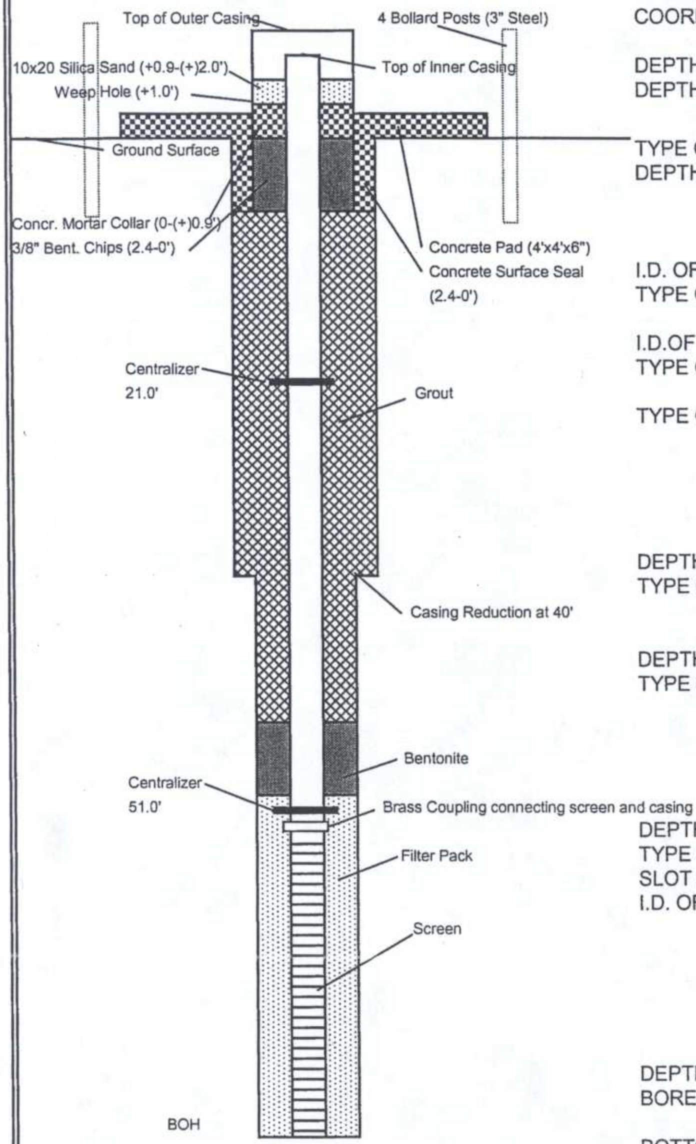
DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE **Hole No.** 02-CD-MW01

PROJECT WYCKOFF SUPERFUND
INSTALLATION SEATTLE DISTRICT
SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	45.0		brn SAND(SP), coarse grained, few pc. fine grav, wet, med. dense 45.0-45.4	8"/8"	J-3	11/19 0800 hrs start drilling @40' 1645 hrs stop drilling C51.9'
			brn sandy SILT(ML), TILL, v.dense, occ. rnd. grav to 2" 45.4-45.8	100%	NS	
	46.0		Same as above 46.0-46.5'	0.8/1.0 80%	NS	
			brn silty SAND(Sm), soft to med. dense, wet, well-sorted; lt gray bottom 2" 46.5-47.0'			
	47.0		brn sandy SILT (ML), TILL, v.dense, moist to wet; med-coarse sand, occ. fine gravel to 1" diam 47.0-47.3'	0.3/0.3 100%	NS	
			NO SAMPLE 47.3-48.0'	—	NS	
	48.0		brn sandy SILT (ML), v.dense, wet 48.0-48.2'	1.1/1.25' 89%	NS	
	49.0		olive gray to brn silty SAND(SP), soft to med. dense, wet, sub-rnded sand (coarse grained), some fine rnded. gravel more silty bottom 2" 48.2-49.05'			
	50.0		gray-brn silty gravelly SAND (SW), dense, wet, poorly sorted, sand mostly med-coarse gravel fine, sub rnd to 1" diam. more silty 50-50.3' 49.5-50.5'	0.9/1.0' 90%	NS	←NO Sample 49.05-49.5' AFTER Refusal @ 49.05'
	51.0		brn silty CLAY(CL) dense, moist, 50.5-51.5'	1.2/1.4' 85%	NS	
			brn gravelly SAND (SW), med. dense, wet, fine gravel, coarse sand 51.5-51.9'			
	52.0		same as above (52.0-52.4')	0.4/0.4' 100%	NS	11/20/02 start drilling @ 0830 hrs stop drilling @ 1640 hrs Blow counts 52.0-52.4' 150/4" 53.0-54.5' 30-32-32 54.5-55.2' 120-100/1" 55.2-55.6' 150/4" 56.0-56.6' 112-100/2" 57.0-57.6' 100-50/1" 58.0-58.9' 30-150/5" 59.0-59.6' 150/6" 60.0-61.4' 40-55-150/5" 61.5-63.0' 45-125/6"
	53.0 54.0		dark gray, sandy Gravel-gravelly Sand (GP-SP), very dense, moist, med-coarse sand, gravel is subrounded to rounded, 1"+/- (53.0-54.5') [lower aquifer]	1.0/1.5'	NS	
	55.0		dark gray, gravelly Sand, (SP), very dense, moist; rest same as above (54.5-55.2')	7"/7" 100%	NS	
			same as above SP-GP (more gravel) (55.2'-55.6')	4"/4" 100%	J-4	
				▨	▨	
	56.0		same as above, 1% silt (GP-GM) (56.0-56.6')	6/6" 100%	NS	
				▨	▨	
	57.0		same as above (57.0-57.6')	7"/7" 100%	NS	
				▨	▨	
	58.0		same as above (58.0-58.9')	0.6/0.9	NS	
	59.0		same as above (59.0-59.6')	0.5'/0.5' 100%	NS	
				▨	▨	
	60.0		brn/gray, gravelly Sand w/silt (SP-SM), very dense, wet, same as above (60.0-61.4')	?	NS	sampler too full, had to knock out sample w/ hammer
	61.0		same as above (61.5-62.1')	12/12" 100%	NS	
	62.0		brown, silty Sand (SM), very dense, damp, (62.1-63.0')			
	63.0		BOTTOM of BORING = 63.0'			Well 02-CD-MW01 SPECS: Stainless Steel screen: 63-53' Steel casing: 53-(+)2.6' Filter pack: 63-50.1' Bentonite seal: 50.1-48' Cement-silica grout: 48-2.4' See MW AS-BUILT FOR MORE DETAIL ON WELL 10/20 SILICA FILTER SAND 7.5 50# BAGS 3/8" BENTONITE CHIPS 1/2 50# BAG Cement-silica grout 20.5 94# bags portland cement T.I & 2 17.5 50# bags silica flour
	64.0					
	65.0					
	66.0					
	67.0					
	68.0					
	69.0					

AS BUILT MONITORING WELL RECORD

HOLE NUMBER: 02-CD-MW01	LOCATION: Wyckoff Superfund Site, Bainbridge, WA		DRILLER: Jim Vignali/Tacoma Pp Drl
PROJECT: MW Installation	ELEVATIONS (FT MSL)		DEPTH TO GW (FT)*: 7.5'
DATE WELL COMPLETED: 11/25/02	SURFACE:		DRILLING METHOD: Cable Tool
DATE DEVELOPMENT COMPLETED: 12/2/02	TOP OF PVC CASING:		DEVELOPMENT METHOD:
INSPECTOR: Jefferey Powers	TOP OF OUTER CASING:		Alternate pumping & surging



COORDINATES:	
DEPTH TO TOP OF OUTERCASING:	(+) 2.9'
DEPTH TO TOP OF INNER CASING:	(+) 2.6'
TYPE OF SURFACE SEAL:	Concrete
DEPTH OF SEAL:	2.4'
I.D. OF OUTER CASING:	6.25"
TYPE OF OUTER CASING:	Round, Steel
I.D.OF RISER PIPE:	2.0"
TYPE OF RISER PIPE:	Black Steel
TYPE OF GROUT:	60:40 Portland Cement: Silica Flour (20.5 94-lb bags cement, 17.5 50-lb bags silica)
DEPTH TO TOP OF SEAL:	48.0'
TYPE OF SEAL:	3/8" diam. Hole Plug Bentonite Chips (0.5 50-lb bag chips)
DEPTH TO TOP OF FILTER PACK:	50.1'
TYPE OF FILTER PACK:	10x20 Colorado Springs Plant Silica Sand (7.5 50-lb bags sand)
DEPTH TO TOP OF SCREEN:	53.0'
TYPE OF SCREEN:	#304 Stainless Steel, Continuous Slot
SLOT SIZE AND LENGTH:	0.020-inch ("20 Slot")/10' Length
I.D. OF SCREEN:	2.0"
DEPTH TO BOTTOM OF SCREEN:	63.0'
BOREHOLE DIAMETER:	10" 0-40' bgs, 6" 40-63' bgs
BOTTOM OF HOLE:	63.0'

* Depth to groundwater measured relative to ground surface

USACE - Seattle District

PROJECT: MW Installation at Wyckoff Superfund Site, City of Bainbridge Island, Washington	HOLE NO.: 02-CD-MW01

Date: 12/2/02 Well ID 02-CD-MW01

MONITORING WELL DEVELOPMENT RECORD

Project: MW Installation
Location: Wyckoff Superfund Site, City of Bainbridge Island, Washington
Develop Team: Jefferey Powers (Seattle District); Jim Vignali (Tacoma Pump and Drill)

Well Serial Number		Well Condition	New
PID Reading	N/A	Weather Conditions	Overcast, 45 degrees F
Static Water Level	7.5'	Reference Point	Below ground surface
Well Depth Sounding	63.0'	Reference Point	Below ground surface
Well Casing Diameter	2.0"	Well Casing Radius	1.0"
α, β Readings	N/A		

Well Volume Calculation: $V = 0.163 * (D-W) *r^2$

V = **17.51 gallons equals one well volume**
V = Volume (gallons)
D = Well depth (feet)
W = Static water level (feet)
r = Well casing radius (inches)

Develop Method: Alternate pumping w/ Geosquirt electric pump and surging with bailer
Pumping Rate: 1.7 to 2.5 gpm Pump Depth: 53' bgs
Sampling Method: Well not sampled as of 12/2/02

Date	Time	Head (bgs)	Total Vol Purged	Qualitative Water Clarity	Temp. (°C)	pH	Conductivity (micro-ohms/cm)	DO (ppm)
12/2/02	0915	7.5'	0 gallons	Brn, silty, turbid	NM	NM	NM	NM
12/2/02	1021	Not Meas	50 gallons	Lt. Brn, silty, turbid	NM	NM	NM	NM
12/2/02	1053	NM	100 gall	Light brown, turbid	NM	NM	NM	NM
12/2/02	1149	NM	150 gall	Light brown, turbid	NM	NM	NM	NM
12/2/02	1233	NM	200 gall	Slightly cloudy	NM	NM	NM	NM
12/2/02	1401	~15.0'	250 gall	Light brown, turbid	NM	NM	NM	NM
12/2/02	1425	NM	300 gall	Cloudy	NM	NM	NM	NM
12/2/02	1449	NM	350 gall	Slightly cloudy	NM	NM	NM	NM
12/2/02	1500	NM	370 gall	Slightly cloudy	NM	NM	NM	NM

SAMPLING RECORD

Parameter	Method Number	Sample Number	QA/QC Sample No.	Preservative
VOC				
SVOC				
Pest/Herb				
Metals (Total)				
Other: ________				
Other: ________				

Method of Water Disposal: Contain development water in 55-gal drums, empty drums away from well
Comments: (color, sheen, odor, etc…) Development water contained no visible sheen, no odor. First 10 gallons of water removed had greenish-brown color, then greenish tint went away.