FINAL

Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California

Prepared For

Air Force Center for Environmental Excellence
Consultant Operations Division (AFCEE/ERC)
Brooks Air Force Base
San Antonio, Texas

and

Defense Logistics Agency (DLA)
Environmental and Safety Policy Office (CAAE)
Fort Belvoir, Virginia

May 2001

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
1700 Broadway, Suite 900 • Denver, Colorado 80290

FINAL

REMEDIAL PROCESS OPTIMIZATION

PHASE II EVALUATION REPORT

FOR THE

TRACY DEFENSE DISTRIBUTION DEPOT

SAN JOAQUIN, CALIFORNIA

Prepared for:

US AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
CONSULTANT OPERATIONS DIVISION (AFCEE/ERC)
BROOKS AIR FORCE BASE, TEXAS

and

DEFENSE LOGISTICS AGENCY
ENVIRONMENTAL AND SAFETY POLICY OFFICE (DLA/CAAE)
FORT BELVOIR, VIRGINIA

MAY 2001

Prepared by:

PARSONS ENGINEERING SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, CO 80290

PROFESSIONAL CERTIFICATION

REMEDIAL PROCESS OPTIMIZATION PHASE II REPORT
for THE
TRACY DEFENSE DISTRIBUTION DEPOT
SAN JOAQUIN, CALIFORNIA

Prepared for:

Air Force Center for Environmental Excellence,
Consultant Operations Division (AFCEE/ERC)
Brooks Air Force Base
San Antonio, Texas

and

Defense Logistics Agency
Environmental and Safety Policy Office (DLA/CAAE)
Fort Belvoir, Virginia

May 2001

This report has been prepared by the staff of Parsons Engineering Science, Inc., under the professional supervision of the Principal Scientist whose signature appears hereon.

The services performed by Parsons Engineering Science, Inc. have been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in central California. The findings, recommendations, specifications, or professional opinions are presented herein, within the limits prescribed by the client, after being prepared in accordance with generally accepted professional geologic practice. There is no other warranty, either expressed or implied.

5/15/2001

John W. Anthony, R.G. #6127
Principal Geological Engineer

Date

EXECUTIVE SUMMARY

Parsons Engineering Science, Inc. (Parsons ES) was contracted by the Defense Logistics Agency Environmental Safety and Policy Office (DLA/CAAE) and the Air Force Center for Environmental Excellence Consultant Operations Division (AFCEE/ERC) to conduct a remedial process optimization (RPO) evaluation of remedial decisions and remedial systems at the Tracy Defense Distribution Depot, San Joaquin, California (DDJC-Tracy) in Tracy, California. The general goals for each site addressed under DLA's RPO program are to: 1) assess the effectiveness of selected remedies; 2) enhance the effectiveness and efficiency of the remedies; and 3) when possible, identify optimization opportunities that could result in annual operating, maintenance, and/or monitoring (OM&M) cost savings for the systems evaluated.

DDJC-Tracy was placed on the National Priorities List (NPL) in 1990 based on documented contamination of soil, sediment, and groundwater with volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and metals. The Depot has been organized into several source-area (soil/sediment) sites, and Defense Site Environmental Tracking and Recording System (DSERTS) sites and one groundwater operable unit (OU1) to facilitate environmental restoration. Most soil contamination has been or is being remediated. Three sites (Solid Waste Management Unit [SWMU] 1 and Defense Site Environmental Recording and Tracking System [DSERTS] 66 and DSERTS 68) with elevated vadose-zone concentrations of chlorinated solvents are undergoing remediation by soil vapor extraction (SVE) to control continuing sources of groundwater contamination. Because the SVE systems were not yet operational during this RPO evaluation, SVE design documents rather than operating data were used to assess expected performance. In groundwater, chlorinated VOCs are the contaminants detected most frequently and exhibiting the broadest areal distribution in groundwater; pesticides also are of concern, but exhibit more localized distribution. Groundwater contamination has migrated off-Depot to the north-northeast beneath agricultural fields that have been acquired by DDJC-Tracy (i.e., the Tracy Annex).

The 1998 Comprehensive Site-Wide Record of Decision (ROD) governs remedial efforts at the Depot and the Annex. The 1998 ROD affirms and modifies a 1993 ROD for OU1 groundwater, identifies tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), and dieldrin as groundwater chemicals of concern (COCs), and defines federal or state maximum contaminant levels (MCLs) or action levels as the aquifer cleanup levels (ACLs) for OU1. Under current land-use conditions, no completed groundwater exposure pathways to human or ecological receptors exist on the Depot or Annex. However, the affected aquifer is classified as a drinking water source, and one off-Annex private residential well has been affected by low levels of VOC contamination. The remedy selected for cleanup of COCs in OU1 involves extraction and treatment of contaminated water, infiltration of treated effluent into shallow groundwater, hydraulic containment to prevent further offsite migration, natural

attenuation (via dispersion/dilution) of dilute portions of the TCE plume that extend beyond the Annex boundaries, and long-term monitoring (LTM).

Groundwater extraction has been targeted in four hydraulically connected hydrostratigraphic “horizons” in the Upper Tulare Aquifer. The groundwater extraction network currently consists of 35 extraction wells, with operation of several additional wells planned for 2001. The extraction system has been successful in reducing contaminant mass in selected VOC "hot spots" near source areas. At least one hot spot, associated with DSERTS 68, is not currently being targeted by the extraction system. Incomplete characterization of the downgradient, off-Annex extent of TCE contamination precludes a complete assessment of plume stability, and therefore of the effectiveness of eastern-boundary extraction wells at limiting plume migration. Characterization efforts by URS for the area east of Banta Road are ongoing. Variations in the wells included in individual sampling events during implementation of the monitoring program also have constrained interpretations of plume continuity, fate, and transport laterally and vertically among the hydrostratigraphic units through time.

Extracted groundwater is treated at two treatment plants (TP-1 and TP-2) using air strippers to remove the VOCs; dieldrin is treated at several wells using point-of-extraction granular activated carbon (GAC) filtration. Treatment plant effluent is returned to the aquifer via nine infiltration galleries, and through percolation from a sewage lagoon, and must meet discharge requirements established in the ROD and a California Regional Water Quality Control Board waste discharge requirements (WDR) order. Because the full-scale extraction/treatment/injection (ETI) system has been only partially operational since TP-2 was brought on-line in November 1998, performance data are insufficient to allow a thorough RPO evaluation.

The 1998 Comprehensive Site-Wide ROD also selects remedies and establishes cleanup goals for soil, sediment, and surface water at source areas. Though contamination in these media do not directly pose unacceptable risks to human or ecological receptors, contamination at some sites represents a continuing threat to groundwater quality. The Comprehensive ROD specifies remedies for all sites that pose such a threat, and establishes cleanup goals for soils based on protection/restoration of groundwater quality. Soil remedies include excavation, SVE, bioventing, institutional controls, and monitoring of groundwater downgradient of source areas for known soil contaminants. Three source sites targeted for SVE were evaluated during this RPO effort.

The following tasks were completed in conjunction with the RPO evaluation for DDJC-Tracy:

- Review existing data and the current conceptual site model (CSM) to evaluate previous site characterization activities, remedial decisions, and actions; to assess ongoing remedial system optimization efforts and progress toward ROD objectives; and to identify data gaps;

- Conduct limited-scale field activities to collect chemical/physical data to fill characterization data gaps at DSERTS 68 and in the southeastern part of the Annex;

- Conduct a seven-well pilot test of diffusion sampler technology as a possible alternative to micropurge groundwater sampling for VOCs;

- Revise the CSM and develop an alternative strategy for presenting groundwater data, de-emphasizing plume delineation by hydrostratigraphic unit;

- Review the results of a monitored natural attenuation study, overland-flow effluent-disposal pilot tests, and the SWMU 4 ecological risk assessment, all prepared by URS;

- Review soil cleanup goals established in the ROD and develop alternative site-specific cleanup goals for PCE and TCE in vadose-zone soils at SWMU 1, DSERTS 66, and DSERTS 68;

- Evaluate the SVE systems planned for sites 1, 66, and 68 and identify optimization opportunities;

- Evaluate the existing OU1 groundwater ETI system with respect to progress toward the ROD remedial action objectives (RAOs) of plume containment and COC mass removal;

- Develop a framework for evaluating the groundwater LTM program; and

- Prepare this RPO Phase II Evaluation report presenting the refined CSM and optimization recommendations for groundwater data reporting, three SVE systems, the OU1 ETI systems, and the groundwater LTM program.

Because the SVE systems at SWMU 1 and DSERTS 66 and 68 were not installed during the RPO evaluation, and because full-scale groundwater ETI has been only partially operational since TP-2 was brought on-line in November 1998, there were insufficient operating data available during this RPO effort to allow for a comprehensive evaluation of system performance and effectiveness. Therefore, this RPO evaluation focused on evaluation of the CSM (Section 2), assessment of vadose-zone soil cleanup goals for selected sites (Section 3), review of pilot-scale studies performed by others to enhance groundwater remediation through MNA and to evaluate effluent-disposal alternatives to reinjection of treated groundwater (Sections 2 and 4), and preliminary assessment of the SVE and ETI systems and groundwater LTM program, based on design and limited performance data.

This RPO evaluation resulted in refinements to the hydrogeologic CSM that could simplify interpretation of contaminant fate and transport in the complex, hydraulically connected saturated units at and downgradient from DDJC-Tracy. The refined model recognizes the Above Upper unit as a finer-grained hydrogeological unit than the underlying units of the Upper Tulare Aquifer, but suggests that the deeper saturated units, currently referred to as the Upper, Middle, and Lower horizons, could be combined as a single, heterogeneous unit for data interpretation and reporting purposes. Shallow and deeper saturated zones are suggested as alternate terminologies for the former horizons. To allow clearer presentation of annual monitoring results with respect to interpretations of plume behavior over time, an alternate graphical data-presentation system is proposed

that simplifies tracking of groundwater data (and therefore COC plumes) over time, and supports the groundwater monitoring program. Use of the revised CSM and data-reporting strategy could streamline the quarterly and annual monitoring reports without adversely affecting plume interpretations or assessment of remedial progress for OU1.

The ROD cleanup goals for VOCs in soil were reviewed, and site-specific data for SWMU 1 and DSERTS 66 and 68 were used to develop revised cleanup goals based on modeling of contaminants in the unsaturated zone. Using the analytical-solution Jury model, the ROD cleanup goals for PCE and TCE in the vadose zone were increased by 90 to 160 parts per billion by volume (ppbv) for PCE, and by 270 to 320 ppbv for TCE at these sites. If site-specific cleanup goals are accepted by the regulatory authorities, soil cleanup times at these sites could be reduced, with potential cost savings in proportion to the reduction in the period of time required to achieve RAOs for soil. Optimization of the SVE systems at these three sites by targeting hot spots and incorporating passive venting during extraction-system cycling periods could further hasten cleanup for negligible additional cost.

Evaluation of the groundwater extraction systems at OU1 suggests that while TP-1 has been effective at reducing COC mass near on-Depot source areas to the northwest of DSERTS 68, the ETI system is not optimized for efficient removal of COC mass, and the area of highest remaining PCE and TCE concentrations in groundwater is not being effectively targeted by the extraction system. Moreover, the well system is pumping excessive amounts of "clean" groundwater with little evidence that the plume-containment RAO is being achieved, and mass-removal rates are low for the volume of water pumped. During fiscal year 1999 (FY99), it was estimated that the ETI system recovered approximately 29 pounds of the primary COCs (PCE + TCE) by extracting and treating about 362.6 million gallons of groundwater at a cost of $7,165 per pound of COCs removed.

Influent COC concentrations at both treatment plants have been low (less than 10 micrograms per liter [µg/L]), and appear to have stabilized near or below the ACLs at many extraction wells. Consequently, most of the existing extraction wells at OU1 are ineffective for mass removal, with 9 wells accounting for more than 75 percent of the mass removed during FY99, largely as a function of pumping rates rather than well-specific contaminant concentrations. As many as 13 extraction wells are pumping "clean" water through the air strippers. Because treatment plant influent concentrations of COCs are so low, and because it may be possible to substantially reduce (by up to 39 percent) the volume of water pumped by optimizing the extraction well network, conversion of the TP-1 air stripper to treat low VOC concentrations using liquid-phase GAC also should be considered. Use of GAC could reduce OM&M costs related to scaling problems in the air stripper, and reduced flow volumes through the treatment system could relieve the current capacity problems at the infiltration galleries. If proposed reductions in pumping volumes can be realized, it eventually should be possible to direct all flow through TP-2, and take TP-1 off line. TP-2 was designed to accommodate this optimization strategy.

The OU1 groundwater monitoring program also was evaluated, and an optimization framework involving qualitative, temporal, and spatial analysis is presented. Use of diffusion sampling for VOC analysis was evaluated, and performance of the incumbent

analytical laboratory was reviewed. Based on the review of the remedial decision process and SVE and groundwater extraction system performance to date, and on an evaluation of the groundwater monitoring program, recommendations were identified to improve SVE and groundwater ETI system performance, optimize the groundwater LTM program, and streamline data reporting in quarterly and annual monitoring reports.

Table ES.1 provides a summary of the optimization recommendations, and potential cost savings associated with their implementation, as identified during the RPO evaluation for DDJC-Tracy. During the May 2, 2001 meeting of remedial project managers for DDJC-Tracy, regulatory agencies concurred in concept with all RPO recommendations, and supported development of specific implementation plans for their review. If all recommendations were implemented, annual cost savings of approximately $307,000 could be realized. Additional, though unquantified, savings could accrue from adopting a refined CSM; completing characterization of COCs in groundwater; streamlining groundwater data presentation in the annual monitoring reports; and amending the WDR order to modify the approved discharge options. Implementation suggestions for the RPO opportunities are included in Section 5 of this document.

TABLE ES.1
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/d/]
Optimization of Conceptual Model and Data-Presentation Strategy				
Recommendation 1: Simplify the presentation of the hydrogeologic CSM for DDJC-Tracy.	TBD[c/]	TBD	Low –Regulatory concurrence has been obtained; implementation planned for 2001 Annual Monitoring Report..	$1 K
Recommendation 2: Complete characterization of: • COC plumes at DSERTS 68 and east of Banta Road, and • Hydrogeologic conditions downgradient from the Tracy Annex.	TBD	TBD	Low – Supplemental characterization efforts are underway.	TBD
Recommendation 3: Revise the data-presentation strategy for tracking COC concentrations and distributions in OU1 groundwater in the annual monitoring reports.	TBD	TBD	Low – Regulatory concurrence has been obtained; implementation planned for 2001 Annual Monitoring Report.	$1 K
Optimization of SVE System				
Recommendation 4: Based on operational performance data, focus SVE in PCE/TCE hot spots at the three SVE sites.	≤ $43 K	$128 K	Low - Implementation mechanisms in place.	$5 K
Recommendation 5: Based on operational performance data, eliminate offgas treatment of SVE vapor effluent based on system monitoring data.	≤ $40 K	$120 K	Low – Requires regulatory concurrence; implementation mechanisms in place..	$1 K
Recommendation 6: Based on operational performance data, implement passive extraction of SVE systems during inactive periods of system cycling.	$2.4 K	$7.2 K	Low –Regulatory concurrence has been obtained; design evaluation underway.	$1 K
Recommendation 7: When COC concentrations reach asymptotic levels, implement STOP and, if necessary, select and implement site-specific soil cleanup goals.	TBD	TBD	Moderate – Requires regulatory approval.	$1 K

TABLE ES.1 (Continued)
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/cd/]
Optimization of the OU1 Groundwater ETI System				
Recommendation 8: Based on data review, temporarily suspend pumping at 13 extraction wells (Table 5.2), monitor COC concentrations for rebounding, and if possible, shut down wells. Remove carbon treatment units from wells EW005AUA and EW021A.	$80.7 K	$2.26 M	Moderate – Requires regulatory approval; preparation of work plan has been authorized.	$10 K
Recommendation 9: Install at least one extraction well near the source area at DSERTS 68 (Area 3) to remove and limit migration of dissolved PCE/TCE mass from this hot spot.	TBD	TBD	Low – Regulatory concurrence has been obtained.	$15 K
Recommendation 10: Replace the air stripper at TP-1 with liquid-phase GAC for treatment of VOCs and pesticides, and route flow from all extraction wells in dieldrin plume to TP-1. Remove all wellhead GAC units.	$10.5 K	$295 K	Low –Regulatory approval has been granted to proceed with design evaluation.	$125 K
Recommendation 11: Replace or supplement the TP-2 recarbonation system with addition of AQUA MAG™ product to better control the scaling problems.	TBD	TBD	Low – Implementation has been initiated.	$5 K
Recommendation 12: Revise the ROD and WDR order to incorporate alternative effluent discharge options.	TBD	TBD	Moderate – Regulatory approval required; ROD amendment in preparation.	$1 K
Optimization of Groundwater Monitoring Program				
Recommendation 13: Perform a monitoring network optimization evaluation once the ETI system is fully operational.	$110 K	$1.1 M	Low –Regulatory concurrence desirable.	$20 K
Recommendation 14: As existing dedicated low-flow pumps require replacement, incorporate diffusion sampling for VOCs into groundwater monitoring program.	$5 K	$150 K	Moderate – Requires regulatory approval.	$22.5 K

TABLE ES.1 (Concluded)
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/d/]
Optimization of Groundwater Monitoring Program (continued)				
Recommendation 15: Continue the current laboratory selection and auditing process to ensure the contract laboratory is consistently meeting all analytical method requirements, and that pricing for analytical services is competitive.	$15 K	$450 K	Low – Implementation underway.	$0 K
TOTAL	$307 K	$4.51 M		$209 K

[a/] Estimated costs given in constant 2000 dollars. K – thousands of dollars. M – million of dollars.
[b/] Life cycle for SVE system is estimated to be a maximum of 3 years.
Life cycle for conceptual model, data presentation strategy, and ETI system is estimated to be 28 years.
Life cycle for groundwater monitoring program is estimated to be 30 years.
[c/] Implementation status as of May 2, 2001 Remedial Project Manager's meeting in Sacramento.
[d/] Estimated implementation costs exclude labor costs associated with regulatory negotiations, as this is inferred to be a DLA role rather than a contractor function.
[e/] TBD – To be determined.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY ES-1

LIST OF ACRONYMS AND ABBREVIATIONS vi

SECTION 1 - INTRODUCTION 1-1

1.1 Facility-Specific Scope and Objectives 1-2
1.2 Report Organization 1-4
1.3 Facility Location and Description 1-4
1.4 Status of Environmental Restoration 1-7

SECTION 2 - CONCEPTUAL SITE MODEL REVIEW 2-1

2.1 Data Sources 2-3
2.1.1 Analytical and Hydrogeologic Data Base 2-3
2.1.2 Treatment Plant Performance Reports 2-4
2.1.3 Treatability Studies 2-4
2.1.3.1 Soil Vapor Extraction Studies and Design Documents 2-4
2.1.3.2 Monitored Natural Attenuation Study 2-4
2.1.3.3 Overland-Flow Effluent-Disposal Studies 2-5
2.1.4 RPO Field Investigations 2-5
2.2 Review of Hydrogeologic Conceptual Site Model 2-7
2.2.1 Surface Water Hydrology 2-7
2.2.2 Local Hydrogeology 2-7
2.3 Nature and Extent of Contamination 2-15
2.3.1 Soil and Sediment Contamination 2-15
2.3.1.1 Pre-RPO Characterization Summary 2-15
2.3.1.2 RPO Soil Characterization 2-17
2.3.2 Groundwater Contamination 2-19
2.3.2.1 Pre-RPO Groundwater Characterization 2-19
2.3.2.2 RPO Geoprobe® Sampling Results 2-23
2.3.3 Natural Attenuation of CAHs in Groundwater 2-27
2.4 Refined Conceptual Model 2-33
2.4.1 Simplification of Hydrogeologic Model Presentation 2-33
2.4.2 Contaminant Distribution 2-35
2.5 Alternative Data-Presentation Method 2-35

SECTION 3 - EVALUATION OF CLEANUP GOALS 3-1

3.1 RAOs and ROD Cleanup Goals 3-1
3.1.1 Remedial Action Objectives 3-2
3.1.2 Matrix-Specific Cleanup Goals 3-3
3.1.3 Groundwater Treatment Plant Discharge Requirements 3-3

TABLE OF CONTENTS (Continued)

Page

3.1.4 SVE System Air Emissions Requirements 3-5
3.2 Review of SWMU 4 Sediment Remedial Decisions 3-6
3.3 Site-Specific Soil Cleanup Goals for Sites 1, 66, and 68..... 3-7

SECTION 4 - REMEDIAL SYSTEMS EVALUATION..... 4-1

4.1 Soil-Vapor Extraction System Evaluation 4-1
4.1.1 Summary of Design Elements of SVE Systems 4-2
4.1.1.1 SWMU 1/Area 2 4-2
4.1.1.2 DSERTS 66/Area 1 4-3
4.1.1.3 DSERTS 68/Area 3 4-6
4.1.1.4 Vapor Treatment Unit and Operational Considerations..... 4-6
4.1.2 Projected SVE System Performance..... 4-7
4.1.2.1 Source-Area Delineation and Areas of Influence of SVE Systems..... 4-7
4.1.2.2 Projected Effectiveness of Emission Controls 4-8
4.1.2.3 Projected Cleanup Times and Cumulative Costs..... 4-9
4.1.3 Potential System Enhancements and Associated Cost Savings..... 4-11
4.1.3.1 Source Area Delineation and SVE Well Locations 4-11
4.1.3.2 Emission Controls..... 4-12
4.1.3.3 Passive Soil Venting 4-12
4.2 Evaluation of Groundwater Remedial System..... 4-14
4.2.1 Current Groundwater ETI System Operations..... 4-14
4.2.2 Extraction System Assessment 4-17
4.2.2.1 Extraction System Operating Efficiency..... 4-17
4.2.2.2 Treatment Plant Utilization..... 4-18
4.2.2.3 Plume Capture..... 4-18
4.2.2.4 COC Mass-Removal Rates 4-20
4.2.2.5 Extraction System Optimization Opportunities 4-35
4.2.2.6 Schedule to Complete Groundwater Remediation..... 4-37
4.2.2.7 Cost Analysis 4-37
4.2.3 Groundwater Treatment System Assessment 4-45
4.2.3.1 Current Operations..... 4-45
4.2.3.2 Reliability/Maintainability Issues 4-46
4.2.3.3 Potential Treatment System Improvements 4-46
4.2.4 Discharge System Assessment..... 4-48
4.3 Evaluation of Groundwater Monitoring Program..... 4-51
4.3.1 2000 Groundwater Monitoring Program 4-51
4.3.2 Overview of Monitoring Program Optimization Process 4-51
4.3.2.1 Monitoring Program Evaluation Process 4-52
4.3.2.2 Cost Analysis 4-58
4.3.3 Diffusion Sampler Evaluation..... 4-60
4.3.3.1 Diffusion-Sampler Field Test..... 4-61
4.3.3.2 Deviations from the Work Plan 4-61

TABLE OF CONTENTS (Continued)

Page

4.3.3.3 Analytical Results and Data Comparability 4-62
4.3.3.4 Cost Comparison 4-64
4.3.3.5 Summary and Recommendations 4-68
4.3.4 Analytical Laboratory Assessment 4-69
4.3.5 Groundwater Monitoring Program Optimization Summary 4-70

SECTION 5 - OPTIMIZATION RECOMMENDATIONS 5-1

5.1 Revise Conceptual Model and Data-Presentation Strategy 5-1
5.2 Optimization of SVE Systems 5-6
5.3 Optimization of the OU1 Groundwater ETI System 5-9
5.4 Optimization of Groundwater Monitoring Program 5-15

SECTION 6 - REFERENCES 6-1

APPENDICES

A - Geoprobe® Sampling Procedures, Boring Logs, and Sampling Records for October 2000 RPO Investigation
B - Summary Analytical Data for October 2000 RPO Soil and Groundwater Sampling
C - Evaluation of Chemical Migration in the Unsaturated Zone
D - Supporting Data for the Extraction System Analysis
E - Supporting Cost Data
F - DLA Responses to URS, CEHNC, and DTSC Comments on the Draft RPO Phase II Evaluation Report for DDJC-Tracy (Dated February 2000)

LIST OF TABLES

No.	Title	Page
ES.1	Remedial Optimization Recommendations Summary	ES-6
1.1	Environmental Program Milestones	1-8
1.2	Status of Sites Evaluated During RPO Phase II	1-12
2.1	Hydraulic Conductivity and Flow Velocity by Horizon	2-14
2.2	Preliminary Natural Attenuation Sampling Results	2-30
3.1	Aquifer Cleanup Levels for Operable Unit 1	3-3
3.2	Cleanup Levels for SWMU 4 Sediment and Surface Water	3-4
3.3	Effluent Discharge Standards for Treated Water	3-5
3.4	Site-Specific Soil Cleanup Criteria Based on Contaminant Concentrations in Soil Vapor	3-10
4.1	SVE System Design and Construction Details	4-4

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

No.	Title	Page
4.2	SVE Well Design Details Remedial Process Optimization DDJC-Tracy, California	4-4
4.3	Estimated Total Costs to Achieve Cleanup Goals Remedial Process Optimization DDJC-Tracy, California	4-5
4.4	Estimated Mass of COCs in Vadose Zone and Projected Times to Achieve Cleanup Goals/Remedial Process Optimization ddjc-Tracy, California	4-5
4.5	Average Annual Groundwater Extraction Rates (FY97 – FY00)	4-16
4.6	Summary of Estimated Capital, Operation, Maintenance, and Monitoring Costs for Groundwater ETI System	4-41
4.7	Summary of Estimated Costs for The Optimized Groundwater ETI System	4-44
4.8	Comparison of Costs for Air Stripping and Activated Carbon At TP-1 Remedial Process Optimization	4-47
4.9	Estimated Costs Associated with Current Monitoring Program	4-59
4.10	Comparison of Diffusion Sampler and Micropurge Sampling Results	4-63
4.11	Current Sampling Program Cost Analysis	4-65
4.12	Optimized Sampling Program Cost Analysis	4-67
5.1	Remedial Optimization Recommendations Summary	5-3
5.2	Extraction System Optimization Recommendations Summary	5-10

LIST OF FIGURES

No.	Title	Page
1.1	Facility Location	1-5
1.2	Depot and Annex Layout	1-6
1.3	Selected Site Locations	1-10
1.4	Groundwater Extraction/Treatment/Infiltration System Layout	1-13
2.1	Current Conceptual Site Model	2-2
2.2	Previous OU1 and RPO Geoprobe® Sampling Locations	2-6
2.3	Hydrostratigraphic Sequence	2-9
2.4	Hydrogeologic Cross-Section Locations for A-A' and B-B'	2-10
2.5	Hydrogeologic Cross-Section A-A'	2-11
2.6	Hydrogeologic Cross-Section B-B'	2-12
2.7	Hydrogeologic Cross-Section C-C'	2-13
2.8	Groundwater Potentiometric Surface for the Upper Horizon (1Q99)	2-16
2.9	RPO Geoprobe® Soil Sampling Results for DSERTS 68 Area	2-18

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

No.	Title	Page
2.10	TCE in Groundwater (3Q98-3Q99)	2-21
2.11	PCE in Groundwater (3Q98-3Q99)	2-22
2.12	RPO Geoprobe® Groundwater Results for DSERTS 68 Area	2-25
2.13	RPO On-Annex Geoprobe® Groundwater Results	2-26
2.14	Revised Conceptual Site Model	2-34
2.15	TCE Concentrations in Groundwater (1992)	2-37
2.16	TCE Concentrations in Groundwater (1994)	2-38
2.17	TCE Concentrations in Groundwater (1996)	2-39
2.18	TCE Concentrations in Groundwater (3Q00 and 10/00)	2-40
2.19	PCE Concentrations in Groundwater (3Q00 and 10/00)	2-41
4.1	VOC Mass Removal - Treatment Plant 1	4-21
4.2	Monthly Influent Volumes at TP-1 and TP-2	4-22
4.3	Influent VOC Concentrations at TP-1	4-23
4.4	VOC Mass Removal - Treatment Plant 2	4-25
4.5	Influent VOC Concentrations at TP-2	4-26
4.6	Cumulative Mass Removal – Treatment Plants 1 and 2	4-27
4.7	Average Annual Well-Specific Extraction Rates (4Q98 – 3Q99)	4-28
4.8	TCE Concentrations By Well (4Q98 – 3Q99)	4-29
4.9	Relative TCE Mass Removal by Well (4Q98 – 3Q99)	4-31
4.10	Relative PCE Mass Removal by Well (4Q98 – 3Q99)	4-32
4.11	Estimated Well-Specific Groundwater Extraction Volumes Required to Remove 1 Pound of TCE	4-33
4.12	Estimated Well-Specific Groundwater Extraction Volumes Required to Remove 1 Pound of PCE	4-34
4.13	COC Concentrations Through Time at EW006AU	4-38
4.14	VOC Concentrations and Mass Removal for Selected Extraction Wells	4-39
4.15	Comparison of Mass-Removal Rates and Costs For Current and Optimized Extraction Systems	4-42
4.16	Monitoring Network Optimization Decision Logic	4-53

LIST OF ACRONYMS AND ABBREVIATIONS

AFBCA	Air Force Base Conversion Agency
amsl	above mean sea level
ACC	Air Combat Command
ACL	aquifer cleanup level
AFB	Air Force base
AFCEE	Air Force Center for Environmental Excellence
APCD	Air Pollution Control District
atm-m^3/mol	atmospheres-cubic meters per mole
ARAR	applicable or relevant and appropriate requirement
ASCE	American Society of Chemical Engineers
atm-m^3/mol	atmosphere-cubic meters per mole
BACT	best available control technology
BERA	baseline ecological risk assessment
bgs	below ground surface
°C	degree(s) Celsius
CAAE	[DLA] Environmental and Safety Policy Office
$CaCO_3$	calcium carbonate
CAH	chlorinated aliphatic hydrocarbon
Caltest	Caltest Analytical Laboratories
CD	chimney drain
CEHNC	Corps of Engineers, Huntsville Engineering and Support Center
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/day	centimeter(s) per day
COC	chemical of concern
CPT	cone penetrometer testing
CSM	conceptual site model
1-D	one-dimensional
DCE	dichloroethene
DDC	Defense Distribution Center
DDJC	Defense Distribution Depot San Joaquin, California
DLA	Defense Logistics Agency
DNAPL	dense nonaqueous-phase liquid
DO	dissolved oxygen
DSERTS	Defense Site Environmental Recording and Tracking System
DTSC	Department of Toxic Substances Control
EDMS	[DDJC] Environmental Data Management System
ERC	[AFCEE] Consultant Operations Division
ERPIMS	Environmental Restoration Program Information Management System
ESD	Explanation of Significant Difference
ETI	extraction/treatment/infiltration
°F	degrees Fahrenheit
FFA	federal facility agreement

FS	feasibility study
FY	fiscal year
GAC	granular activated carbon
g/cm^3	gram(s) per cubic centimeter
gpm	gallon(s) per minute
HELP	Hydrologic Evaluation of Landfill Performance
Hg	mercury
IDW	investigation-derived waste
IG	infiltration gallery
IRM	interim remedial measure
°K	degree(s) Kelvin
kg	kilogram(s)
L	liter(s)
lb(s)	pound(s)
lbs/day	pound per day
LTM	long-term monitoring
µg	microgram(s)
µg/L	microgram(s) per liter
MCL	maximum contaminant level
mg	milligram(s)
mg/kg	milligram(s) per kilogram
MNA	monitored natural attenuation
mV	millivolt(s)
NAPL	nonaqueous-phase liquid
NCP	National Contingency Plan
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPV	net present value
OM&M	operation, maintenance, and monitoring
ORP	oxidation/reduction potential
OU	operable unit
Parsons ES	Parsons Engineering Science, Inc.
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photo ionization detector
ppbv	parts per billion by volume
PVC	polyvinyl chloride
Q	quarter (e.g. 4Q99 = fourth quarter 1999)
QA	quality assurance
QC	quality control
Radian	Radian International LLC *or* Radian URS
RAO	remedial action objective
redox	reduction/oxidation
RPD	relative percent difference

RI	remedial investigation
ROD	record of decision
ROI	radius of influence
ROW	right of way
RPM	remedial project manager
RPO	remedial process optimization
RSV	RPO scoping visit
RWQCB	Regional Water Quality Control Board
SAP	sampling and analysis plan
scfm	standard cubic feet per minute
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
STC	schedule-to-complete
STL	Severn Trent Laboratories
STOP	SVE Termination or Optimization Process
SVE	soil-vapor extraction
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TBC	to-be-considered criterion
TCE	trichloroethene
TOC	total organic carbon
TP	treatment plant
UP	Union Pacific Railroad
URS	URS Corporation
US	United States
USACE	US Army Corps of Engineers
USGS	US Geological Survey
USEPA	US Environmental Protection Agency
UST	underground storage tank
UV	ultraviolet
VEW	vapor extraction well
VMP	vapor monitoring point
VOA	volatile organics analysis
VOC	volatile organic compound
WCC	Woodward Clyde Consultants
WDR	Waste Discharge Requirement

SECTION 1

INTRODUCTION

Parsons Engineering Science, Inc. (Parsons ES) was awarded task order TG03 under Air Combat Command (ACC) contract F44650-99-D0005 on 21 March 2000, to support remedial process optimization (RPO) scoping visits (RSVs) and to conduct RPO Phase II evaluations at selected Defense Logistics Agency (DLA) facilities. The Defense Distribution Depot, San Joaquin, California (DDJC) Tracy facility (DDJC-Tracy, or "the Depot") in Tracy, California is the subject of this RPO Phase II evaluation report. The DLA Environmental and Safety Policy Office (CAAE) has initiated the RPO program to evaluate existing and planned environmental remediation systems with the intention of identifying and implementing changes to improve the efficiency and effectiveness of those systems. The US Air Force Center for Environmental Excellence, Consultant Operations Division (AFCEE/ERC) is providing technical oversight for the task order.

The RPO approach is described as a three-phase process in the draft *Air Force Remedial Process Optimization Handbook* (AFCEE and Air Force Base Conversion Agency [AFBCA], 1999). Phase I consists of an annual review of site cleanup objectives, remedial system performance, and progress toward achieving cleanup goals. Phase II is an intensive evaluation to explore system optimization, new technologies, and/or regulatory opportunities. For sites such as DDJC-Tracy, at which environmental restoration is governed by a record of decision (ROD), Phase II evaluations should occur at least 1 year prior to mandatory 5-year ROD reviews. Phase III consists of implementing the opportunities developed during Phase I and/or Phase II evaluations. The benefits of RPO can include reduced operation, maintenance, and monitoring (OM&M) costs while maintaining adequate protection of human health and the environment; reevaluation of cleanup goals; better tracking of remediation progress; and accelerated site closure.

The RSV is an additional tool for identifying RPO opportunities. The purpose of an RSV is to evaluate the overall effectiveness of remediation systems and monitoring programs, identify sites and/or remedial systems that could benefit from Phase II evaluations, and make specific recommendations for areas to be addressed during follow-up RPO assessments. The specific objectives of this RPO Phase II evaluation were developed during the RSV conducted at DDJC-Tracy in May 2000, and during subsequent meetings. The RSV team included representatives from DLA/CAAE, AFCEE/ERC, the Defense Distribution Center (DDC), DDJC-Tracy, Mitretek Systems, the US Army Corps of Engineers (USACE) Engineering and Support Center-Huntsville (CEHNC), URS Corporation (the current remediation contractor for DDJC-Tracy, formerly Radian International LLC [Radian]), and Parsons ES.

1.1 FACILITY-SPECIFIC SCOPE AND OBJECTIVES

Since 1942, DLA has operated DDJC-Tracy as a storage and distribution depot for various supplies common to United States (US) military services in the western US and throughout the Pacific. Because past operations resulted in contamination of soil, sediment, and groundwater, DDJC-Tracy was placed on the National Priorities List (NPL) in 1990. Contaminated soils and sediment associated with source areas, and contaminated groundwater underlying and downgradient from the facility, have warranted remedial action. To facilitate environmental restoration at DDJC-Tracy, non-petroleum source areas have been designated as solid waste management units (SWMUs) or Defense Site Environmental Reporting and Tracking System (DSERTS) sites, and contaminated groundwater has been designated Operable Unit 1 (OU1).

Site restoration is governed by a ROD developed in accordance with the Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA), as amended. The primary purpose of this Phase II RPO evaluation is to develop a framework within which the decisions documented in the ROD and other site materials can be reviewed, the effectiveness of current or planned remedial systems in meeting remediation goals can be assessed, and RPO opportunities to reduced cleanup costs and expedite site closures can be identified.

The RPO Phase II work plan for DDJC-Tracy (Parsons ES, 2000a) outlined the objectives and activities to be completed during the RPO Phase II evaluation for DDJC-Tracy. Based on the information available for consideration during this project, and the operational status of the remedial systems at the facility, the final objectives of the RPO Phase II evaluation for this Depot were as follow:

- Review the conceptual hydrogeologic model for DDJC-Tracy based on hydrogeologic and groundwater-quality data collected to date, identify potential characterization data gaps relating to source areas and plume continuity, and revise the model, as appropriate.

- Plan and execute a field program to address data gaps identified during conceptual site model (CSM) review.

- Identify opportunities to optimize the existing groundwater monitoring program through review/revision of monitoring decision trees; assessment of statistical methods for spatial and temporal optimization of the monitoring network; evaluation of diffusion samplers as an alternative to conventional sampling technologies for volatile organic compounds (VOCs) in groundwater; and review of contract laboratory performance.

- Assess soil remediation goals by conducting site-specific soil-to-groundwater modeling for sites slated for soil vapor extraction (SVE) to remediate VOCs in the vadose zone.

- Evaluate the appropriateness of sediment ROD-specified cleanup goals and remedy for SWMU 4 (storm water retention pond).

- Evaluate work plans prepared by URS for pilot-scale studies being, or to be, conducted pursuant to optimizing DDJC-Tracy remedial systems.

- Identify opportunities to optimize remedial systems operations and long-term monitoring (LTM).

- Recommend an implementation plan for the RPO opportunities identified.

The following activities were completed by Parsons ES to accomplish these objectives:

- Preparation of the RPO Phase II work plan and a site-specific addendum to the project health and safety plan (Parsons ES, 2000a);

- Review of site groundwater monitoring data and the current CSM to identify data gaps and assess the nature, extent, fate, and transport of contamination and the restoration status of selected sites and of OU1;

- Collection of supplemental soil and groundwater characterization data to address data gaps and refine the CSM;

- Review and evaluation of recent studies and design documents prepared by URS to meet ROD objectives and/or to optimize existing remedial systems, including:

- Radian's (2000a and 2000d) SVE design document and implementation work plan;

- Radian's (1999b) monitored natural attenuation study work plan;

- The pilot-scale overland-flow report (Radian, 2000b) and the work plan for an expanded pilot test (Radian, 2000e) to evaluate this alternative method for disposal of treated groundwater; and

- The baseline ecological risk assessment for SWMU 4 (Radian, 2000f; URS, 2001).

- Modeling of contaminant transport in the unsaturated zone at three sites and calculation of site-specific soil cleanup goals that will ensure that groundwater cleanup objectives are met;

- Evaluation of the performance of the OU1 groundwater ETI system, based on the limited operating data available to date;

- Development of an LTM program analysis framework to complement the temporal-trend analysis (currently conducted by URS on an annual basis) in optimizing the LTM program for OU1;

- Performance of a seven-well test of diffusion samplers for collection of groundwater samples for VOC analysis; and

- Preparation of this RPO Phase II evaluation report presenting conclusions regarding the effectiveness of the existing or planned remedial systems in meeting

ROD requirements, and recommendations for optimizing the remediation systems and processes at DDJC-Tracy.

1.2 REPORT ORGANIZATION

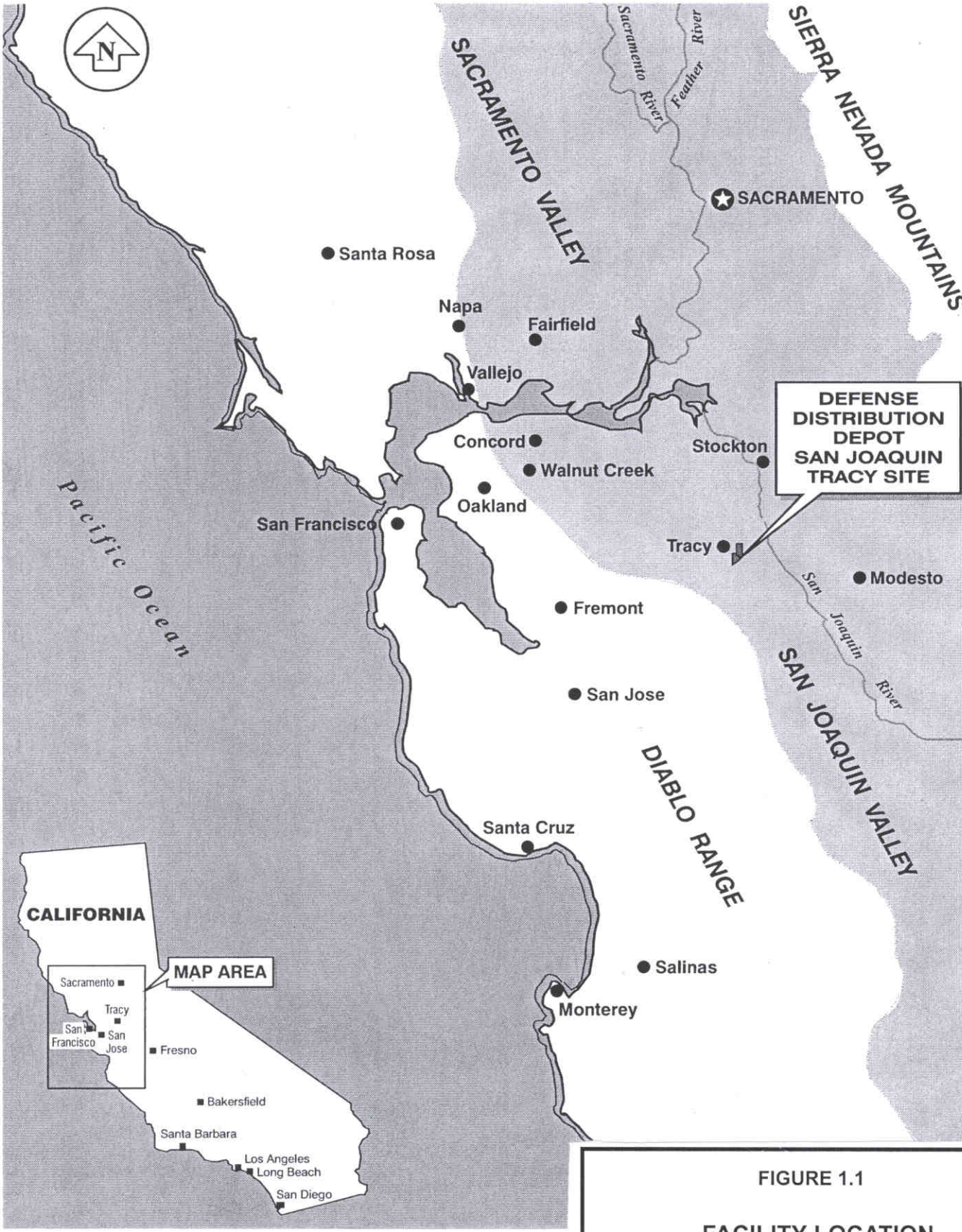
This RPO Phase II evaluation report is organized into six sections, including this introduction, and six appendices. A review of the facility history and other background information is presented in the remainder of Section 1. Section 2 includes review and revision of the existing CSM, including descriptions of environmental conditions that influence contaminant fate and transport, and the nature and extent of contamination remaining at DDJC-Tracy. Section 3 provides a review of remedial action objectives (RAOs) and the SWMU 4 sediment remedy, and an evaluation of ROD-established cleanup goals for VOCs in soil. Section 4 presents evaluations of the remedial systems and groundwater monitoring program and a review of alternative treatment system discharge studies being conducted to enhance OU1 remedial system effectiveness. Section 5 presents recommendations and implementation suggestions for RPO opportunities, and Section 6 lists the references cited in this document.

Field procedures, Geoprobe® boring logs, and sampling records for the RPO characterization sampling are provided in Appendix A. Soil and groundwater characterization data collected by Parsons ES during this RPO Phase II evaluation have been transmitted to URS for incorporation into the DDJC-Tracy database, and are summarized in Appendix B. Appendix C presents results of vadose-zone contaminant transport modeling for three sites slated for remediation via SVE. Appendix D presents summary analytical and performance data in support of the OU1 groundwater extraction system analysis, and Appendix E provides groundwater treatment cost analysis information. DLA responses to comments received from URS, CEHNC, and the California Department of Toxic Substances Control (DTSC) on the February 2001 draft RPO Phase II evaluation report for DDJC-Tracy are provided in Appendix F.

1.3 FACILITY LOCATION AND DESCRIPTION

DDJC-Tracy is located within the San Joaquin Valley, approximately 1.5 miles southeast of Tracy, California, and 20 miles southwest of Stockton, California (Figure 1.1). The 448-acre active portion of the installation forms a triangle, with the western side measuring approximately 1.4 miles, and northeastern and southeastern sides each measuring approximately 1.15 miles. In late 1992, DLA purchased approximately 460 acres of agricultural land north of (downgradient from) the Depot to facilitate remediation and monitoring of the downgradient OU1 contaminant plumes. This northern parcel, referred to as the Tracy Annex, is separated from DDJC-Tracy by a Union Pacific Railroad (UP) right of way (ROW) (Figure 1.2).

The active installation includes storage, loading, and administrative facilities; the operational infrastructure for the Depot; and an OU1 groundwater extraction, treatment, and infiltration (ETI) system. The on-Depot ETI system includes Treatment Plant 1 (TP-1), a series of groundwater monitoring and extraction wells, and two infiltration galleries (IG-1 and Chimney Drain 1 [CD-1]) for discharging treated water. All source sites also



Source: Radian, 2000c.

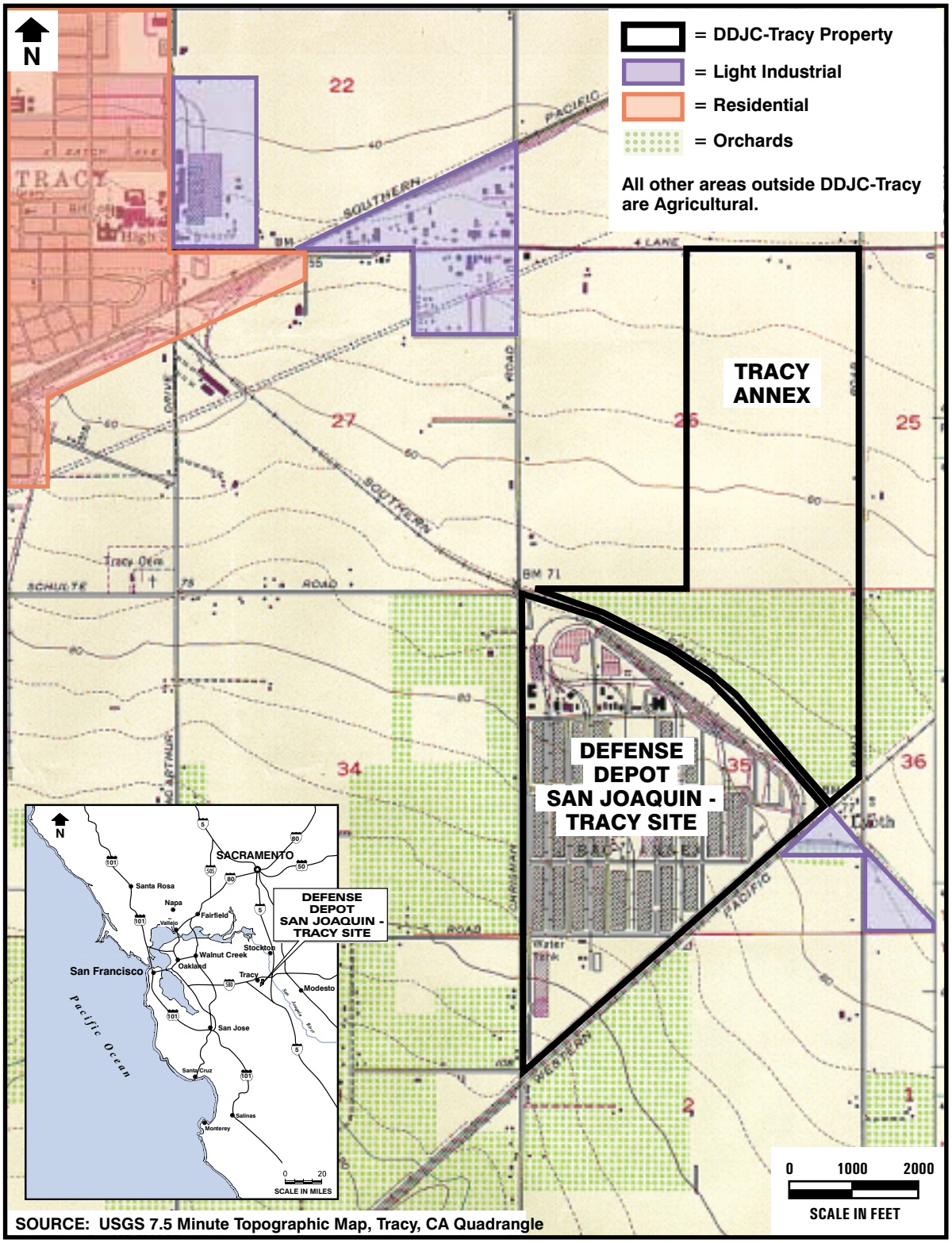
FIGURE 1.1

FACILITY LOCATION

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyA.cdr nap p1 pup 1/8/01



SOURCE: USGS 7.5 Minute Topographic Map, Tracy, CA Quadrangle

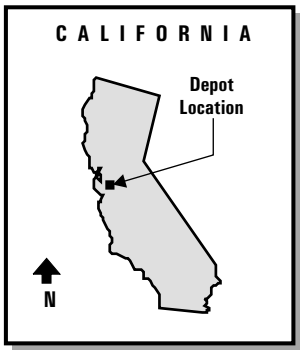


FIGURE 1.2

DEPOT AND ANNEX LAYOUT

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 2000c.

draw\TracyA.cdr bbs p2 5/11/01

are located on the Depot. Most of the Tracy Annex is leased for agriculture, and supports walnut trees and seasonal row crops. Also located on the Annex is a second groundwater ETI system that includes Treatment Plant 2 (TP-2), monitoring and extraction wells, and two groups of infiltration galleries (IG-2 through IG-9) for discharging treated water. The area around the installation comprises mixed-use light industrial, agricultural, and residential areas (Figure 1.2).

1.4 STATUS OF ENVIRONMENTAL RESTORATION

Characterization of contamination at DDJC-Tracy began in 1980, and the Depot was added to the NPL in 1990. Based on results from remedial investigations (RIs) and feasibility studies (FSs), RAOs and cleanup goals for chemicals of concern (COCs) in affected media were established, remedies were selected, and groundwater monitoring and effluent discharge requirements were set forth in RODs for OU1 (Woodward Clyde Consultants [WCC], 1993; Montgomery Watson, 1996a) and source areas (Radian, 1998a). Table 1.1 lists environmental program milestones for DDJC-Tracy. Key reports generated during previous investigations at DDJC-Tracy and used in preparing this RPO Phase II evaluation are:

- The OU1 RI/FS (WCC, 1992a and 1992b);
- The OU1 ROD (WCC, 1993);
- The OU1 ROD explanation of significant difference (ESD) (Montgomery Watson, 1996a);
- The Comprehensive RI/FS report (Montgomery Watson, 1996b);
- The final Site-Wide Comprehensive ROD (Radian, 1998a); and
- Annual groundwater monitoring reports for 1995 through 1999 (Radian, 1996, 1997, 1998b, 1999d, and 2000c).

Other data sources are reviewed in Section 2.1.

Inadvertent releases of chemicals and fuels at DDJC-Tracy have contaminated installation soils, groundwater, and, at the storm water retention pond (SWMU 4), surface water and sediment. Approximately 76 localized source areas contaminated with VOCs, semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), herbicides, total petroleum hydrocarbons, and/or metals have been investigated at the Depot (Montgomery Watson, 1996a; Radian, 1999a). Thirty-one of these are former underground storage tank (UST) sites, 40 have been designated as SWMUs or DSERTS sites, and 5 are other general areas of soil contamination. Selected site locations are shown on Figure 1.3. The majority of the UST sites were remediated under the state UST

TABLE 1.1
ENVIRONMENTAL PROGRAM MILESTONES
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Date	Activity/Event
1980	Installation Assessment
1986- 1992	Operable Unit 1 (OU1) Remedial Investigation/Feasibility Study (RI/FS)
1990	Installation added to National Priorities List
1990	Installation of Interim Remedial Measure (IRM) system for the OU1 groundwater plumes
1991	Federal Facility Agreement (FFA) signed
1991	OU1 IRM brought online
1992	Draft Final OU1 Remedial Investigation/Risk Assessment (RI/RA) Report produced
1992	OU1 FS and Proposed Plan produced
1992	IRM treatment system repaired, tested, and operated
1993	FFA amended and OU1 Record of Decision (ROD) signed
1994	Final Comprehensive Phase I Site Characterization Report produced
1994	OU1 Remedial Action Plan produced
1995	Draft Comprehensive RI/FS Report produced
1995	Environmental Baseline Study for OU1 Easements conducted
1995	Draft Underground Storage Tank (UST) Closure Report produced
1995	Engineering Evaluation/Cost Analysis conducted for Industrial Waste Pipelines, Sewage, and Industrial Waste Lagoons
1996	Final Comprehensive RI/FS Report produced
1996	Final UST Closure Report produced
1996	90% Design produced for Removal Action for the Sewage and Industrial Waste Lagoons and Industrial Waste Pipeline

TABLE 1.1 (Continued)
ENVIRONMENTAL PROGRAM MILESTONES
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Date	**Activity/Event**
1998	Final Comprehensive ROD signed and Waste Discharge Requirements Order updated
1997-1998	Installation and startup of OU1 Treatment Plant 2 for OU1 groundwater plume.
1998	Removal actions completed for the Sewage and Industrial Waste Lagoons and Industrial Waste Pipeline.
1998	Low-flow pumps installed in monitoring wells
1999-2000	Monitored natural attenuation pilot study conducted
1999-2001	Overland-flow effluent-disposal pilot studies conducted
2000	Final SVE design for sites 1, 20, 66, and 68 submitted
2000	Removal actions completed for small excavation sites and Child Care Center
2001	Final Baseline Ecological Risk Assessment Report for SWMU 4 produced
2000-2001	RPO Phase II evaluation with diffusion sampler demonstration conducted
2001	Draft ROD amendment to revise effluent disposal options prepared

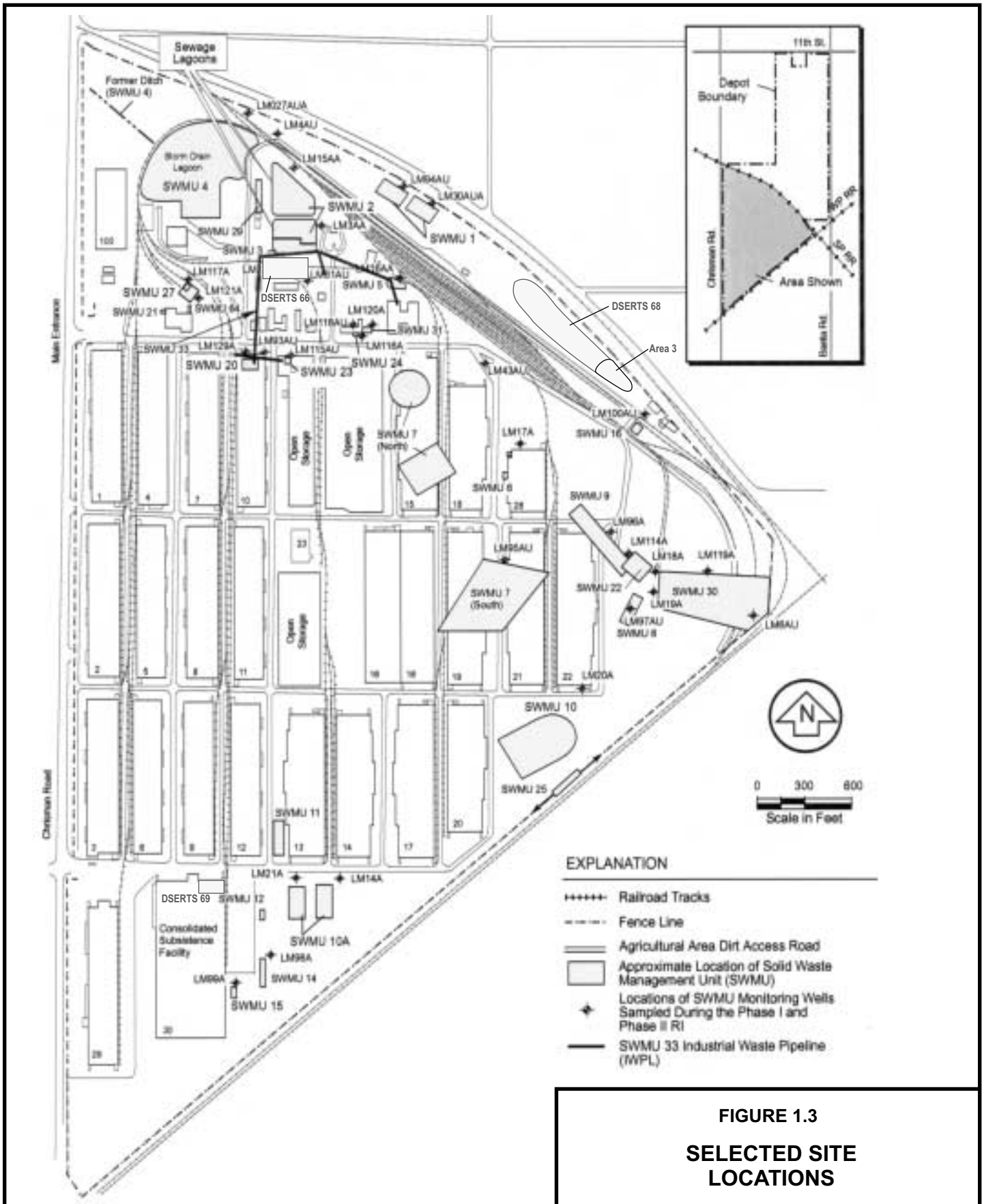


FIGURE 1.3

SELECTED SITE LOCATIONS

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 1998a.

draw\TracyA.cdr bbs p3 5/11/01

program, and the five general areas of soil contamination have been recommended for no further action (NFA) (Radian, 1999a). As of August 2000, 26 of the sites had been recommended for NFA, and the 14 remaining sites are undergoing remediation through removal actions, institutional controls, bioventing, SVE, monitored natural attenuation (MNA), and/or LTM (Radian, 1999a and 1999c). The 40 SWMUs/DSERTS sites and their current remediation status are summarized in the RPO work plan (Parsons ES, 2000a). Remedies and/or remedial systems for SWMUs 1 and 4 and DSERTS 66 and 68 were evaluated during this RPO assessment (see Sections 3 and 4). These four sites are summarized in Table 1.2.

OU1 groundwater at DDJC-Tracy has been contaminated primarily with chlorinated aliphatic hydrocarbons (CAHs) and pesticides; metals and SVOCs also have been detected at low concentrations (WCC, 1992a; Montgomery Watson, 1996b). The OU1 ROD and ESD identify tetrachloroethene (PCE), trichloroethene (TCE), 1,1-dichloroethene (DCE), and dieldrin as the groundwater COCs, and establish federal maximum contaminant levels (MCLs) or California action levels as the aquifer cleanup levels (WCC, 1993; Montgomery Watson, 1996a). Dissolved contaminant plumes originating at multiple on-Depot sources areas have migrated northeast, in the direction of groundwater flow, beneath the Tracy Annex and possibly onto private lands northwest and east of the Annex. The magnitude and extent of COC contamination in OU1 groundwater are reviewed in Section 2.3.

The remedies selected in the ROD and ESD to restore OU1 groundwater quality to its highest beneficial use (i.e., as a drinking water source) are ETI with LTM for the COC plumes beneath the Depot and the Annex, supplemented by MNA for dilute portions of the plume that have migrated beneath private property downgradient from (east of) the Annex. MNA (primarily dispersion) was selected for off-Annex portions of the contaminant plume because extraction of groundwater east of Banta Road (i.e., the eastern Annex boundary) would result in the inadvertent capture of a carbon tetrachloride/chloroform plume in this area that is thought to originate at an off-Depot source (Montgomery Watson, 1996a).

TP-1 and TP-2 treat VOCs in extracted groundwater using air strippers, and dieldrin is treated using point-of-extraction granular activated carbon (GAC) units at extraction wells located near pesticide plume hot spots. Ideally, all treated water is returned to the shallow aquifer via multiple infiltration galleries (Figure 1.4). However, due to capacity problems with the infiltration galleries, treatment plant effluent historically has been discharged to the DDJC-Tracy sewage lagoons and to SWMU 4 (the storm water pond) (Radian 1998b, 1999d, and 2000c). The ESD for the OU1 ROD (Montgomery Watson, 1996a) and an order from the California Regional Water Quality Control Board (RWQCB, 1998a) establish waste discharge requirements (WDRs) for 14 chemicals that could be present in treated groundwater, and for general water quality parameters (see Section 3).

TABLE 1.2
STATUS OF SITES EVALUATED DURING RPO PHASE II [a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Identification	Past Use	Selected Remedy	Remedial Status
SWMU 1/Area 2 [b/]	Old Sewage Lagoon and Former Drum Storage Area-This area was used as a drum storage area from 1957 through 1984. Chemicals in drums possibly leaked or were discharged accidentally.	Soil Vapor Extraction (SVE)	SVE System Installed Winter 2000
SWMU 4	Storm Pond Lagoon-Storm water has been discharged to the lagoon since 1971. The storm drain lagoon reportedly received rinse water from paint-stripping, degreasing, and steam cleaning operations. The area was used for open storage before 1952. Manganese ore was stockpiled northeast of the lagoon area from 1957 to 1968.	Institutional Controls and Monitoring (ROD ESD Pending) [c/]	Revised Final Ecological Risk Assessment Completed March 2001
DSERTS 66 [d/]	(Formerly Area 1 Building 237) - Former Solvent Storage Area-Now used for cleaning asphalt application tools and equipment.	SVE	SVE System Installed Winter 2000
DSERTS 68	(Formerly Area 3) - Former drum storage area. Some drums may have leaked or spills may have occurred.	SVE/Monitoring	SVE System Installed Winter 2000

[a/] As of October 2000.
[b/] SWMU = solid waste management unit.
[c/] ROD = Record of Decision; ESD = Explanation of Significant Difference.
[d/] DSERTS = Defense Site Environmental Reporting and Tracking System.

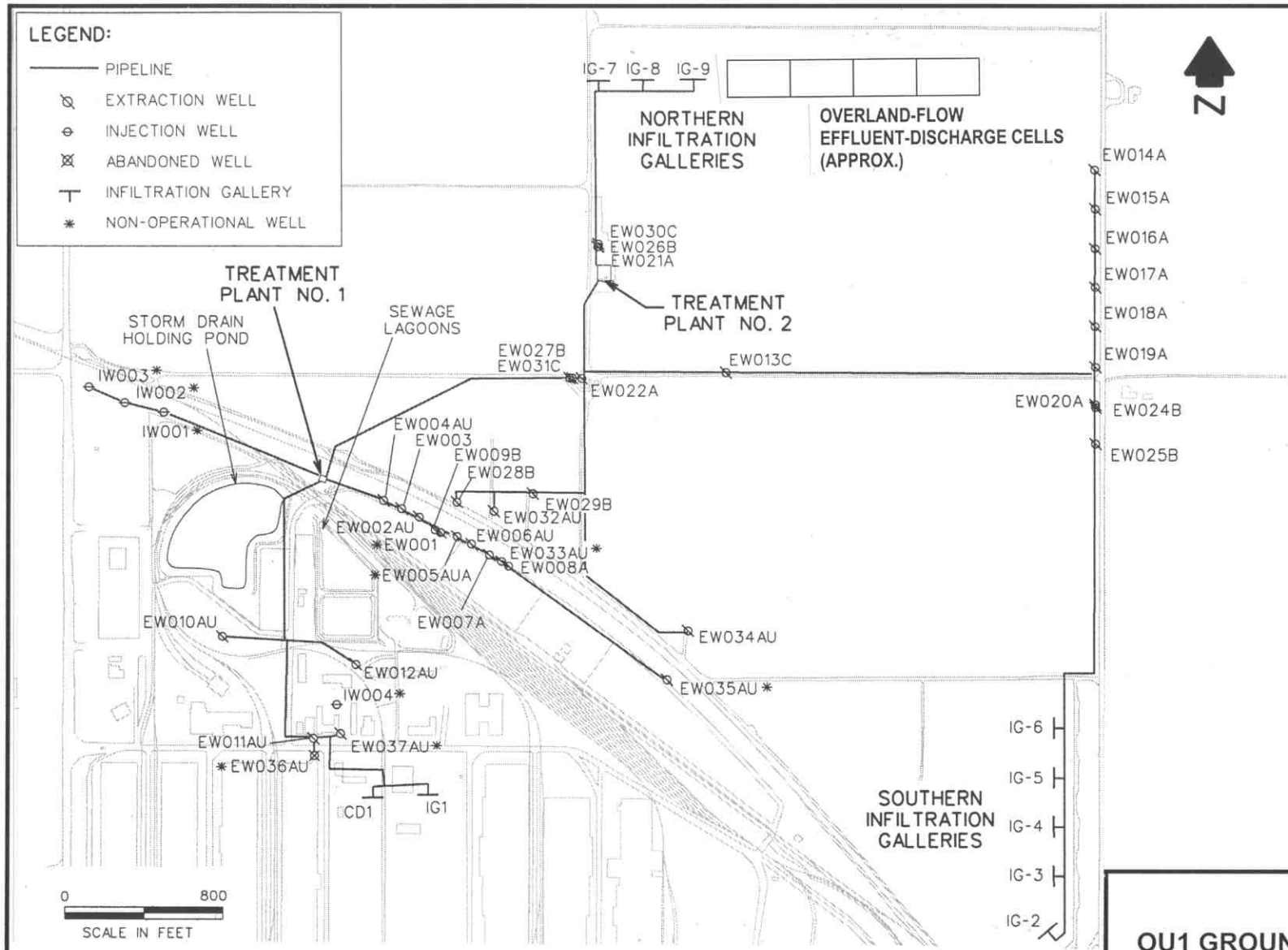


FIGURE 1.4

OU1 GROUNDWATER EXTRACTION/ TREATMENT/INFILTRATION SYSTEM LAYOUT

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 2000c.

draw\TracyD.cdr nap p1 pup 1/8/01

Because the SVE systems at SWMU 1 and DSERTS 66 and 68 were not installed during the RPO evaluation, and because full-scale groundwater ETI has been only partially operational since TP-2 was brought on-line in November 1998, there were insufficient operating data available during this RPO effort to allow for a comprehensive evaluation of system performance and effectiveness. Therefore, this RPO evaluation focused on evaluation of the CSM (Section 2), assessment of vadose-zone soil cleanup goals for selected sites (Section 3), review of pilot-scale studies performed by others to enhance groundwater remediation through MNA and to evaluate effluent-disposal alternatives to reinjection of treated groundwater (Sections 2 and 4), and preliminary assessment of the SVE and ETI systems and groundwater LTM program, based on design and limited performance data.

SECTION 2

CONCEPTUAL SITE MODEL REVIEW

The CSM provides the basis for understanding the occurrence and movement of water and contaminants at DDJC-Tracy. The CSM incorporates and organizes contaminant sources, geologic, and hydrologic information into a framework that guides site investigations and subsequent remediation activities. The DDJC-Tracy CSM is based on site activities performed during this study as described in Sections 1.3 and 1.4, the site environmental setting, and the nature and extent of contamination. The nature and extent of contamination in the subsurface are dependent on the sources of contamination, local hydrogeologic characteristics, and geochemistry.

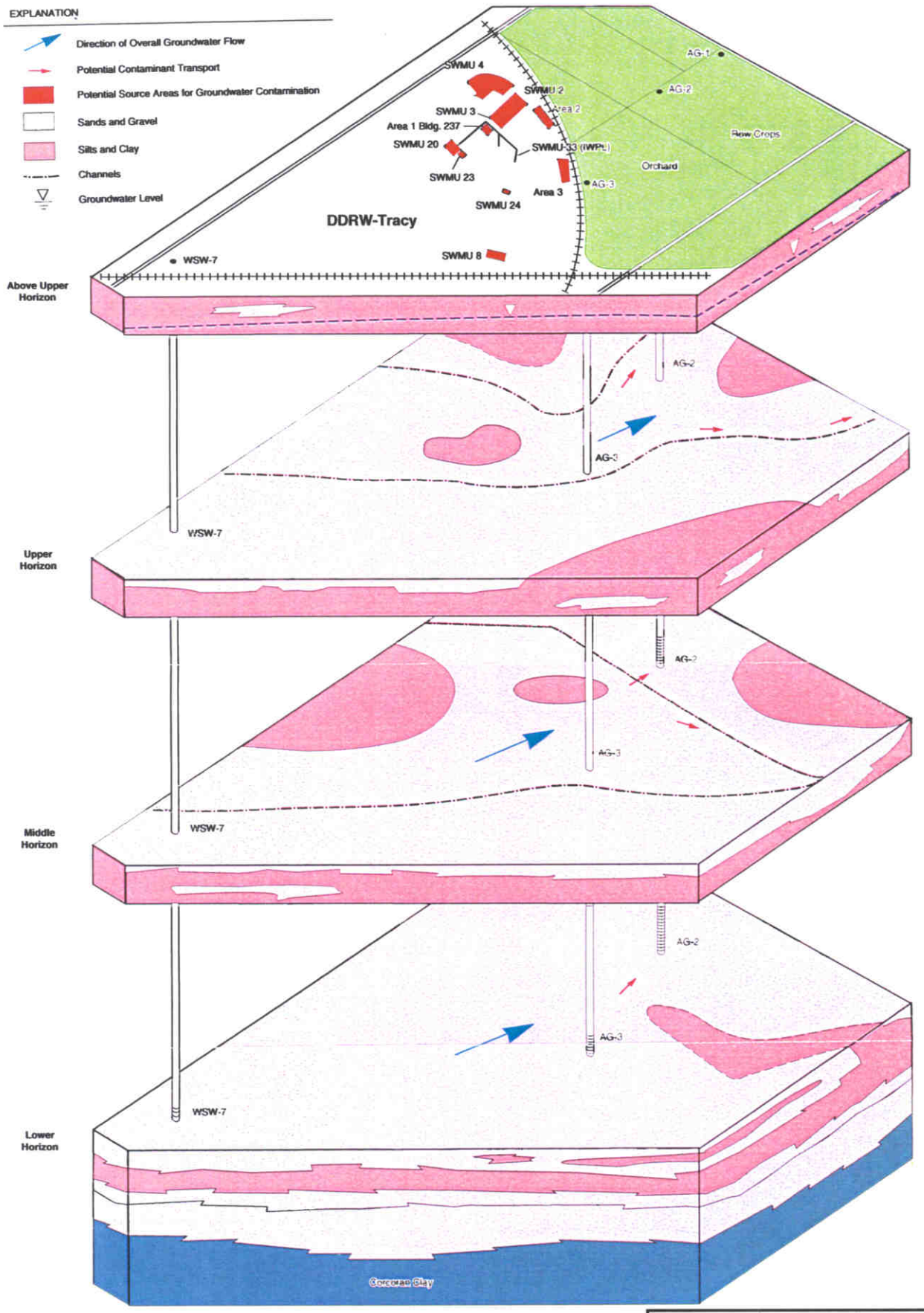
The CSM for DDJC-Tracy developed by Montgomery Watson (1996b) and Radian (2000c) represents the framework within which the current remediation systems were conceived, evaluated, and designed. The current CSM, shown on Figure 2.1, incorporates the following principal elements:

- Groundwater beneath DDJC-Tracy and the Annex occurs in four relatively permeable horizons within the Upper Tulare member of the Tulare Formation. These horizons are designated as the Above Upper, Upper, Middle, and Lower horizons. The horizons consist of silty sand, clayey sand, sand, and gravel layers separated by discontinuous, lower-permeability silt and clay layers.

- Groundwater in the four horizons moves generally from southwest to northeast beneath DDJC-Tracy and the Annex under the influence of horizontal hydraulic gradients. Vertical gradients in the groundwater system are generally of low magnitude and directed downward, indicating that groundwater moves downward between horizons.

- Although the depth, thickness, and lithology of the horizons vary across DDJC-Tracy and the Annex, the various horizons are in hydraulic communication, and contaminants have migrated from sources at or near the ground surface on DDJC-Tracy (e.g., several SWMUs near the northern boundary of the Depot). Contamination has been found in groundwater within the Above Upper, Upper, and Middle horizons of the aquifer. Dissolved contaminants have also migrated with groundwater flow to the Upper, Middle, and Lower horizons beneath and east of the Annex.

- Most contaminant sources have been remediated. Soil removal actions, SVE, and/or bioventing with LTM are planned for the remaining source areas.



Source: Montgomery Watson, 1996b.

FIGURE 2.1

CURRENT CONCEPTUAL SITE MODEL

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\Tracy0.cdr nap p4 pup 1/8/01

- The dissolved solvents TCE and PCE are the most widespread contaminants in groundwater at DDJC-Tracy. Dissolved TCE is apparently present at detectable concentrations in groundwater beneath more than 300 acres of DDJC-Tracy and the Annex, and may have migrated beneath private property east of Banta Road.

- Pesticides in groundwater are generally restricted to the area near and north of the northern boundary of DDJC-Tracy, and extend off Annex to the northwest.

This section reviews data sources used to evaluate and refine the current CSM (Section 2.1); describes the Depot/Annex environmental setting (Section 2.2); reviews the nature, extent, fate, and transport of contamination in soil and groundwater (Section 2.3); proposes refinements to the CSM (Section 2.4); and propose an alternative data-presentation strategy (Section 2.5). The results of RPO investigations conducted to fill characterization or temporal data gaps are included in Section 2.3.

2.1 DATA SOURCES

Review of the CSM for DDJC-Tracy was based on an assessment of data collected during previous site investigations, groundwater monitoring, treatability studies, and the limited field effort undertaken by Parsons ES in October 2000 as part of this RPO Phase II evaluation. The sources of data considered in reviewing and refining the CSM for DDJC-Tracy, and the subsequent remedial system evaluation (Section 4), are discussed in the following subsections.

2.1.1 Analytical and Hydrogeologic Data Base

As discussed in Section 1.4, environmental investigations and monitoring have been conducted at DDJC-Tracy since 1980. Much of the soil characterization information was collected during the course of the RIs and during removal actions for USTs (WCC, 1992a; Montgomery Watson, 1996b). Surface water and sediment data were collected for SWMU 4 during the Comprehensive RI and the baseline ecological risk assessment for this site (Montgomery Watson, 1996b; Radian, 2000f; URS, 2001). Groundwater monitoring has been conducted for OU1 since 1987, though the scope of the monitoring program has evolved through time. Currently, approximately 150 groundwater wells are sampled for a number of chemicals and water quality parameters during the course of each year (Radian, 2000c). Groundwater data are presented in quarterly and annual monitoring reports on a fiscal-year (FY) basis).

Analytical results from these characterization efforts have been incorporated into an electronic Depot-specific Environmental Restoration Program Information Management System (ERPIMS) database, also referred to as the DDJC Environmental Management System (EDMS) in project documentation. The EDMS database includes results of borehole logging, groundwater level measurements, and sampling location surveying. The database, which currently is maintained by URS using Oracle® software, includes most of the characterization and monitoring data collected at DDJC-Tracy since 1987, and was current through August 2000 at the time this report was prepared. The DDJC-Tracy database served as the primary source for hydrogeologic and chemical data evaluated during this RPO effort. Interpretive information was obtained from key documents prepared by others, including the RODs (WCC, 1993; Montgomery Watson,

1996a; Radian, 1998a), the OU1 and site-wide RI/FSs (WCC, 1992a and 1992b; Montgomery Watson, 1996b), and annual groundwater monitoring reports (Radian, 1996, 1997, 1998b, 1999d, and 2000c). The results of an October 1999 cone penetrometer testing (CPT) investigation of CAH contamination in the shallow aquifer on private property east of the Tracy Annex are included as an attachment to the final 1999 annual monitoring report (Radian, 2000c). Other important data sources are reviewed in the following subsections.

2.1.2 Treatment Plant Performance Reports

Performance monitoring data such as extraction well flow rates, treatment plant influent and effluent COC concentrations, and effluent sampling results for the OU1 groundwater ETI systems are not currently incorporated into the EDMS database. Rather, these data are reported in monthly and annual performance monitoring reports. Available reports were reviewed for assessment of OU1 treatment plant performance and operating data (Kvaerner Davy, 1997a-h; Kvaerner Environmental, 1998a-j and 1999a-l; Radian, 2000g-p).

2.1.3 Treatability Studies

In addition to historical and monitoring data available electronically, data from recent or ongoing treatability studies being conducted at DDJC-Tracy by Radian also were assessed during the RPO Phase II evaluation. Results of these studies are not fully incorporated into the EDMS database.

2.1.3.1 Soil Vapor Extraction Studies and Design Documents

In 1998, Radian (2000a and 2000d) performed soil gas and soil geotechnical sampling and pilot-scale SVE testing at four sites for which SVE is specified as a remedy component in the Comprehensive ROD (Radian, 1998a). NFA has since been recommended for one of these sites (SWMU 20) (Radian, 1999c). Data from the sampling and pilot testing were used in the assessment of site-specific soil cleanup goals (Section 3.3) and the evaluation of the SVE system designs for SWMU 1 (Area 2), DSERTS 66 (Area 1/Building 237), and DSERTS 68 (Area 3) (Section 4.1). The 100-percent SVE design document (Radian, 2000a) also was reviewed.

2.1.3.2 Monitored Natural Attenuation Study

Beginning in third quarter 1998 (3Q98), Radian (1999b) also performed a 1-year limited-scope evaluation of MNA of COCs in OU1 groundwater at the Depot. In an effort to assess the potential contribution of biodegradation to removing CAH mass from contaminated groundwater, Radian (1999b) collected quarterly geochemical data at seven monitoring wells. Because the quality of these data has not been fully assessed, they have not yet been incorporated into the EDMS database. URS provided preliminary results for four quarters of MNA sampling for qualitative assessment by Parsons ES during the CSM review (see Section 2.3.3).

2.1.3.3 Overland-Flow Effluent-Disposal Studies

In November/December 1999, Radian (2000b) conducted a 33-day pilot-scale evaluation of overland flow as an alternative method for discharging treated groundwater from the two treatment plants. A 1-year scale-up pilot test was initiated in early 2001 (Radian, 2000e). TP-1 and TP-2 currently discharge to the Above Upper/Upper water-bearing units via a series of infiltration galleries. However, hydraulic capacity and scaling problems have affected the performance of the infiltration systems, resulting in reduced efficiency for the ETI system. Hydrogeologic and summary ETI-performance data from the overland-flow study were used in the RPO evaluation of the ETI system (see Section 4.2.4).

2.1.4 RPO Field Investigations

Based on potential data gaps identified during RPO work plan preparation, Parsons ES conducted additional soil and groundwater sampling at DDJC-Tracy and the Annex in October 2000. Except as noted in Appendix A, the RPO field activities generally followed the sampling and analysis plan (SAP) presented in the RPO Phase II work plan (Parsons ES, 2000a). The primary objectives of this field effort were to:

- Characterize the magnitude and extent of PCE and TCE contamination in soils and groundwater northwest of the Area 3 former drum storage area (DSERTS 68) to fill data gaps and to support optimization of soil and groundwater remediation planned or underway in this portion of DDJC-Tracy and the Annex (see Section 2.3.1.3); and

- Investigate the continuity of dissolved solvent plumes in OU1 groundwater beneath the east-central portion of the Annex, where monitoring well coverage is relatively sparse and supplemental data have not been collected since 1996 (Section 2.3.2.2).

Eight soil samples were collected from Geoprobe® direct-push locations in the DSERTS 68 (Area 3 former drum storage area) source area, and six groundwater samples were collected from temporary wells installed at and downgradient from this source area. For the Annex plume-continuity assessment, an additional seven groundwater samples were collected from temporary wells, installed using the Geoprobe®, in the southeastern quadrant of the Tracy Annex. The RPO Phase II soil and groundwater sampling locations are shown on Figure 2.2 along with OU1 groundwater sampling locations established during previous field investigations.

All soil and groundwater samples collected by Parsons ES were analyzed for PCE and TCE in accordance with the project SAP (Parsons ES, 2000a). Field activities are described in Appendix A, and results of the supplemental characterization soil and groundwater sampling are discussed in Section 2.3. Borehole logs and groundwater-sampling records also are provided in Appendix A, and laboratory analytical results have been submitted to URS for inclusion in the DDJC-Tracy EDMS database (Appendix B).

In addition to the RPO sampling to address characterization data gaps, a limited-scale demonstration of diffusion-sampler technology, involving collection of samples for VOC analysis from seven existing groundwater monitoring wells, also was performed during

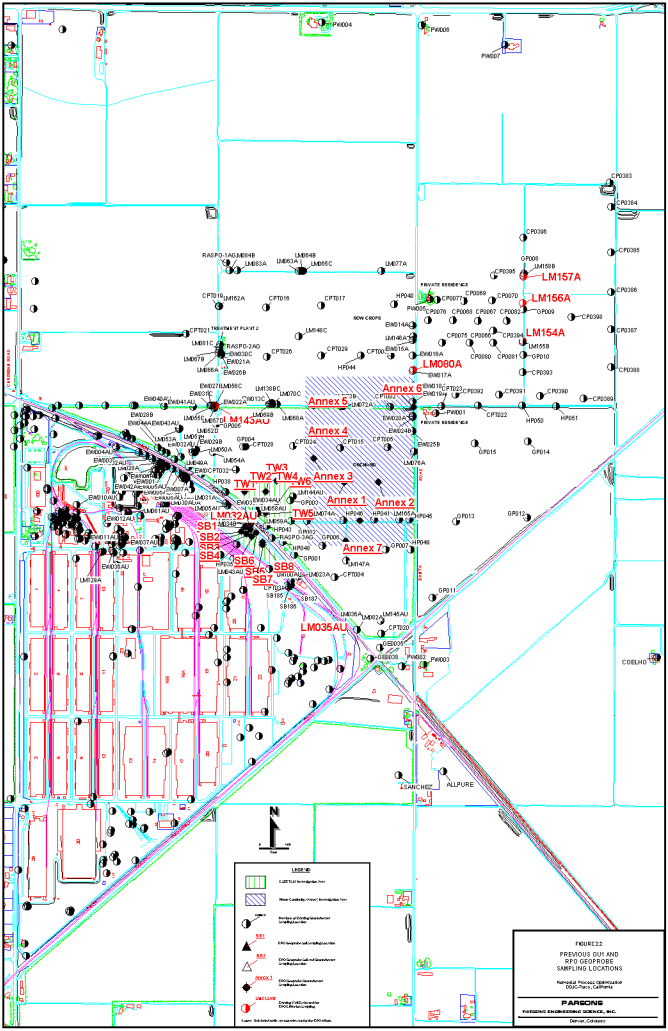


FIGURE 2.2

PREVIOUS GW AND RFG GEOPROBE SAMPLING LOCATIONS

Nanostat Process Optimization DOD Chem, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

the fall of 2000. The sampling technology, field methods, and results of the demonstration are reviewed in Section 4.3.3.

2.2 REVIEW OF HYDROGEOLOGIC CONCEPTUAL SITE MODEL

This section describes the aspects of the DDJC-Tracy environment that influence the interpretation of the hydrogeologic CSM and the nature and extent of contamination in the subsurface. Contaminant distributions are reviewed in Sections 2.3 and 2.5.

2.2.1 Surface Water Hydrology

Surface water drainage in the DDJC-Tracy vicinity is generally to the northeast, toward the San Joaquin River. Surface drainage in the area is controlled by the topography of the Corral Hollow Creek alluvial fan (Montgomery Watson, 1996b). However, no natural drainage features are present at the Depot or the Annex, where ground surface elevations range from 110 feet above mean sea level (amsl) in the southwestern part of the Depot to 45 feet amsl in the northeastern part of the Annex (Banta Road).

Stormwater runoff within the DDJC-Tracy installation is collected in drains that discharge to the unlined Storm Drain Lagoon (SWMU 4), located in the northwestern corner of the Depot (Figure 1.3). Stormwater runoff occurs during periods of significant precipitation (typically during December through April). Precipitation in this part of the Central Valley averages 14 inches per year, but can range from 30 inches annually in wetter years, to as little as 5 inches in drier years (Radian, 2000c).

The WDR order allows discharge of treated effluent from TP-1 to the stormwater pond when water cannot be discharged into the infiltration galleries because of mechanical or electrical failure at the treatment plant, or when the capacity of the infiltration galleries is exceeded (California RWQCB, 1998a). Treated effluent from TP-1 also has historically been discharged to the Tracy sewage lagoons (Radian, 1998b and 2000c). Water in the stormwater and sewage lagoons (Figure 1.4) percolates to recharge the Above Upper water-bearing unit, or evaporates. Occasional discharge of overflow from the stormwater pond to an off-Depot irrigation conveyance system is allowed under the terms of a general National Pollutants Discharge Elimination System (NPDES) permit.

The Tracy Annex supports a walnut orchard and row crops. The fields are irrigated using a system of perimeter ditches and flood irrigation (Montgomery Watson, 1996b). Irrigation water is supplied to the Annex via canals, and on-Annex ditches convey stormwater runoff to local percolation swales between cultivated fields and roads (Radian, 2000c). The 8-acre overland-flow pilot test plot was recently constructed just east of the northern infiltration galleries (Figure 1.4).

2.2.2 Local Hydrogeology

The geology of subsurface deposits beneath DDJC-Tracy has been compiled from data collected during monitoring well logging, CPT, time-domain electromagnetic surveys, evaluation of agricultural well logs, and installation of extraction wells and piezometers. Geologic deposits in the DDJC-Tracy area consist of the Tertiary- and Quaternary-age Tulare Formation, which forms an important regional aquifer system in the San Joaquin

Valley. The Tulare Formation is generally divided into Upper and Lower formations separated by the Corcoran Clay Member (Figure 2.3). Of primary importance in the interpretation of the DDJC-Tracy CSM is the Upper Tulare Formation, which consists of interbedded gravels, sands, silts, and clays deposited in alluvial and fluvial environments. This formation comprises the unconfined Upper Tulare Aquifer that underlies the site. Groundwater flow is generally to the northeast, and the base of the aquifer is bounded by the Corcoran Clay at approximately 220 feet below ground surface (bgs) (Radian, 2000c).

Overlying the Upper Tulare Member at DDJC-Tracy are 25 to 35 feet of surficial alluvium, which consists of unconsolidated clay, sand, and gravel (Figure 2.3). These alluvial deposits are generally finer grained than the underlying Upper Tulare deposits. Surface soils at DDJC-Tracy are loams to sandy loams that have been disturbed by cultivation and/or industrial development.

The Upper Tulare Member and overlying alluvial deposits at DDJC-Tracy have been divided into four hydrostratigraphic units, designated the Above Upper (AU), Upper (A), Middle (B), and Lower (C) "horizons" (WCC, 1993; Montgomery Watson, 1996b) (Figures 2.1 and 2.3). The depth, thickness, and lithology of the horizons vary across DDJC-Tracy and the Annex property, as shown on geologic cross-sections for the site (Figures 2.4 through 2.7). As seen on Figures 2.5 through 2.7, the A, B and C horizons consist of sand, silty sand, clayey sand, and gravel layers separated by discontinuous silt and clay layers (Radian, 2000c). These horizon designations were used by Montgomery Watson (1996b) to evaluate flow potential and categorize monitoring intervals during the Comprehensive RI/FS. Since the Comprehensive RI, the concept of different “horizons” within the heterogeneous and unconfined to semiconfined Upper Tulare aquifer has been used to evaluate hydraulic characteristics and contaminant distribution, and to design remedial systems and the monitoring well network (Radian, 1996, 1997, 1998b, 1999d, and 2000c).

The Above Upper (AU) horizon comprises the uppermost 10 to 35 feet of alluvial sediments beneath the Depot and Annex. This horizon consists mainly of fine-grained layers of clay, silt, silty sand, and clayey sand. Lithologic data show silt/sandy silt in the southern portion of the installation that grade into clay/silty clay to the north (Radian, 2000c). The AU horizon becomes thinner from south to north, and pinches out in the vicinity of Banta Road (Figure 2.5). Lithologic logs from the Robertson-property CPT investigation (Radian, 2000c) show that this horizon is unsaturated or nonexistent east of Banta Road.

The AU horizon is saturated only in the northern portion of the Depot and the central portion of the Annex (Montgomery Watson, 1996b). Hydraulic characteristics of the saturated portions of the AU horizon are summarized in Table 2.1.

The Upper (A) horizon consists of silty and poorly graded sand interbedded with clay and silt layers from south to north. The top of the A horizon occurs at depths of approximately 25 to 35 feet bgs, and the horizon has an average thickness of 35 feet. Southeast of TP-1, the A horizon is dominated by well-graded sands to silty sands that represent highly permeable paleochannels that trend northeast. These paleochannels converge in the center of the Annex and bifurcate again in the north and northeast directions, as shown on Figure 2.1. These preferential pathways influence groundwater

Age	Stratigraphic Units		Description	Regional Hydrostratigraphic Zones	DDJC—Tracy Geologic Horizons	Horizon Description	Thickness (at Tracy)	DDJC—Tracy Horizon Designations
Quaternary (Pleistocene and Holocene)	Alluvium	Qhfw—Holocene fan and terrace deposits.	Qhfw—Unconsolidated clay, sand, and gravel.		Above Upper Horizon	Fine-grained deposits found from the ground surface to a depth of 25 or 35 feet below ground surface.	0–35'	"AU"
		Qhlw— Levee deposits.	Qhlw—Unconsolidated sand, silt, and gravel.					
		Qhq—Gravel quarry spoils and disturbed ground.	Qhq—Gravel and sand.					
Tertiary & Quaternary (Pliocene and Pleistocene)	Tulare Formation	Upper Tulare Member	Interbedded gravel, sand, silt, and clay. Deposited in alluvial and fluvial environments.	Upper Tulare Aquifer— Upper water-bearing zone; contains water under semiconfined and unconfined conditions.	Upper Horizon	Relatively coarse-grained deposits found between depths of 25 and 60 feet below ground surface.	5'–35'	"U" or "A"
					Upper/Middle Aquitard	Relatively fine-grained deposits found at 50 to 70 feet below ground surface.	10'–40'	"MU"
					Middle Horizon	Relatively coarse-grained deposits found between the depths of 55 and 85 feet below ground surface in northern portions of the depot and between the depths of 75 and 115 feet below ground surface in southern portions of the depot.	5'–30'	"M" or "B"
					Middle/Lower Aquitard	Relatively fine-grained deposits found at 85 to 115 feet below ground surface.	15'–35'	"ML"
					Lower Horizon	The top of these relatively coarse-grained deposits are found at 110 feet below ground surface in northern portions of the depot and at 125 feet below ground surface in southern portions of the depot.	30'	"L" or "C"
					Geologic Unit Below Lower Horizon	Relatively fine-grained deposits found below 170 feet below ground surface.	50'–60'	"BL"
		Corcoran Clay Member	Sandy clay, silty clay, silt, and clay interbedded with fine-grained sand. Deposited in a lacustrine environment.	Regional confining layer between the upper and lower water-bearing zones.	Corcoran Clay	Found at 220 feet below ground surface at the depot.	220'–250'	None
		Lower Tulare Member	Lenticular and interfingering beds of gravel, sand, and clay. Deposited in alluvial and fluvial environments.	Lower Tulare Aquifer—Lower water-bearing zone; contains freshwater under confined conditions to an estimated depth of 490 feet below ground surface in the DDJC—Tracy area.	Lower Tulare	Found at 430 feet to 500 feet below ground surface at the depot.	300'–1400'	None

NOTE: All depths and thicknesses are approximate.

Source: Radian, 2000c.

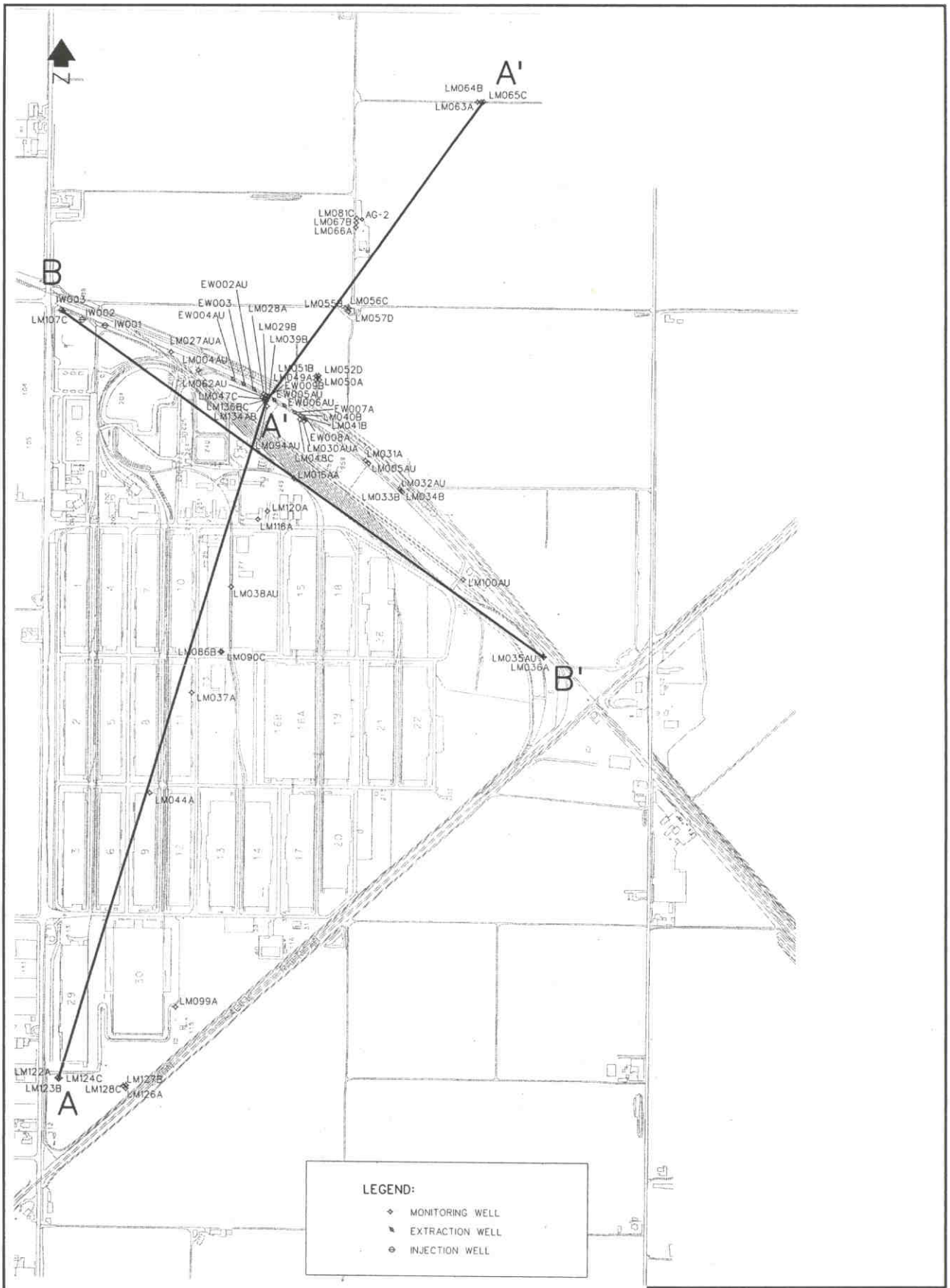
FIGURE 2.3

HYDROSTRATIGRAPHIC SEQUENCE

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyA.cdr nap p4 pup 1/8/01



Source: Radian, 2000c.

draw\TracyD.cdr nap p3 pup 1/8/01

FIGURE 2.4

HYDROGEOLOGIC CROSS-SECTION LOCATIONS FOR A-A' AND B-B'

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

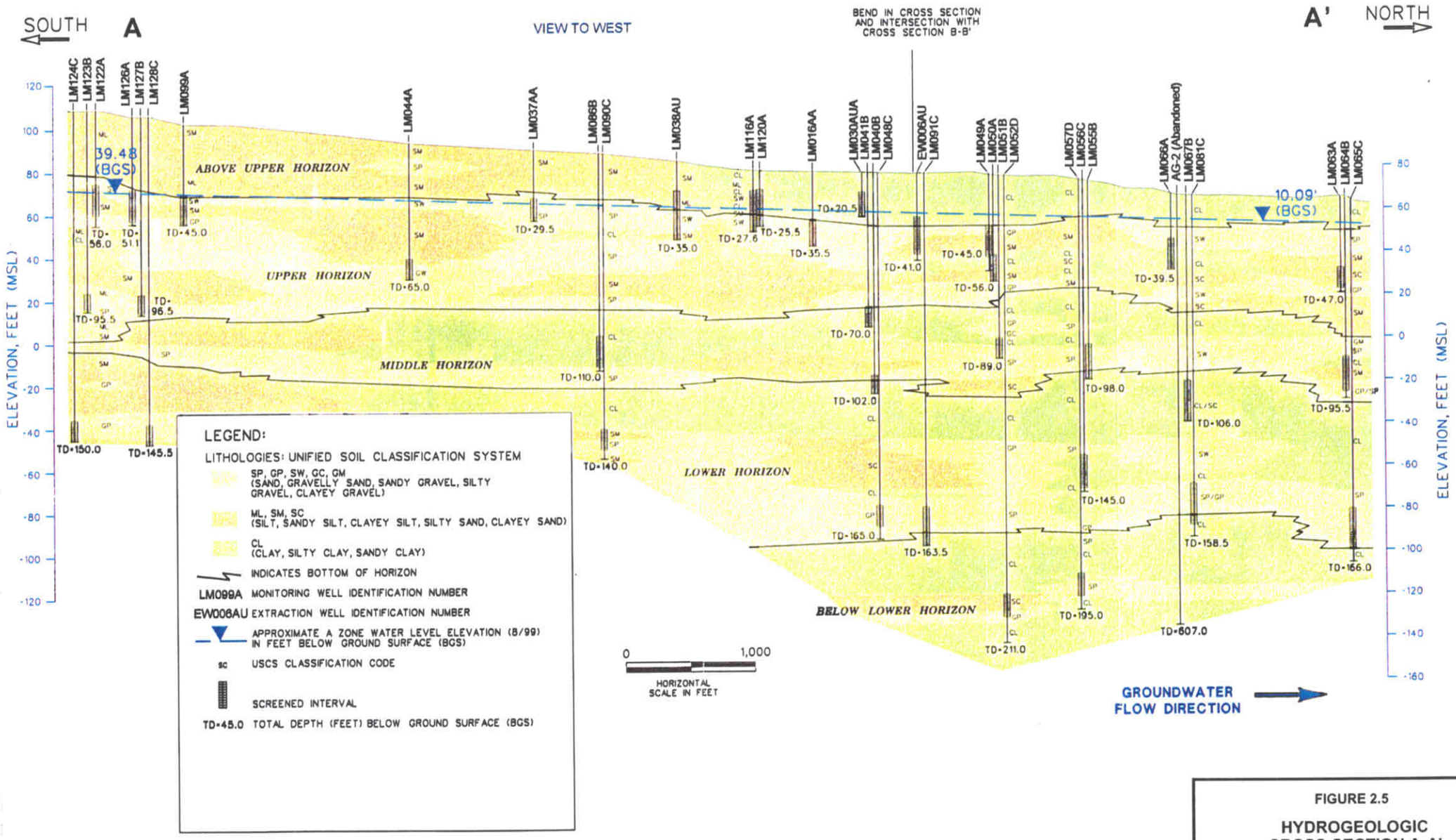


FIGURE 2.5

HYDROGEOLOGIC CROSS-SECTION A-A'

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 2000c.

draw\TracyD.cdr nap p1 pup 1/8/01

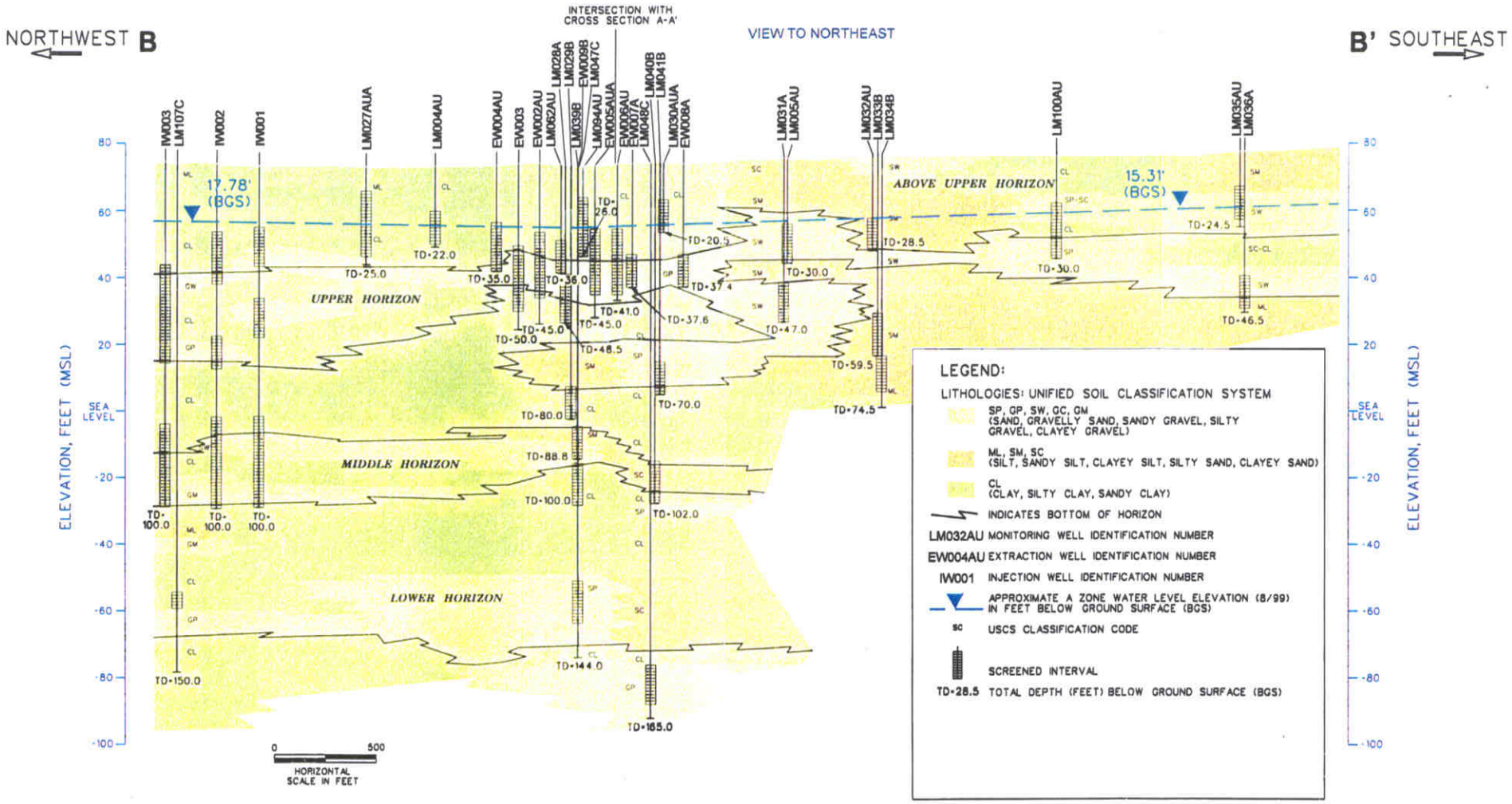


FIGURE 2.6

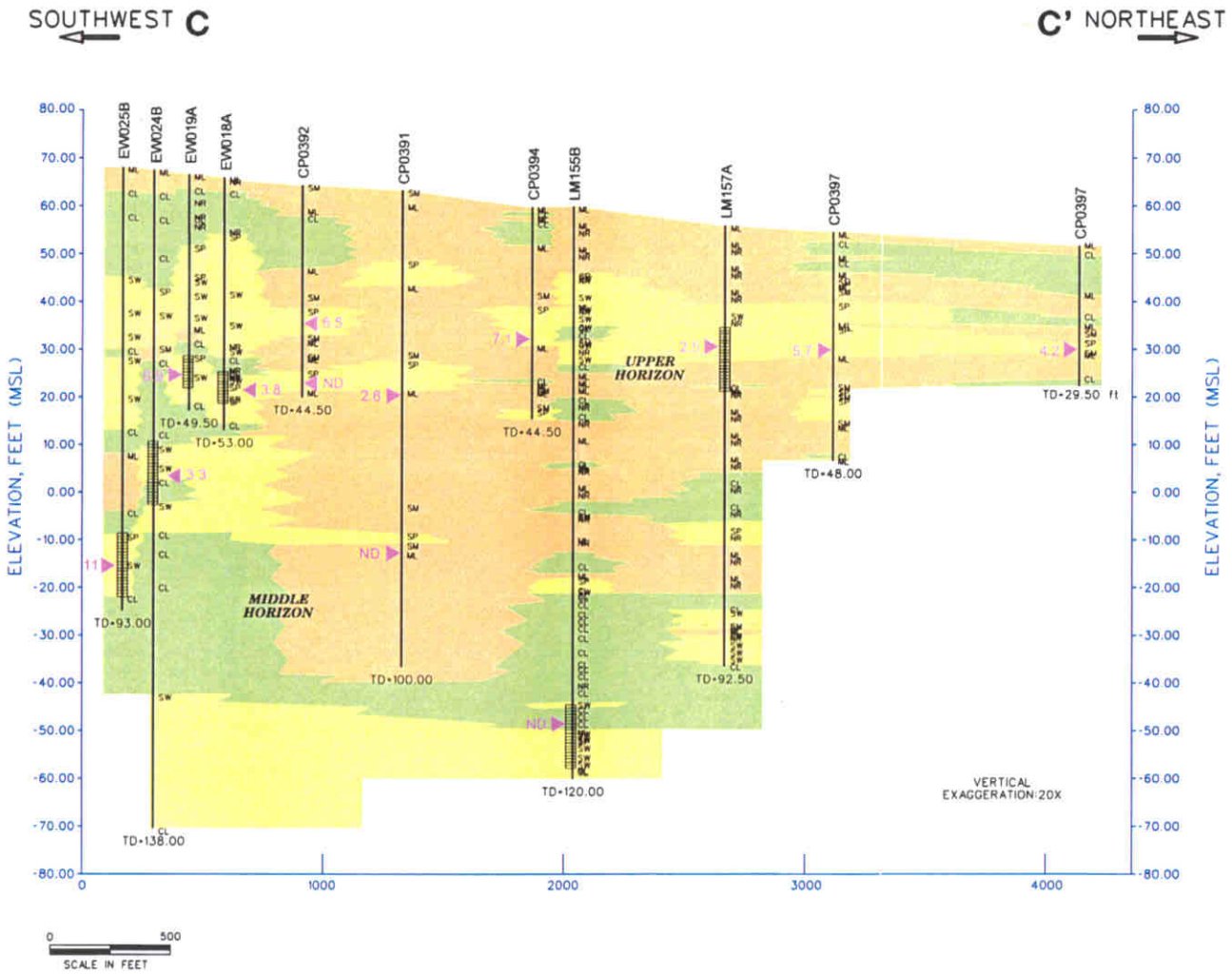
HYDROGEOLOGIC CROSS-SECTION B-B'

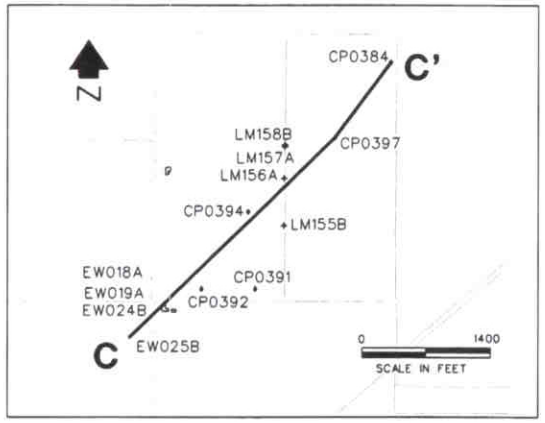
Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 2000c.

draw\TracyD.cdr nap p2 pup 1/8/01





LEGEND:

LITHOLOGIES: UNIFIED SOIL CLASSIFICATION SYSTEM

- SP, GP, SW, GC, GM (SAND, GRAVELLY SAND, SANDY GRAVEL, SILTY GRAVEL, CLAYEY GRAVEL)
- ML, SM, SC (SILT, SANDY SILT, CLAYEY SILT, SILTY SAND, CLAYEY SAND)
- CL (CLAY, SILTY CLAY, SANDY CLAY)

LM032AU MONITORING WELL IDENTIFICATION NUMBER

EW004AU EXTRACTION WELL IDENTIFICATION NUMBER

CP0394 CONE PENETROMETER BORING IDENTIFICATION NUMBER

APPROXIMATE A ZONE WATER LEVEL ELEVATION (2/00) IN FEET BELOW GROUND SURFACE (BGS)

sc USCS CLASSIFICATION CODE

8.6 SAMPLE DEPTH WITH TCE RESULT IN UG/L

ND TCE NOT DETECTED

SCREENED INTERVAL

TD=28.5 TOTAL DEPTH (FEET) BELOW GROUND SURFACE (BGS)

Source: Radian, 2000c.

FIGURE 2.7

HYDROGEOLOGIC CROSS-SECTION C-C'

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyD.cdr nap p5 pup 1/8/01

TABLE 2.1
HYDRAULIC CONDUCTIVITY AND FLOW VELOCITY BY HORIZON
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Hydro-stratigraphic Horizon	Type of Test(s)	Hydraulic Conductivity (feet/day)		Average Effective Porosity (percent)	Average Horizontal Gradient (foot/foot)	Average Ground-water Velocity (feet/year)
		Range	Average[a/]			
Above Upper	Slug	0.1 - 20	5	26	0.0021	15
Upper	Pump	16 - 329	134	28	0.0025	437
Middle	Pump	175 - 310	240	34	0.0018	464
Lower	Pump	22 - 67	50	35	0.0017	89

Source: Montgomery Watson, 1996b.

[a/] Geometric mean.

flow and transport of contaminants in this horizon (Montgomery Watson, 1996b). Hydraulic characteristics are summarized in Table 2.1. Vertical gradients show some downward flow toward the Middle horizon.

The Middle (B) horizon occurs between 55 and 105 feet bgs. This horizon has the thickest sand and gravel deposits among the four horizons beneath the southern and central portions of the installation (Figure 2.5). The Middle horizon sands become thinner, finer-grained, and interbedded with clays from south to north. Paleochannels are also present in this horizon, following the trends similar to those exhibited in the Upper horizon. As indicated in Table 2.1, the groundwater velocities and gradients for the Upper and Middle horizons are fairly similar. However, groundwater in the Middle horizon may be under locally semiconfined conditions based on vertical hydraulic gradients observed at the site and on storativity values obtained from pumping tests (Montgomery Watson, 1996b). Vertical gradients also show some downward flow toward the Lower horizon.

The Lower (C) horizon occurs from 110 to 125 feet bgs. This horizon mainly consists of sand and gravel, with interbedded lenses of silty sand, clayey sand, and clayey gravel. Hydraulic characteristics for this horizon indicate lower conductivity and flow rates than those reported for the A and B horizons (Table 2.1), with groundwater under semiconfined conditions.

Across DDJC-Tracy, 3Q99 water table elevations ranged from 36 to 72 feet amsl. Depth to the water table is shallowest beneath the northern part of the Annex (about 10 feet bgs), and deepest (about 35 feet bgs) beneath the southern portion of the Depot (Radian, 2000c). Quarterly groundwater elevation maps indicate that the groundwater flow direction has typically been generally from southwest to north-northeast in all four horizons beneath DDJC-Tracy. A typical groundwater elevation map is show on

Figure 2.8. Groundwater cones of depression at extraction/pumping wells and mounding at the infiltration galleries, sewage lagoons, and stormwater pond have created local variations in groundwater flow across the facility. Well hydrographs typically show increases in water levels (ranging from about 1 to more than 2 feet) during the summer months, which correspond to increased seasonal irrigation in the Depot vicinity and at the Annex (Radian, 2000c).

Since September 1992, vertical hydraulic gradients between the Upper and Middle horizons and the Middle and Lower horizons have been predominantly downward (Montgomery Watson, 1996b; Radian, 2000c). However, local upward gradients also have been observed at some DDJC-Tracy well-cluster locations. Extraction wells operating in the Upper and Middle (A and B) horizons do not appear to be influencing the vertical gradients between these two horizons.

2.3 NATURE AND EXTENT OF CONTAMINATION

During the course of investigations spanning a period of nearly 20 years, numerous constituents, including VOCs, SVOCs, fuel hydrocarbons, pesticides, herbicides, PCBs, and inorganic constituents, have been analyzed in soil, sediment, surface water, and groundwater samples at DDJC-Tracy. Most samples collected at DDJC-Tracy have been analyzed for VOCs and metals, while a subset of the samples have been analyzed for herbicides, pesticides, PCBs, and SVOCs. The results of previous soil and groundwater investigations, along with data gathered during the MNA study (Radian, 1999b) and this RPO evaluation, are summarized in the following subsections.

2.3.1 Soil and Sediment Contamination

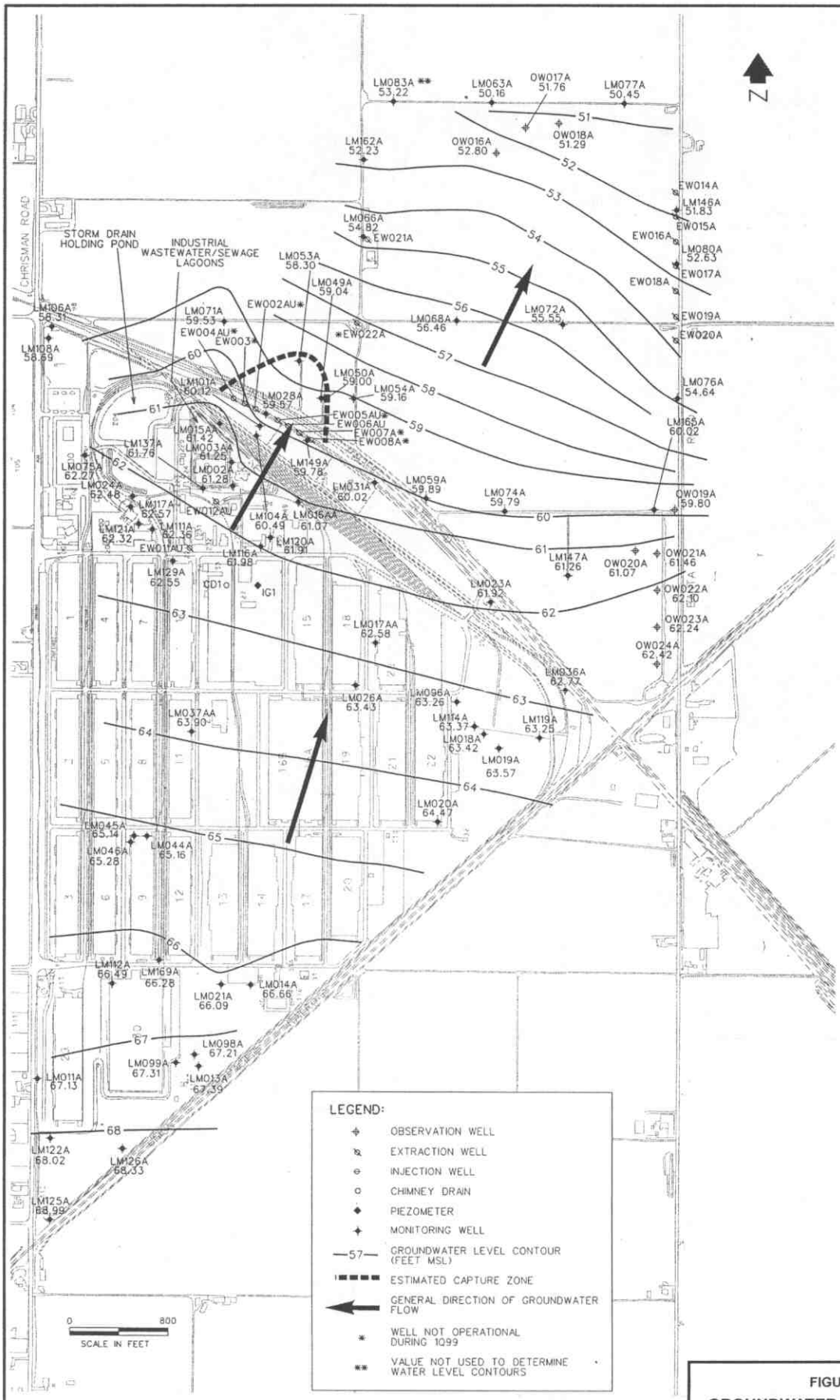
This subsection reviews the general nature and extent of soil and sediment contamination in source areas at DDJC-Tracy. The discussions are organized based on the information available before this RPO evaluation, followed by a review of the field investigations undertaken to fill data gaps identified during this project, and the results of those investigations.

2.3.1.1 Pre-RPO Characterization Summary

Soils at many of the sites at DDJC-Tracy have been contaminated by past Depot activities, and contaminated soil has served as a source for groundwater contamination (Parsons ES, 2000a). The primary classes of contaminants detected in source area soils include VOCs (also identified in soil gas), SVOCs, TPH, metals, and pesticides. Metals and SVOCs generally are minor soil contaminants (Radian, 1998a).

At SWMU 4, the stormwater retention pond located in the northwestern part of the Depot (Figure 1.3), pond sediments were found to be contaminated with organic and inorganic compounds, including SVOCs, PCBs, pesticides, and metals. These contaminants have the potential to affect pond surface water and underlying groundwater quality.

For the most part, soil COCs identified in the Comprehensive ROD (Radian, 1998a) are those contaminants (primarily VOCs and pesticides) with the potential to leach to groundwater at concentrations greater than the criteria protective of the highest beneficial



Source: Radian, 2000c.

FIGURE 2.8

GROUNDWATER POTENTIOMETRIC SURFACE FOR THE UPPER HORIZON (1Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyD.cdr nap p6 pup 1/8/01

uses of groundwater (e.g., drinking water MCLs) or background groundwater quality. The SWMU 4 sediment COCs identified in the ROD are those contaminants (DDT, DDT metabolites, and metals) that pose a potentially unacceptable risk to ecological wildlife receptors that use the pond on a seasonal basis, or that could pose a potential threat to groundwater and/or surface water quality (Montgomery Watson, 1996a, 1996b, and 1997; Radian, 1998a).

As discussed in Section 1.4, soil contamination considered to pose a threat to groundwater quality has been or is being remediated at source sites in accordance with the Comprehensive Site-Wide ROD for DDJC-Tracy (Radian, 1998a). For many sites, removal actions have been completed (Parsons ES, 2000a), thereby eliminating sources of continuing groundwater contamination. The Comprehensive ROD identifies excavation as the remedy for SWMU 4 sediments that pose unacceptable risks to ecological receptors (Radian, 1998a). However, based on the findings of the baseline ecological risk assessment completed for the stormwater pond in 2001 (Radian, 2000f; URS, 2001), institutional controls and monitoring have been recommended for pond sediments and surface water. SWMU 4 is discussed further in Section 3.2.

2.3.1.2 RPO Soil Characterization

Three sites are slated for remediation of VOCs in the vadose zone using SVE (see Sections 3.3 and 4.1). One of these sites is DSERTS 68, former Drum Storage Area 3. As noted in Section 2.1.4, DSERTS 68 was a target of the RPO field effort conducted in October 2000 to fill characterization data gaps. Soil and groundwater sampling procedures are reviewed in the project work plan (Parsons ES, 2000a) and in Appendix A to this report.

Elevated VOC concentrations in soil vapor in the portion of DSERTS 68 immediately upgradient from monitoring well LM032AU have been documented (WCC, 1992a; Montgomery Watson, 1996b; Radian, 2000d). Despite characterization of vapor-phase contamination in the vadose zone at DSERTS 68 (Radian, 2000a), soil data for this area were limited to results for samples collected from 1991 through 1994, largely in the previously defined Area 3 that lies southeast of the highest reported soil vapor VOC concentrations (Montgomery Watson, 1996b). During the Phase I RI (Montgomery Watson, 1995), PCE and TCE were detected in site soils at maximum concentrations of 227 micrograms per kilogram (µg/kg) and 440 µg/kg, respectively. Both chemicals persisted at concentrations greater than 100 µg/kg to depths of at least 12 feet bgs (Montgomery Watson, 1996b). Dissolved PCE and TCE concentrations at well LM032AU have historically been among the highest at the Depot, though this dissolved solvent plume is poorly delineated (see Section 2.3.2.2).

To better characterize residual solvent contamination in vadose zone soils at this site, Parsons ES used a truck-mounted Geoprobe® direct-push rig to install eight boreholes (designated SB1 through SB8) to the water table (approximately 15 to 20 feet bgs) at DSERTS 68 in October 2000. Approximate locations of the soil sampling locations at DSERTS 68 are shown on Figure 2.9.

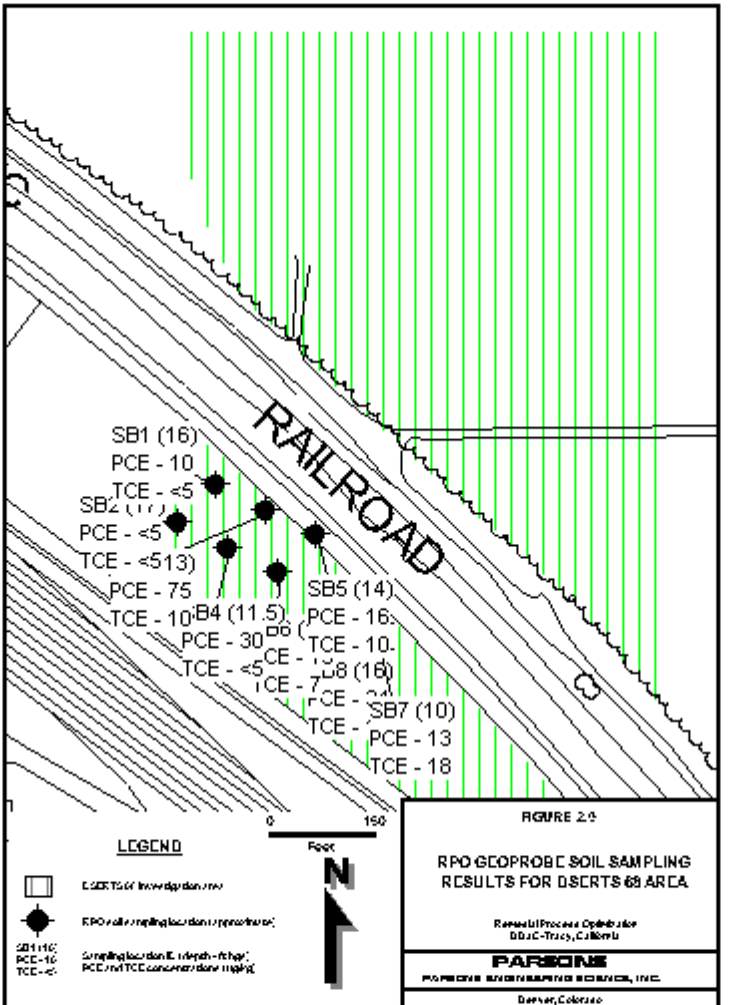


FIGURE 2-9

RPO GEOPROBE SOIL SAMPLING RESULTS FOR DSCRTS 68 AREA

Remedial Process Optimization
DDJC-Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

For each of the eight soil boreholes, the section of core that produced the highest headspace VOC reading was submitted to Caltest Analytical Laboratory (Caltest) for analysis of VOCs using US Environmental Protection Agency (USEPA) Method SW8260B. Analytical results for the Geoprobe® soil samples are provided in Appendix B and summarized on Figure 2.9.

Concentrations of PCE in soil samples collected in October 2000 ranged from nondetect to 75 µg/kg; TCE concentrations ranged from nondetect to 18 µg/kg. Except at SB7, PCE concentrations were consistently higher than TCE concentrations (Figure 2.9), and detectable concentrations of both VOCs occurred at depths ranging from 10 to 17 feet bgs. These results indicate that PCE and TCE remain sorbed to soils in the vadose zone and capillary fringe at DSERTS 68, representing a continuing source of contamination for groundwater and soil vapor. The Geoprobe® boring with the highest detected PCE concentration (SB3) in soil exhibited significant groundwater contamination as well (Section 2.3.2.2).

2.3.2 Groundwater Contamination

This subsection reviews the general nature and extent of OU1 groundwater contamination at and downgradient from DDJC-Tracy. The pre-RPO interpretation of dissolved contaminant plumes is briefly reviewed, and the results of the RPO groundwater investigations undertaken to fill data gaps are presented.

All groundwater contamination beneath DDJC-Tracy and the Annex is assigned to OU1 for CERCLA remediation purposes. The RODs specify PCE, TCE, 1,1-DCE, and dieldrin as the groundwater COCs for which containment objectives and aquifer cleanup levels (ACLs) must be attained (WCC, 1993; Montgomery Watson, 1996a; Radian, 1998a). Because 1,1-DCE, is detected infrequently and most of these concentrations are below the ROD-specified ACL of 6 micrograms per liter (µg/L), this COC was not evaluated during the RPO project. The dieldrin plume, which is limited to the areas at and north of the northern Depot boundary and northwest of the Annex(Radian, 2000c), is not evaluated in this report. This section reviews the distributions and magnitudes of TCE and PCE in groundwater at DDJC-Tracy.

2.3.2.1 Pre-RPO Groundwater Characterization

Since investigations began in 1980, approximately 259 wells have been installed to characterize or monitor OU1 contamination. Detectable concentrations of VOCs, primarily PCE and TCE, have occurred in wells completed in all four water-bearing horizons (Above Upper, Upper, Middle, and Lower horizons), though detections of PCE and TCE in the Lower unit have been limited to the area near TP-2 along the western edge of the Annex (e.g., at wells LM56C and LM81C). Historically, PCE and TCE have been detected at maximum concentrations of 467 µg/L and 560 µg/L, respectively (Montgomery Watson, 1996a).

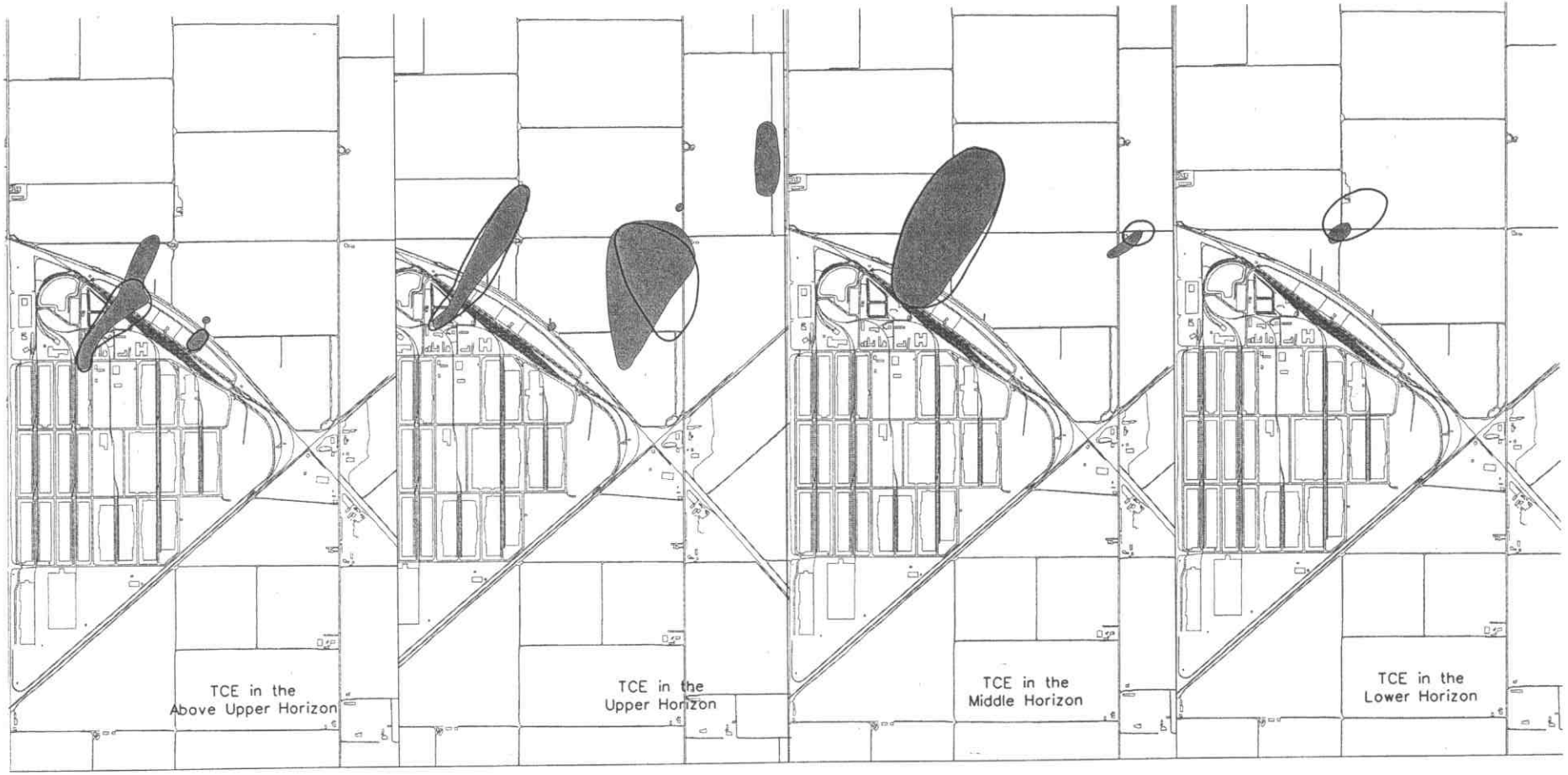
In general, historical contaminant concentrations have been greatest in the Above Upper horizon near and immediately downgradient from sources areas located in the northern part of the Depot. COC concentrations decrease with distance from the sources and with depth, with contamination being most laterally extensive in the Upper and

Middle horizons. The results of early investigations suggested that VOC contamination in groundwater occurred as two or three separate and distinct plumes. However, the current interpretation of the TCE and PCE plumes, as shown on Figures 2.10 and 2.11, suggests greater areal extent resulting from dispersion and commingling of plumes that originated at different source areas.

As indicated on Figures 2.10 and 2.11, the COC plumes at DDJC-Tracy traditionally have been interpreted by hydrostratigraphic horizon. The VOC plume configurations across the horizons suggest that contaminant migration has been influenced by the regional horizontal groundwater flow gradient to the northeast, the prevailing downward vertical gradients through the four water-bearing horizons, and potentially by flood irrigation on the Annex. Based on 1999 groundwater data, the CAH plumes appear to originate in the Above Upper horizon from several general source areas (e.g., near SWMU 2 [the sewage lagoons], DSERTS 66 [Area 1], and DSERTS 68 [Area 3]) along the northern Depot boundary, with plumes extending into underlying horizons and northeastward onto the Annex and beyond Banta Road. TCE has migrated farther and at higher concentrations than PCE, though maximum concentrations of these COCs near the source areas are of the same order of magnitude. As shown on Figure 2.2, monitoring well coverage in the eastern half of the Annex is relatively sparse, and some of the interpretations of the plume configurations and magnitudes are affected by the resulting data gaps (see Sections 2.3.2.2 and 2.5).

Based on data collected during well abandonment conducted at DDJC-Tracy in 1994 and 1995, operation of former irrigation wells contributed to vertical migration of the OU1 contaminant plumes into the Middle and Lower Horizons (Montgomery Watson 1996b). Irrigation well AG-2, screened in the Middle and Lower horizons (from 69 to 180 feet bgs), was located on the Annex adjacent to TP-2 (Figure 2.1). Well AG-2 was operated seasonally in late spring and summer to irrigate row crops and orchards on the Annex property until late 1993. Pumping rates from this well were estimated at 200 gallons per minute (gpm) from the Middle horizon and 500 gpm from the Lower Horizon, with a radius of influence of approximately 1,500 feet (Montgomery Watson, 1996b). These estimated pumping rates are conservative for irrigation wells in the area; former irrigation wells AG-1 (also located on the Annex) and AG-3 (located at the northern DDJC-Tracy boundary near Area 3) had the minimum capacities at installation of 3,284 gpm and 1,090 gpm, respectively.

Relatively elevated TCE and PCE concentrations are found in the Middle and Lower horizons in the vicinity of AG-2. Downward contaminant transport occurred upgradient from well AG-2 as a result of strong increases in vertical gradients induced by seasonal pumping (Montgomery Watson, 1995). Similarly, operation of irrigation well AG-3 may have contributed to contamination of the Middle and Lower horizons during its period of operation. This well, abandoned in June 1995, was screened in several intervals (127 to 195 feet bgs, 372 to 374 feet bgs, and 495 to 606 feet bgs). The shallowest screened interval corresponds to the Lower Horizon. Groundwater sampling during well abandonment indicated that TCE was present at 130 feet bgs (Montgomery Watson, 1996b). A similar phenomenon can be observed in the Middle horizon near Banta Road (east of the Annex), where pumping of PW001 may have drawn TCE contamination into the Middle horizon from the overlying Upper horizon.



LEGEND

AREA IN WHICH TCE CONCENTRATIONS EQUAL OR EXCEED 5 μg/L (ACL) THIRD QUARTER, 1998

AREA IN WHICH TCE CONCENTRATIONS EQUAL OR EXCEED 5 μg/L (ACL) THIRD QUARTER, 1999

0 1750
SCALE IN FEET

FIGURE 2.10

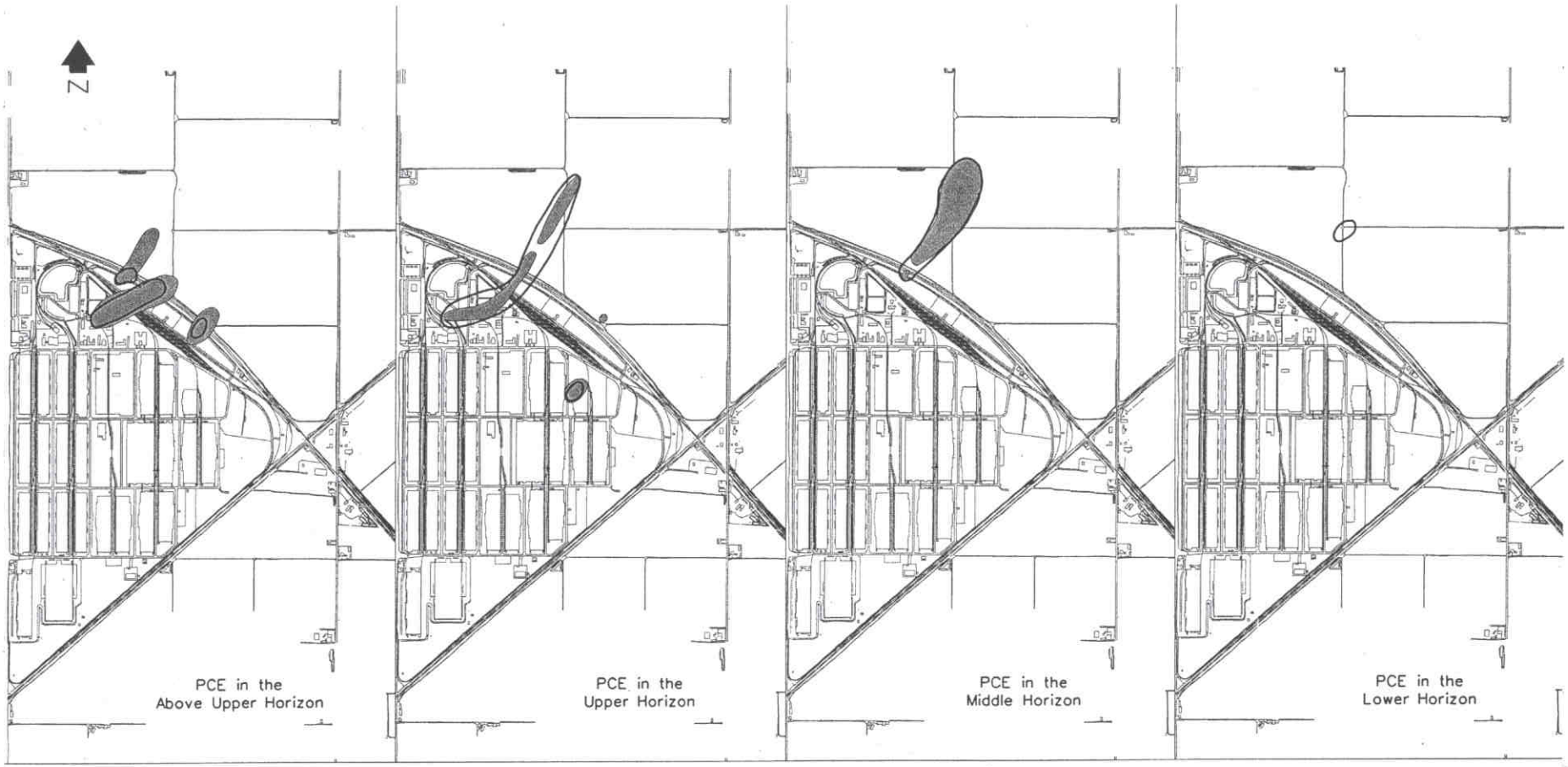
TCE IN GROUNDWATER (3Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: Radian, 2000c.

draw\TracyD.cdr nap p8 pup 1/8/01



LEGEND

AREA IN WHICH PCE CONCENTRATIONS EQUAL OR EXCEED 5 $\mu g/L$ (ACL) THIRD QUARTER, 1998

AREA IN WHICH PCE CONCENTRATIONS EQUAL OR EXCEED 5 $\mu g/L$ (ACL) THIRD QUARTER, 1999

0 1750
SCALE IN FEET

Source: Radian, 2000c.

FIGURE 2.11

PCE IN GROUNDWATER (3Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyD.cdr nap p7 pup 1/8/01

In October 1999, Radian (2000c) conducted a 16-point CPT investigation east of the Tracy Annex on the Robertson's property. Groundwater samples were collected for TCE analysis from all CPT points, and laboratory results indicate the presence of dissolved TCE in the Upper horizon farther east of Banta Road than previously thought (Figure 2.10). Though low TCE concentrations (<5 µg/L) have been detected along Banta Road, predominantly in the Upper horizon, no contamination has been detected immediately upgradient from the TCE concentrations detected east of Banta Road. This discontinuity of contamination within the same hydrostratigraphic unit defies historical contaminant migration patterns, and may suggest a secondary TCE source east of the Annex. To identify the leading edge of the TCE plume, Radian (2000c) recommended further characterization of the affected horizons and sampling of residential/potable wells along Bird Road to the east and Lovely Road to the north.

Through fiscal year 1999 (FY99), historical data and statistical temporal trend analyses (Radian, 2000c) generally suggest that the TCE and PCE plumes are diminishing in all horizons, and PCE/TCE concentrations in most monitoring wells historically have been near or below the ACLs of 5 µg/L. Exceptions occur at wells located near source area "hot spots" (e.g., wells LM093AU near Building 10 and LM032AU at DSERTS 68), where though decreasing, TCE and PCE concentrations remain one to two orders of magnitude higher than the ACLs.

Of the 35 Above Upper monitoring wells sampled during the 3Q00 monitoring event, only 10 wells exhibited TCE concentrations above the ACL (5 µg/L). The maximum TCE concentration detected by URS during the 3Q00 event (55 µg/L) was detected at Above Upper horizon well LM032AU. Eight Above Upper wells exhibited PCE concentrations above the ACL of 5 µg/L in 3Q00, with values ranging from 6 to 160 µg/L (maximum value detected at well LM032AU).

Of the 43 Upper horizon monitoring wells sampled in 3Q00, 11 had TCE concentrations greater than 5 µg/L, and 8 had PCE concentrations greater than the ACL. Of 20 Middle horizon monitoring wells sampled during 3Q00, 10 exhibited TCE concentrations above 5 µg/L (maximum detected value of 14 µg/L), and 3 had PCE concentrations above the ACL (maximum value of 11 µg/L).

Twelve Lower horizon wells were sampled during 3Q00. The maximum TCE concentration detected in this horizon was 38 µg/L at well LM056C. This is the only Lower horizon well at which TCE concentrations exceeded the 5-µg/L ACL. PCE was detected in this well at a concentration of 12 µg/L during the 3Q00 sampling event. Measured concentrations of CAHs in the Lower horizon suggest that migration of PCE and TCE into this horizon is limited, though well coverage for this horizon is not extensive (Figure 2.2).

2.3.2.2 RPO Geoprobe® Sampling Results

Well LM032AU, located just downgradient from the northwestern-most extension of DSERTS 68, has consistently produced the highest concentrations of PCE, and some of the highest of TCE, detected at DDJC-Tracy. As discussed in Section 2.3.1.2, high CAH concentrations also have been detected in vadose zone soils and soil vapors in this area. However, the associated dissolved CAH plume is poorly delineated, and there are few

control points to support the current interpretation of its areal extent (Figure 2.11). Based on available data for nearby wells screened in deeper horizons, this PCE/TCE plume appears to be largely limited to the Above Upper horizon (Figures 2.10 and 2.11). In 3Q00, TCE and PCE were detected at 55 µg/L and 160 µg/L, respectively, at well LM032AU.

To better characterize groundwater contamination associated with the documented DSERTS 68 vadose-zone contamination, Parsons ES conducted a limited-scale groundwater investigation as part of this RPO evaluation. Groundwater samples were collected in October 2000 from eight temporary Geoprobe® monitoring points screened in the Above Upper horizon at and downgradient from DSERTS 68 (see Appendices A and B). These samples were analyzed for PCE and TCE using USEPA Method 8260B. The DSERTS 68 RPO groundwater sampling locations are shown on Figures 2.2 and 2.12.

Results for the October 2000 Geoprobe® groundwater samples, and for permanent wells near DSERTS 68 that were sampled by URS during the 3Q00 monitoring event, also are presented on Figure 2.12. Groundwater results indicate that TCE and PCE concentrations in this area are highest upgradient from well LM032AU, and persist at concentrations that exceed the 5-µg/L ACLs at least 400 feet downgradient to the north-northeast. The highest TCE (150 µg/L) and PCE (470 µg/L) concentrations were measured in the groundwater sample collected from SB3 (Figure 2.12). The up- and downgradient boundaries of the COC plume sourced at DSERTS 68 are not fully defined, though the lateral (i.e., northwestern and southeastern) edges of the plume appear to be bounded. Based on contaminant distribution, shallow groundwater flows in a northerly direction near DSERTS 68 before resuming its regional northeasterly flow path north of the site (Figures 2.1 and 2.8)

In addition to the DSERTS 68 groundwater investigation, Parsons ES also collected groundwater samples for TCE and PCE analysis from seven additional temporary monitoring points (Annex-1 through Annex-7) installed in the east-central portion of the Annex. The placement of these points, as shown on Figures 2.2 and 2.13, was intended to fill data gaps in permanent monitoring point coverage in order to allow better delineation of the extent of CAH contamination in this area. Samples were collected from two depths at two of the Geoprobe® locations (Annex-1 and Annex-5). Based on hydrogeologic cross-sections for the general vicinity of the temporary wells (Figures 2.5 and 2.7), the shallower samples (collected at all seven locations) generally correspond to the approximate contact between the Above Upper and Upper horizons, and the deeper samples collected at two locations correspond approximately to the interface between the Above and Middle horizons. As shown on Figure 2.10, no TCE plume is thought to be present in the thin Above Upper unit in this portion of the Annex, but a large plume exceeding the TCE ACL in the Upper horizon has been inferred based on 3Q98 and 3Q99 data from a few monitoring and extraction wells (Radian, 2000c).

Results of the October 2000 RPO groundwater sampling are summarized on Figure 2.13. Results from 3Q00 monitoring conducted by URS at nearby monitoring and extraction wells also are posted on this figure. The sampling results generally support the presence of a dissolved TCE plume in the Upper horizon, with concentrations at or above the ACL spanning the area between wells LM147A to the south, Annex-4 to the west, LM072A/73B to the north, and well LM076A to the east (Figure 2.13). Based on

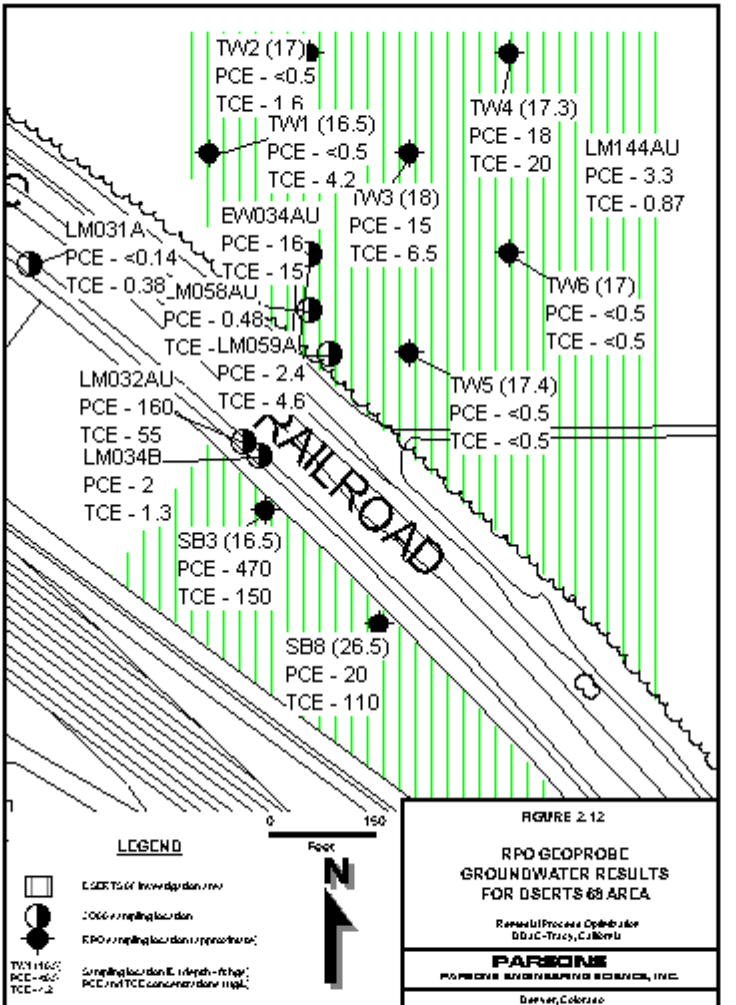


FIGURE 2.12

RPO GEOPROBE GROUNDWATER RESULTS FOR DSERTS 68 AREA

Remedial Process Optimization
DDJC-Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

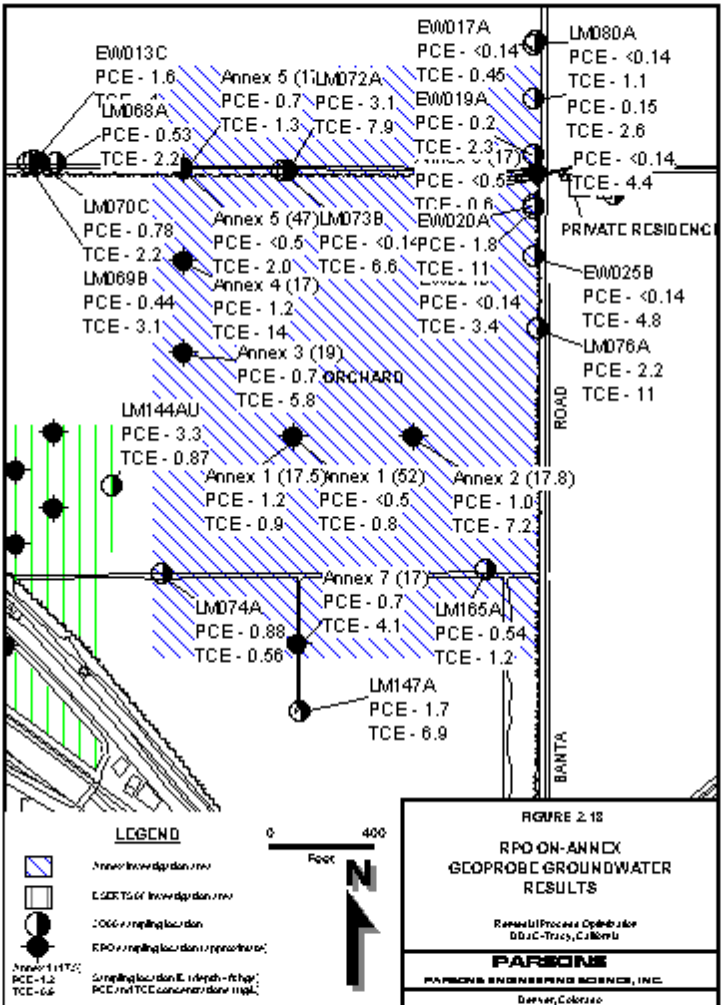


FIGURE 2.18

RPO ON-ANNEX
GEOPROBE GROUNDWATER
RESULTS

Remedial Process Optimization
DOJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

groundwater flow directions, the source of TCE at well LM147A is unclear. This contamination may be related to a source to the south (e.g., the former burn pits at SWMUs 8 and 9). It also is possible that seasonal flood irrigation and/or pumping of the former well AG-3 and private wells off-Depot to the east (PW002 and PW003 north of the All Pure/Pioneer facility) have altered local flow gradients, inducing southward migration of contamination emanating from the DSERTS 68 area. Anomalous (lower than expected) water levels have been reported historically at well LM145AU in this area (Radian, 2000c), though these data may be related to erroneous survey data (Sharpe, 2001).

PCE concentrations appear to generally decrease in a northeasterly pattern from well LM144AU (Figure 2.13). The distribution of PCE concentrations strongly suggest that DSERTS 68 is the source for this plume. Variability among concentrations of COCs in this portion of the Annex probably can be attributed to heterogeneities in the Upper Tulare Aquifer, different sampling dates (July and October 2000), different screened depths at the wells and Geoprobe® locations, and hydraulic influences of irrigation and extraction on local flow gradients. Apparent COC concentrations at extraction wells and private pumping well PW001 are not directly comparable to results for monitoring and temporary wells.

Although the RPO data collected in October 2000 help refine interpretations of the CAH plume downgradient from DSERTS 68 and farther northeast on the Annex, plume-delineation data gaps remain, as noted by Radian (2000c) for areas east of Banta Road. Planned TCE characterization efforts on private lands east of the Annex should include investigation of potential secondary sources or other satisfactory explanations for the discontinuous nature of the currently documented TCE plume in the shallow saturated zone (Upper horizon) in this area relative to TCE contamination on the Annex.

2.3.3 Natural Attenuation of CAHs in Groundwater

Natural attenuation of dissolved CAHs can occur via the processes of advection, dispersion, sorption, volatilization, and biodegradation. The ESD to the OU1 ROD (Montgomery Watson, 1996a) acknowledges the efficacy of relying on natural attenuation processes (especially dispersion) for remediation of dilute portions of the CAH plume that have migrated east of Banta Road. To investigate biodegradation of CAHs in OU1 groundwater, Radian (1999b) is conducting a small-scale MNA evaluation.

Temporal concentration trend data for dissolved TCE and PCE (Section 2.3.2.1) suggest that plume magnitudes generally are decreasing, and plume interpretations show that concentrations decrease with distance from the source area (Figures 2.10 and 2.11). These phenomena reflect the effects of natural attenuation, cultural practices, and operation of the ETI system. Decreases in CAH concentrations downgradient from source areas may be due largely to flushing of flood irrigation waters through the shallow horizons beneath the Annex, which accelerates plume attenuation through dispersion/dilution, but also may accelerate the downgradient migration of the dilute contaminant concentrations. The effect may be further magnified beneath the Annex relative to the on-Depot source areas because many of the source sites have impermeable surface coverings (e.g., pavement and structures) that inhibit infiltration of precipitation.

Though nondestructive attenuation mechanisms likely are the dominant processes affecting the CAH plumes in OU1 groundwater, the focus of the recent MNA study at DDJC-Tracy was the destructive mechanism of biodegradation (Radian, 1999b).

Reductive dehalogenation is the most common biodegradation reaction for PCE and TCE in the subsurface (Vogel, 1994). For this reaction to occur, low-oxygen, reducing reduction/oxidation (redox) conditions must predominate in the groundwater system. If reductive dehalogenation is occurring at DDJC-Tracy, PCE/TCE concentrations would be expected to be greatest near the source areas, and the concentrations of the biodegradation daughter product *cis*-1,2-DCE would be expected to increase immediately downgradient from the source area. The further reductive dechlorination of *cis*-1,2-DCE would result in increased concentrations of vinyl chloride and ethene downgradient from the source area.

Examination of the data for CAHs detected in groundwater at and downgradient from DDJC-Tracy reveals that daughter products from the reductive dechlorination of PCE and TCE are few to nonexistent. DCE isomers have been detected infrequently at DDJC-Tracy and the Annex. Vinyl chloride has been detected only once (1993) in OU1 groundwater samples. Ethene has not been a target analyte during routine groundwater monitoring, but this daughter product was not detected during the MNA study. This lack of PCE/TCE daughter products suggests that biodegradation via reductive dechlorination is not contributing significantly to the removal of PCE and TCE mass from the groundwater system. Moreover, because the shallow depth to groundwater at DDJC-Tracy facilitates introduction of oxygenated water into the unconfined Upper Tulare Aquifer via percolation of precipitation and irrigation waters, and via infiltration of treated groundwater, it is unlikely that the anaerobic, reducing conditions required to sustain reductive dechlorination are present. Therefore, the available contaminant data suggest that reductive dehalogenation is not a significant attenuation mechanism for TCE and PCE at the Depot. However, geochemical parameters reflective of reductive dechlorination are not routinely analyzed during LTM groundwater monitoring.

To address groundwater geochemical data gaps, Radian (1999b) undertook a 1-year pilot-scale evaluation, beginning in 3Q98, of the potential usefulness of MNA, particularly biodegradation of CAHs, to supplement active groundwater ETI at DDJC-Tracy. Radian's (1999b) work plan for the MNA study was reviewed as part of this RPO evaluation, along with preliminary analytical results for the sampling events conducted to date. Per the work plan, the objectives of the study at DDJC-Tracy are to:

- Aid in evaluating whether or not natural attenuation (i.e., biodegradation) of COCs is occurring, and

- Aid in determining if MNA is a feasible and efficient remedial option for COCs in OU1 groundwater.

Seven groundwater monitoring wells (LM028A, LM050A, LM053A, LM066A, LM083A, LM129A, and LM162A) were selected for the MNA evaluation at DDJC-Tracy (Figure 2.2). These wells are all completed in the Upper (A) horizon and are located along the longitudinal axis of a dissolved CAH plume that appears to originate in the northern portion of the Depot and migrates in a northeasterly direction toward TP-2 on the Annex property (Figure 2.10). Geochemical parameters analyzed during this

effort include aquifer characteristics that govern biodegradation potential (i.e., temperature, total organic carbon [TOC], oxidation/reduction potential [ORP], and alkalinity); competing electron acceptors that may be used by microorganisms to facilitate biodegradation of available hydrocarbons (i.e., dissolved oxygen [DO], nitrate, and sulfate); and byproducts of biodegradation (i.e., methane, ferrous iron, carbon dioxide, chloride, and ethene (Radian, 1999b).

During the MNA sampling events, the maximum detected concentrations of PCE and TCE in the selected wells were approximately 8 µg/L and 16 µg/L, respectively (Table 2.2). Concentrations of these COCs typically were below detection limits at the farthest up- and downgradient locations for all sampling events, suggesting the entire plume length was bound by the monitoring network.

A total of four consecutive quarters (3Q99 through 2Q00) of preliminary (i.e., unvalidated) analytical results from URS's MNA evaluation were available during preparation of this RPO Phase II evaluation report. As expected, these data (Table 2.2) indicate that the groundwater system at DDJC-Tracy is aerobic and oxidizing, with low organic carbon content. These conditions inhibit reductive dechlorination of CAHs, which requires reducing, anaerobic conditions, and an adequate carbon substrate. The absence of detectable concentrations of PCE/TCE daughter products such as *cis*-1,2-DCE and vinyl chloride provides further evidence that biodegradation of CAHs is not occurring at a significant rate in OU1 groundwater.

DO concentrations measured in groundwater during this investigation ranged from a minimum of approximately 3 milligrams per liter (mg/L) to a maximum of approximately 16 mg/L (Table 2.2). DO concentrations of this magnitude are common in shallow groundwater systems where frequent surface recharge (e.g., via periodic flood irrigation at the Tracy Annex) occurs. The observed concentrations of DO indicate an aerobic environment in OU1 groundwater; DO concentrations of less than 0.5 mg/L are optimal for reductive dechlorination to proceed (USEPA, 1998). The absence of a clear trend of decreasing concentrations of DO in the plume downgradient from the source area is further evidence that reductive dechlorination is not occurring at the site. ORPs ranged from -154.5 to 342.4 millivolts (mV), with the majority of the readings well above 50 mV (Table 2.2). The optimal ORP range for reductive dechlorination of CAHs is about -100 to 50 mV (USEPA, 1998). Groundwater TOC concentrations measured in DDJC-Tracy wells (Table 2.2) were well below the 20-mg/L concentration considered optimal to support the reductive dechlorination process (USEPA, 1998).

The preliminary results for other geochemical parameters (nitrate, sulfate, ferrous iron, and methane) also support the inference that reductive dechlorination is not a viable degradation pathway for CAHs in OU1. Based on review of the preliminary data collected for the MNA evaluation (Table 2.2), it appears that biodegradation through reductive dechlorination is not a significant contributor to the natural attenuation of chlorinated solvents at DDJC-Tracy. However, due to the frequent recharge of groundwater via flood irrigation, the natural attenuation mechanism of dispersion (i.e., dilution and diffusion) likely is contributing significantly to the natural attenuation of chlorinated solvent plumes downgradient from DDJC-Tracy.

TABLE 2.2
PRELIMINARY RESULTS OF NATURAL ATTENUATION SAMPLING
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Analyte/Parameter [a/] (Units) [b/]	Sampling Event	Sampling Location						
		LM028A	LM050A	LM129A	LM053A	LM066A	LM083A	LM162A
Trichoroethene (µg/L)	3Q99	16.3	3.76	ND [c/]	6.7	7.8	ND	ND
	4Q99	15	3	ND	5.8	5.51	ND	0.854
	1Q00	3.1	4	ND	8.3	6.4	ND	ND
	2Q00	14	3	ND	5.6	7.2	ND	0.8
Tetrachloroethene (µg/L)	3Q99	7.73	2.37	ND	4.97	5.43	ND	ND
	4Q99	7.9	1.7	ND	4.7	4.7	ND	ND
	1Q00	0.42	ND	ND	5.7	4.7	ND	ND
	2Q00	8.1	2.1	ND	4.2	5.5	ND	ND
Alkalinity, total (mg/L)	3Q99	200	250	230	250	310	250	260
	4Q99	230	210	220	280	170	280	280
	1Q00	210	230	220	330	310	250	280
	2Q00	210	220	230	260	320	260	280
Chloride (mg/L)	3Q99	200	180	170	190	210	240	240
	4Q99	230	210	220	280	170	280	280
	1Q00	130	130	110	120	130	240	160
	2Q00	350	140	120	370	150	230	180
Nitrogen,Nitrate (mg/L)	3Q99	52	57	53	12	64	40	90
	4Q99	NA [d/]	NA	NA	10	NA	NA	NA
	1Q00	11	12	9	13	13	20	20
	2Q00	50	10	24	13	12	23	19

TABLE 2.2 (Continued)
PRELIMINARY RESULTS OF NATURAL ATTENUATION SAMPLING
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Analyte/Parameter [a/] (Units) [b/]	Sampling Event	Sampling Location						
		LM028A	LM050A	LM129A	LM053A	LM066A	LM083A	LM162A
Sulfate (mg/L)	3Q99	130	140	130	140	200	190	260
	4Q99	130	140	140	170	160	200	270
	1Q00	150	150	140	170	220	310	290
	2Q00	380	170	150	410	220	340	300
Manganese (mg/L)	3Q99	ND	ND	ND	ND	ND	ND	ND
	4Q99	ND	ND	ND	ND	ND	ND	ND
	1Q00	ND	ND	ND	ND	ND	ND	ND
	2Q00	ND	ND	0.01	ND	ND	ND	ND
Total OrganicCarbon (mg/L)	3Q99	6	2	1	4	6	3	6
	4Q99	14	1	ND	3	2	2	2
	1Q00	5	5	3	11	10	3	6
	2Q00	2	2	4	2	2	6	4
Dissolved Oxygen (mg/L)	3Q99	8.18	16.19	6.61	5.67	1.85	6.38	2.67
	4Q99	4.24	8.55	10.35	7.97	8.25	9.57	7.9
	1Q00	2.69	7.7	13.27	15.06	6.99	8.33	7.49
	2Q00	9.32	15.48	11.43	7.72	11.1	12.72	10.74
pH (SU)	3Q99	7.14	6.9	6.99	6.92	6.93	6.95	6.95
	4Q99	7.38	6.92	7.22	7.12	7.03	7.09	7.1
	1Q00	7.01	7.2	7.52	7.43	7.13	7.04	7.28
	2Q00	7.12	7.03	7.94	7.79	7.1	7.06	7.19

TABLE 2.2 (Continued)
PRELIMINARY RESULTS OF NATURAL ATTENUATION SAMPLING
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Analyte/Parameter [a/] (Units) [b/]	Sampling Event	Sampling Location						
		LM028A	LM050A	LM129A	LM053A	LM066A	LM083A	LM162A
Oxidation/Reduction Potential (mV)	3Q99	139.2	159.7	132.5	154.1	155.6	153	153.4
	4Q99	185.8	207.2	103.7	11.9	-36.3	14.8	-5.1
	1Q00	281.3	283.7	163.3	165.1	308.1	306.5	305.1
	2Q00	265.6	324.2	-154.5	-122.4	342.4	287.4	298.7
Temperature (degrees Celcius)	3Q99	21.8	20.2	23.2	20.5	19.2	20.2	20.7
	4Q99	19.5	19.2	20.2	20.1	18.4	20	20
	1Q00	19.3	19.7	21.2	20.7	18.7	18.3	19.1
	2Q00	19.5	19.6	23.1	21.7	18.8	19.6	20.8

Source: Preliminary data provided by URS.

[a/] Sulfide, methane, and ferrous iron also were analyzed for at all eight wells during all four monitoring events, but were not detected.

[b/] µg/L = micrograms per liter; mg/L = milligrams per liter; µg/mL = micrograms per milliliter; SU = standard pH units;mV = millivolts.

[c/] ND = not detected.

[d/] NA = not analyzed.

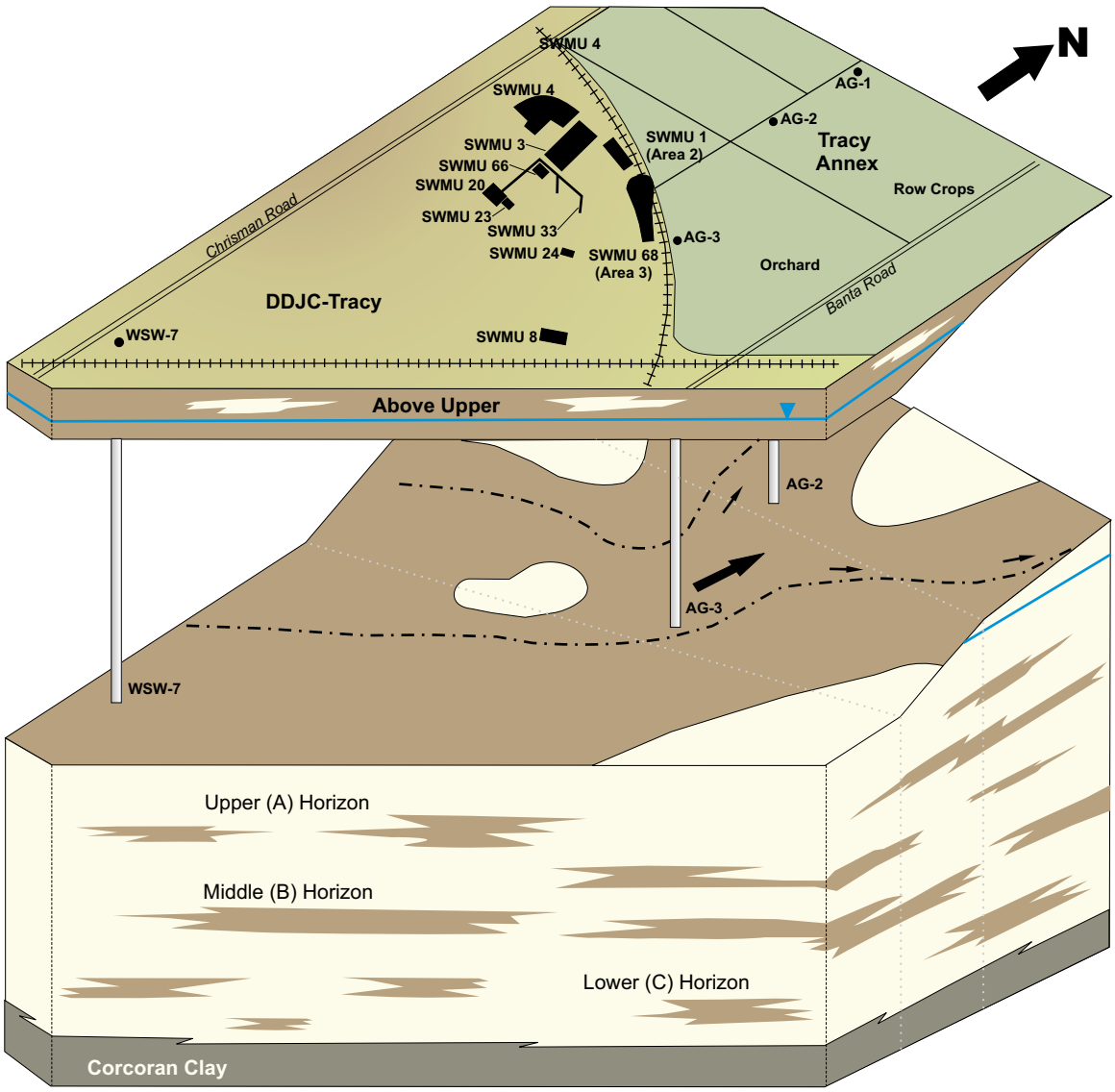
2.4 REFINED CONCEPTUAL MODEL

2.4.1 Simplification of Hydrogeologic Model Presentation

Based on geologic cross sections, hydraulic gradients, aquifer characteristics, and contaminant distributions, groundwater in the described four horizons is in hydraulic communication (Radian, 2000c). The discontinuous clay layers between the horizons do not prevent vertical flow. Geologic logs for wells installed at DDJC-Tracy and the Annex indicate that distinctions among the horizons are complex and unclear, and that in general, the water-bearing horizons above the Corcoran Clay can be viewed as a single, heterogeneous hydrogeologic unit (i.e., the Upper Tulare Aquifer). The northeast-trending paleochannel observed in the Upper (A) horizon serves as a preferential flow pathway for shallow groundwater, and conducts dissolved contamination from on-Depot sources beneath the Annex in a northeasterly direction.

Moreover, average hydraulic gradients in horizons A, B, and C are about the same (Table 2.1), with some variations due to local pumping. Hydraulic conductivity values, and consequently groundwater velocities, in the Upper and Middle horizons are also fairly similar. These data support a revised conceptual hydrogeologic model that reduces distinctions among essentially similar hydrostratigraphic units. The concept introduced by Montgomery Watson (1996b) of four separate horizons at the site, although appropriate for categorizing monitoring intervals, has unfortunately contributed to the misconception that the contaminant plume occurs separately and behaves differently within four different "horizons" or water-bearing units at the site. All plume-migration interpretations have followed the "horizons" concept such that data evaluation, presentation of results, and the extraction and monitoring wells installed at DDJC-Tracy and the Annex have been horizon-specific. This approach may be contributing to piecemeal plume remediation rather than targeting the entire dissolved CAH migrating through any given location. Consequently, this approach may have contributed to potential misinterpretations of CAH plume behavior, unnecessary monitoring and/or pumping, as well as cumbersome data analysis and reporting.

Figure 2.1 presents the current CSM originally promoted by Montgomery Watson (1996b), and Figures 2.10 and 2.11 present 1998/1999 plume interpretations by horizon (Radian, 2000c). Based on the preceding discussion, Parsons ES has refined the conceptual hydrogeologic model for DDJC-Tracy to reflect consolidation of the three lower horizons into a single, heterogeneous sand and gravel unit with discontinuous lenses of finer-grained silts and clayey sands (Figure 2.14). Parsons ES suggests that reporting analytical results from quarterly and annual groundwater monitoring events could be streamlined if a simplified, two-unit model is used. Because the lower units are of similarly heterogeneous lithologies and share similar hydraulic characteristics (e.g., downward vertical gradients), contaminant migration could be presented for a shallow saturated zone composed of the upper 15 to 20 feet of the aquifer, and a deeper unit consisting of all other underlying horizons to the top of the Corcoran Clay. The Above Upper horizon, which is composed of finer–grained materials than the underlying horizons, would be retained as the shallow unit for its saturated extent across DDJC-Tracy and the Annex. Where the Above Upper horizon pinches out, the Upper horizon would comprise the shallow saturated zone.



Not to Scale

Legend

- Predominant Groundwater Flow Direction
- Potential Contaminant Transport
- Suspected Source Area for Groundwater Contamination
- Sands and Gravels
- Silts and Clays
- Paleochannel
- Groundwater Surface
- Union Pacific Railroad

FIGURE 2.14

REVISED CONCEPTUAL SITE MODEL

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw/TracyC.cdr bbs p1 5/11/01

This simplified model could facilitate continuing implementation of the ETI remedy for the COCs in OU1, and presentation of LTM data for these two units could clarify plume and remaining hot-spot configurations to facilitate refinement of the extraction and monitoring networks and assessment of progress toward ROD ACLs.

2.4.2 Contaminant Distribution

Currently, two TCE/PCE plumes can be identified for OU1 (see Section 2.5). The western plume, originating near Building 10, has migrated northeast toward the former irrigation well AG-2 location. This plume remains on-Depot in the shallow portion of the aquifer (Above Upper and Upper horizons) and migrates downward into deeper portions of the aquifer as it moves northward toward former irrigation well AG-2.

A second TCE/PCE plume originates around DSERTS 68 (former Area 3 drum storage area) and has migrated northeast beneath the Annex. This plume mainly occurs in the shallow portion of the aquifer (Above Upper and Upper horizons), and has migrated to Banta Road. A southward extension of the TCE plume near well LM147A (Figure 2.13) may be related to a different source (e.g., SWMUs 8 and 9) or to localized influences of irrigation and pumping. The discontinuity of the TCE "plume" between Banta Road and the north/south quarter-section road 0.25 mile to the east (Figure 2.10) raises questions about the sources and migration dynamics of contamination in this area. Additional characterization has been recommended to better define the extent and origins of TCE contamination in this area (Radian, 2000c).

It appears that some groundwater contamination is being drawn downward into the middle portion of the aquifer by pumping at extraction wells EW024, EW025, and private well PW001. These wells are located near the eastern Annex boundary (Banta Road), approximately 2,500 feet downgradient from Area 3 (Figures 1.3 and 1.4). TCE and PCE contaminant concentrations generally are decreasing or stable throughout the plumes.

2.5 ALTERNATIVE DATA-PRESENTATION METHOD

URS currently provides detailed analyses of groundwater monitoring results in the annual monitoring reports. Evolution of contaminant plumes typically is reviewed in the annual reports only for the most recent 12-month period. However, variations in well density (horizontally and vertically) across the Depot and Annex, and among the wells sampled during a given monitoring event; interpretation of contaminant movement by horizon; and use of diluted COC concentrations measured at extraction wells can affect interpretations of plume continuity and stability. Interpolations of plume continuity between widely spaced wells appear to be based in part on results of one-time sampling during historical characterization efforts (e.g., CPT and Hydropunch sampling across the Annex and on private lands to the east). The TCE and PCE plumes depicted on Figures 2.10 and 2.11 are examples from the 1999 annual groundwater monitoring report (Radian, 2000c).

To provide clearer data presentation to support remedial decision-making, to better illustrate the evolution of plumes (and the groundwater monitoring program) over time, and to demonstrate the impact of sampling design on interpretations of plume

configurations and migration, Parsons ES developed a series of thematic concentration maps for TCE and PCE in groundwater. Maps were generated using all analytical data for these COCs included in the electronic data base for the time periods selected. To provide insight into historical sampling programs and plume interpretation, figures showing OU1 distributions of TCE in all horizons for 1992 (pre-IRM system startup), 1994 (year of extensive CPT/Hydropunch® investigations in the Annex), 1996 (year of preliminary CPT investigation east of Banta Road), and 3Q00 (including Radian's quarterly monitoring data and the October 2000 RPO data). These maps are presented as Figures 2.15 through 2.18.

On each figure, only wells sampled during the monitoring period(s) represented are depicted, allowing the reader to readily assess changes in the sampling design among monitoring events. The maximum TCE concentration detected at each well during the sampling period is represented thematically by well using a colored, size-graded symbol to indicate concentration intervals ranging from less than the ACL of 5 µg/L to greater than 200 µg/L. Using this display method, results are associated with their appropriate monitoring locations, and the contaminant magnitudes and distributions are readily traceable to the EDMS database. For simplicity, horizons are not distinguished (i.e., results for all sampled wells in all horizons are presented), though data could easily be presented by saturated zone or horizon.

Comparison of the information presented on Figures 2.15 through 2.18 shows the variability of sampling locations through time, as characterization of the COC plumes progressed and LTM wells were established, and allows ready identification of persistent hot spots as well as areas where TCE concentrations have decreased. If COC isoconcentrations were to be contoured, the basis for (and reliability of) the contouring would be readily apparent to reviewers. This would minimize misinterpretations of plume extent and shape (and contaminant migration) due to sampling coverage. These figures also highlight areas where supplemental characterization could enhance remediation efforts (e.g., Figures 2.17 and 2.18, area east of Banta Road). The demonstrated data-presentation method is flexible, and can accommodate a wide range of reporting variables (e.g., individual sampling events, all events within a specified period of time, discrete horizons or zones, discrete analytes, concentrations ranges of particular interest, etc.).

A thematic map of PCE concentrations in OU1 groundwater, based on the most current EDMS database information, is presented as Figure 2.19. Examination of the concentrations in the vicinity of DSERTS 68 (indicated by two red circles reflecting PCE concentrations greater than 100 µg/L detected at well LM032AU and RPO temporary monitoring point SB3) draw attention to this significant source-area hot spot. Such figures could be valuable tools for regulatory discussion and optimization of the extraction and monitoring systems.

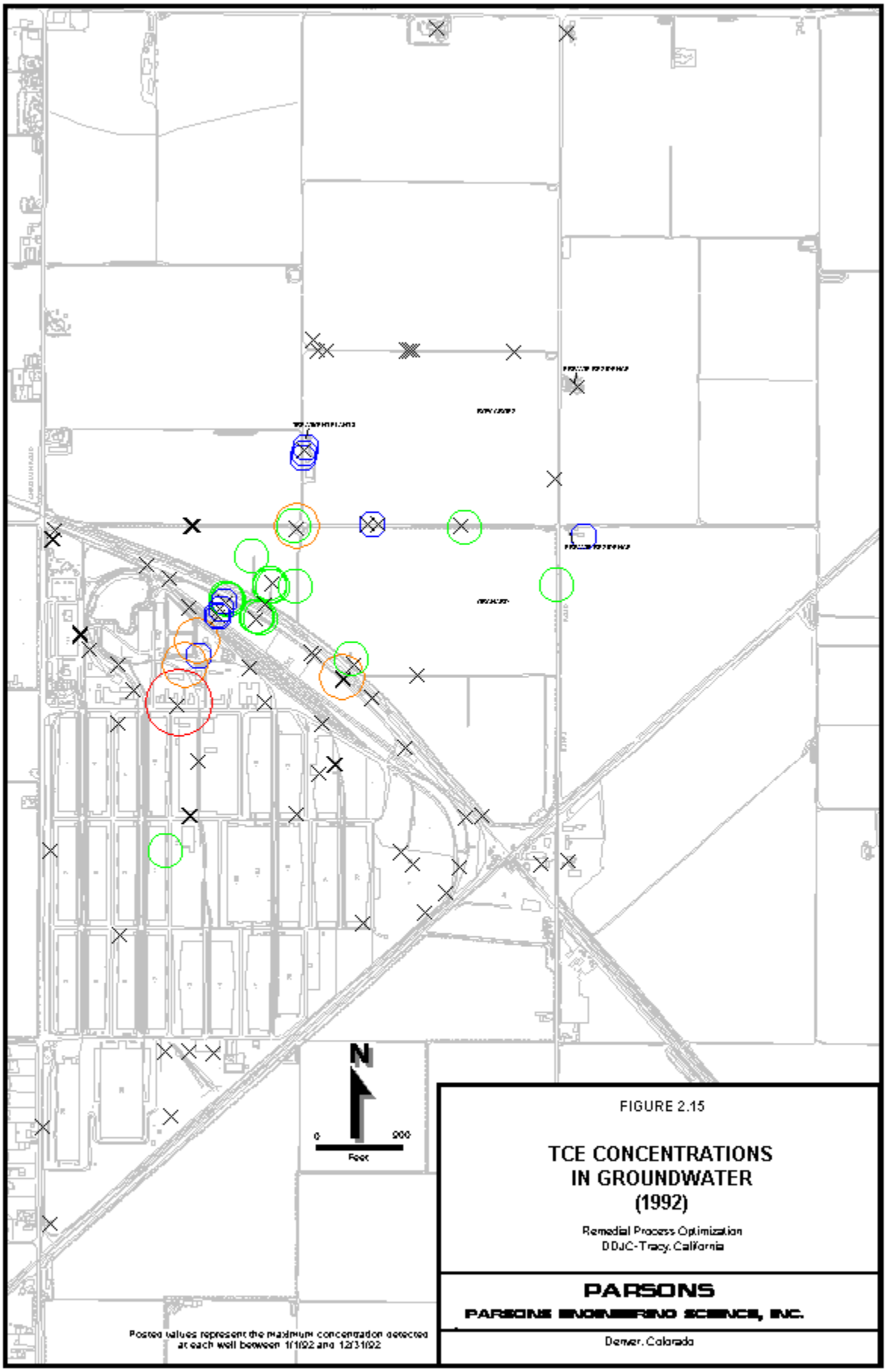


FIGURE 2.15

TCE CONCENTRATIONS IN GROUNDWATER (1992)

Remedial Process Optimization
DDJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

s:\site\remedi\ppoddic-tracy\mapinfo\workspaces\pos_tce_92.wor 05/14/2001 1000

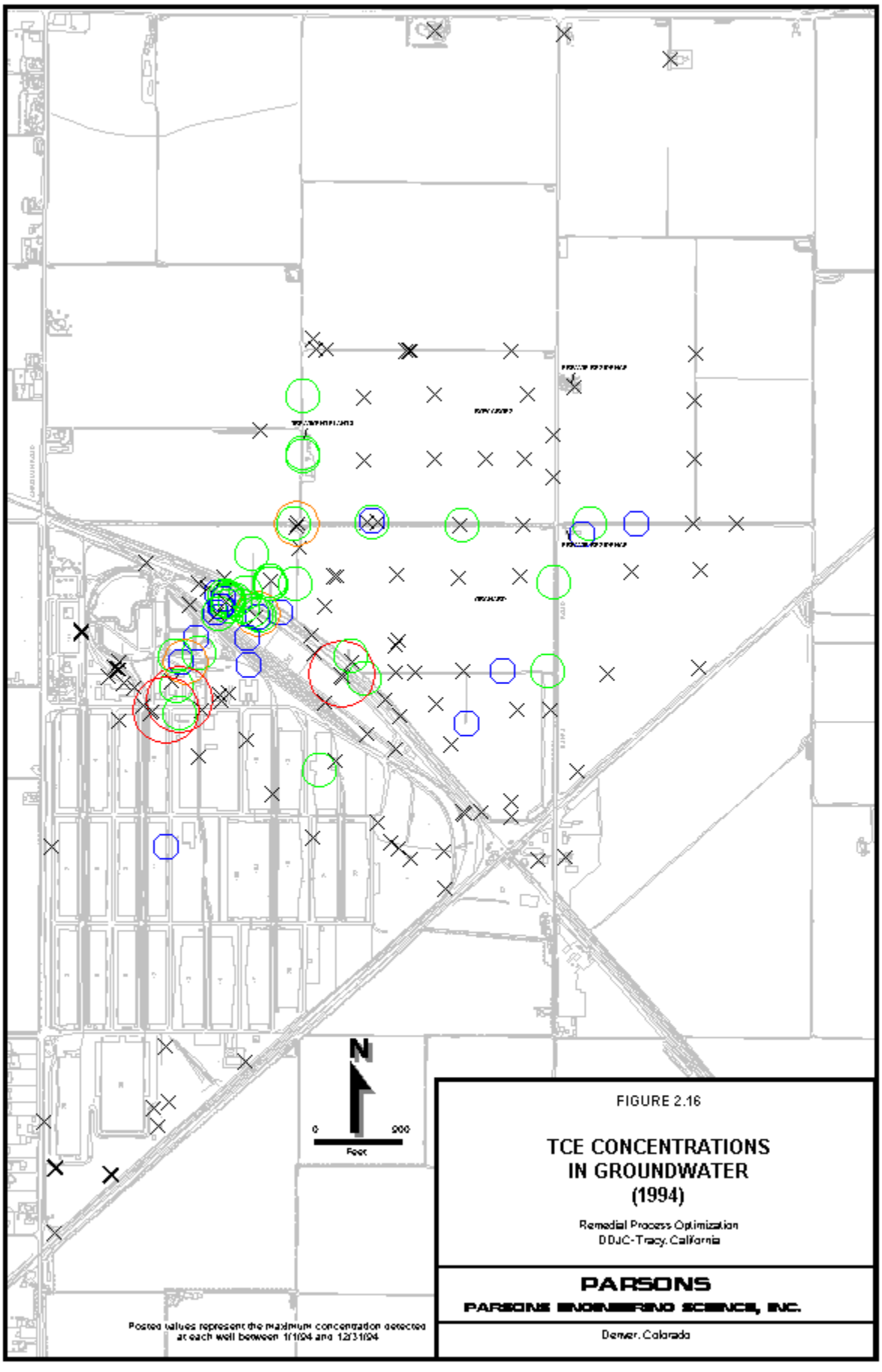


FIGURE 2.16

TCE CONCENTRATIONS IN GROUNDWATER (1994)

Remedial Process Optimization
DDJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

s:\sites\remed\ddjc-tracy\mapinfo\workspaces\tce_tcz_94.wor 05/11/2001 11:55

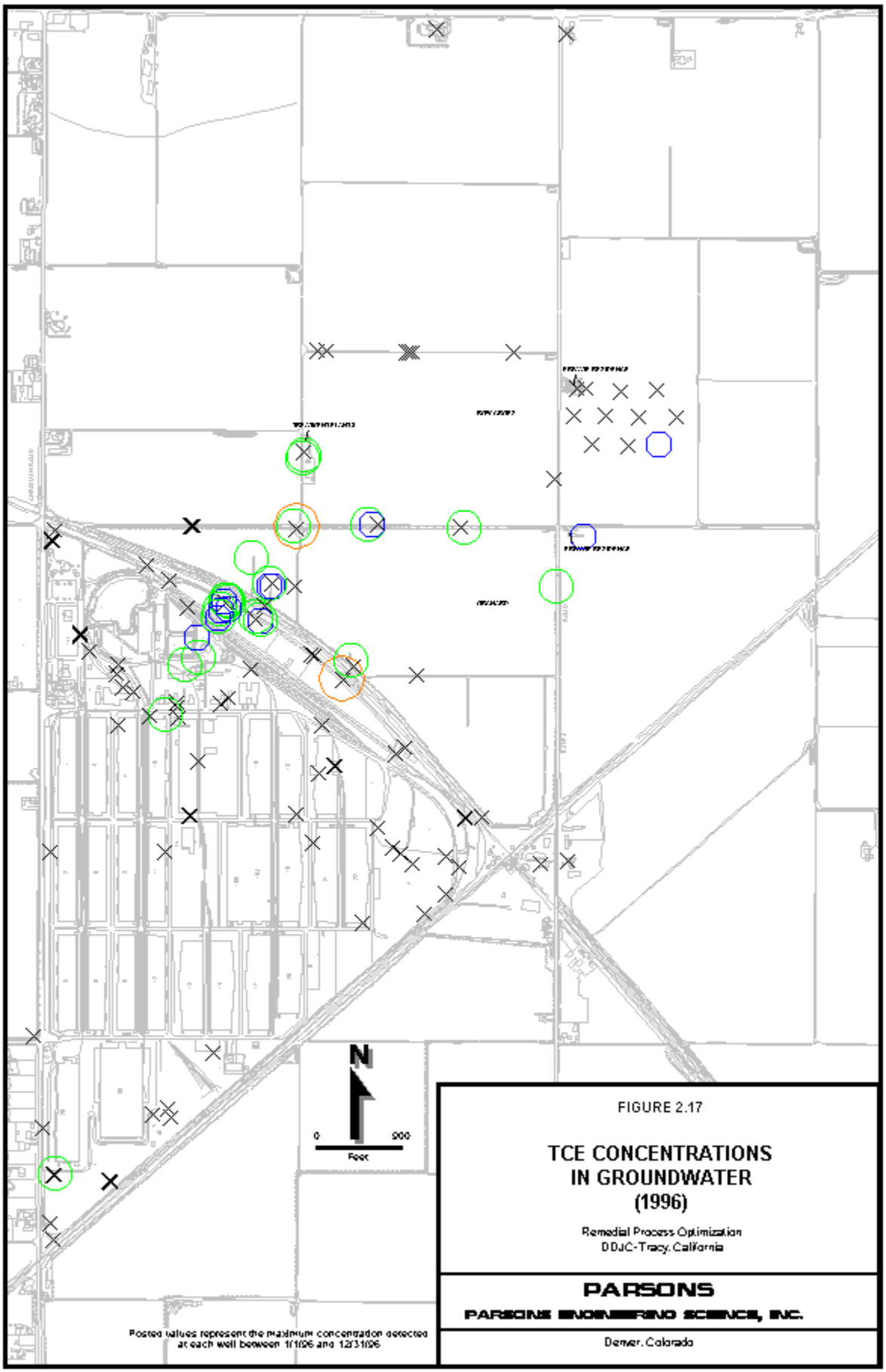


FIGURE 2.17

TCE CONCENTRATIONS IN GROUNDWATER (1996)

Remedial Process Optimization
DDJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

s:\sites\remedy\ddjc-tracy\maplink\workspaces\tce_ice_96.wor 05/14/2001 10:15

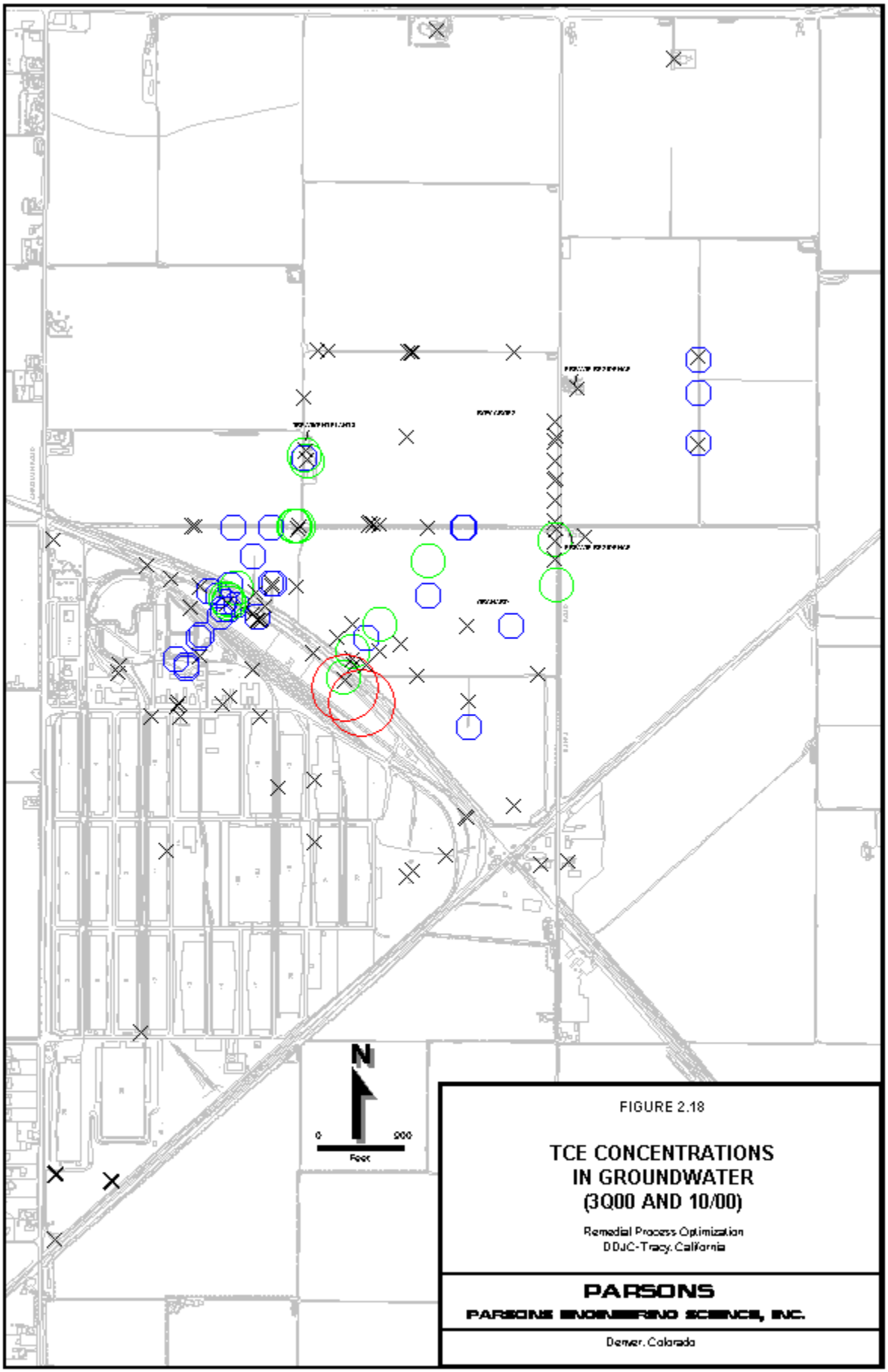


FIGURE 2.18

TCE CONCENTRATIONS IN GROUNDWATER (3Q00 AND 10/00)

Remedial Process Optimization
DDJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

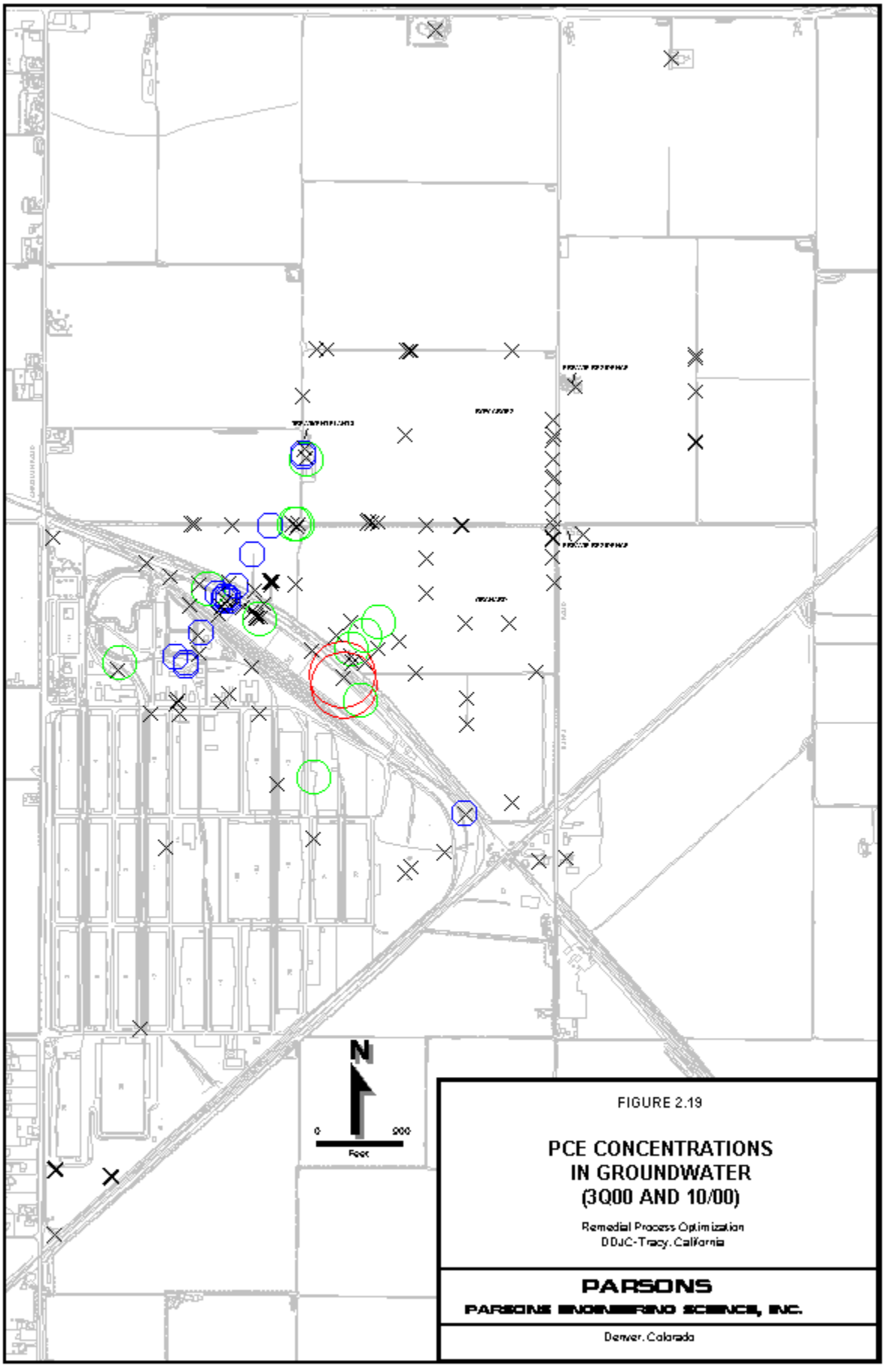


FIGURE 2.19

PCE CONCENTRATIONS IN GROUNDWATER (3Q00 AND 10/00)

Remedial Process Optimization
DDJC-Tracy, California

PARSONS

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

SECTION 3

EVALUATION OF CLEANUP GOALS

The RPO evaluation provided an opportunity to review the RAOs and cleanup goals for DDJC-Tracy, and to provide input regarding these goals to the ongoing dialogue with regulatory officials responsible for oversight of remediation activities. As site information is updated, new opportunities may arise to recommend and justify revision of monitoring requirements, cleanup goals, and/or treatment processes during 5-year ROD reviews. The next ROD review for DDJC-Tracy is scheduled for 2003.

3.1 RAOs AND ROD CLEANUP GOALS

DDJC-Tracy is listed on the NPL, and the environmental restoration program is being implemented in accordance with CERCLA, with regulatory oversight provided by USEPA Region 9 and the State of California. Pursuant to Section 121(d) of CERCLA, as amended, remedial actions must attain a degree of cleanup that assures protection of human health and the environment. RAOs are established in the DDJC-Tracy RODs to define the objectives of the selected remedies for groundwater and source sites.

CERCLA requires compliance with applicable or relevant and appropriate requirements (ARARs). Chemical- and action-specific ARARs for contaminants in groundwater and treatment plant effluent at the Depot are specified as ACLs in the two RODs and as discharge requirements in the WDR order (California RWQCB, 1998a). ROD cleanup goals for soil, stormwater discharge to SWMU 4, and SWMU 4 sediment are back-calculated from groundwater ARARs, are risk-based, or are based on other to-be-considered criteria (TBCs). Rules promulgated by the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) represent action-specific ARARs applicable to the discharge of vapor emissions to the atmosphere from air-stripping towers at the groundwater treatment plants and from operating SVE systems. No location-specific ARARs have been identified for DDJC-Tracy (WCC, 1993; Radian, 1998a).

Under CERCLA, the ROD documents the regulatory decisions, made with public input, regarding remediation of a site in compliance with ARARs and TBCs. In order to modify ROD-specified cleanup goals or discharge requirements for DDJC-Tracy, a convincing argument, based on technological and/or scientific data, must be made to persuade regulatory authorities that a change is warranted. If such an argument can be made, the terms of the ROD can be modified through either an ESD or a ROD amendment. Based on the results of this RPO evaluation and ongoing work at DDJC-Tracy being performed by URS, revision of the ACLs for OU1 is not recommended at this time. However, revision of the soil vapor cleanup goals for TCE and PCE, as specified in the Comprehensive ROD (Radian, 1998a), may be appropriate (see Section 3.3). Based on the results of the updated ecological risk assessment (URS, 2001), the

remedy for SWMU 4 sediment is being revised via an ESD to the Comprehensive ROD (see Section 3.2)

3.1.1 Remedial Action Objectives

RAOs for sites and OU1 at DDJC-Tracy are established in the RODs (WCC, 1993; Montgomery Watson, 1996a; Radian, 1998a). The 1993 ROD prioritized remediation of groundwater over source-area remediation because TCE had been detected in an offsite residential potable water well, and was threatening a second private well (WCC, 1993). To remediate impacts on/threats to human health and to restore the affected aquifer to its highest beneficial use (i.e., as a potable water source), the ROD establishes the following RAOs for OU1:

- Remediate hot spots (portions of groundwater plumes exhibiting the highest concentrations of COCs);
- Minimize migration of contamination off-Depot;
- Minimize overall plume migration; and
- Clean up the plumes to ACLs for the COCs.

The OU1 ROD identified PCE, TCE, and 1,1-DCE as groundwater COCs to be cleaned up, and selected ETI with LTM as the remedy for achieving the RAOs. In 1996, an ESD to the ROD added dieldrin to the list of groundwater COCs, modified effluent discharge requirements to better reflect achievable detection limits for selected chemicals, and expanded the remedy to include natural attenuation (i.e., dispersion, volatilization, and biodegradation) for portions of the plume that had migrated onto private property east of the Annex (Montgomery Watson, 1996a). The incorporation of natural attenuation into the OU1 remedy for off-Annex contaminant plumes (Montgomery Watson, 1996a), and the installation of a GAC unit on the domestic well at the downgradient Rose residence (where TCE has been detected) are examples of the application of risk-based remediation and institutional controls in lieu of strict ARAR compliance.

The Comprehensive Site-Wide ROD (Radian, 1998a) reaffirmed the OU1 ROD and ESD, and established RAOs for source sites. Because the risk assessments determined that contaminated soils do not pose an unacceptable risk to current receptors at the Depot (Montgomery Watson, 1996b), the general RAO for soils is to prevent leaching of contaminant to underlying groundwater at concentrations that could result in exceedances of ACLs (Radian, 1998a). At SWMU 4, a site-specific RAO is the protection of ecological receptors exposed to contaminated surface water and sediments in the stormwater pond.

The RODs provide for re-evaluation of cleanup goals during 5-year ROD reviews based on the progress toward achieving those goals, and the expectation that the goals will be met within a reasonable remedial time and cost framework. Regulatory options for revising cleanup levels and modifying the selected remedies are reviewed in Sections 3.2 and 3.3.

3.1.2 Matrix-Specific Cleanup Goals

Pursuant to State Water Resources Control Board Resolution 88-63 and the California Porter-Cologne Water Quality Act, the California RWQCB (1998b) Central Valley Basin Plan classifies OU1 water-bearing units as having "existing or potential beneficial uses as sources of drinking water." Therefore, the chemical-specific ARARs for OU1 aquifer restoration are federal drinking water standards, or standards promulgated by the State of California that are more stringent than federal standards. The OU1 ACLs for DDJC-Tracy are summarized in Table 3.1.

TABLE 3.1
AQUIFER CLEANUP LEVELS FOR OPERABLE UNIT 1[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Chemical of Concern	Aquifer Cleanup Level (µg/L)[b/]	Basis
1,1-Dichloroethene	6.0	California MCL [c/]
Tetrachloroethene	5.0	USEPA MCL
Trichloroethene	5.0	USEPA MCL
Dieldrin	0.05	California Action Level

a/ Aquifer cleanup levels for groundwater established in the OU1 ROD (WCC, 1993) and ESD (Montgomery Watson, 1996b).

b/ µg/L = micrograms per liter.

c/ MCL = maximum contaminant level.

Soil, sediment, and surface water cleanup goals for source areas are listed in the Comprehensive Site-Wide ROD (Radian, 1998a). Soil cleanup levels were developed to be protective of groundwater (i.e., back-calculated using conservative RWQCB leaching models, partitioning calculations, and groundwater ACLs). Soil removal actions are completed or underway for most of the remaining sites. Three sites (SWMU 1 and DSERTS 66 and 68) are undergoing remediation of CAH-contaminated soils using SVE. The soil vapor cleanup goals for PCE and TCE in vadose-zone soils at sites 1, 66, and 68 are 780 parts per billion by volume (ppbv) and 320 ppbv, respectively (Radian, 1998a).

The risk-based SWMU 4 sediment cleanup levels specified in the Comprehensive ROD were established using conservative exposure assumptions and allometric equations for plant and wildlife species representative of ecological receptors known or thought to be present at the pond for foraging (Montgomery Watson, 1996b); SWMU 4 surface water cleanup levels are based on federal ambient water-quality criteria (i.e., TBCs) for the protection of freshwater aquatic organisms (Radian, 1998a). ROD-specified sediment and surface water (i.e., stormwater discharge) cleanup goals for COCs at SWMU 4 are listed in Table 3.2.

3.1.3 Groundwater Treatment Plant Discharge Requirements

Action-specific ARARs include restrictions that define acceptable treatment and disposal procedures for waste streams from remedial actions and for hazardous substances. The quality of treated water discharged from the TPs at DDJC-Tracy is

TABLE 3.2
CLEANUP LEVELS FOR SWMU 4 SEDIMENT AND SURFACE WATER[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Chemical of Concern	Cleanup Level		Basis for Cleanup Level
	Sediment (µg/kg) [b/]	Surface Water (µg/L) [c/]	
DDT	241	0.1	Ecological risk assessment (Montgomery Watson, 1996b); federal ambient water quality criteria for surface water, and the risk-based concentration in sediment that will not produce adverse effects in ecological receptors (Radian, 1998a).
Dieldrin	NA [d/]	0.05	
Lead	5,130	NA	
Selenium	616	NA	

a/ Cleanup goals for sediment and surface water at SWMU 4 were established in the Site-wide Comprehensive ROD (Radian, 1998a).
b/ µg/kg = micrograms per kilogram.
c/ µg/L = micrograms per liter in stormwater discharge.
d/ NA = not applicable; cleanup level not established in ROD (Radian, 1998a).

controlled under WDR Order No. 98-053, adopted by the California RWQCB (1998a) in February 1998. Treated groundwater from TP-1 and TP-2 is discharged into 10 infiltration galleries (IG-1 through IG-9 and CD-1) installed in the Above Upper and Upper horizons (Figure 1.4). Because the infiltration galleries have experienced frequent capacity and maintenance problems since their installation, the WDR order also allows seasonal discharge of treatment system effluent into the stormwater retention pond (SWMU 4) located along the northern Depot boundary (Figure 1.3). Per recent annual groundwater monitoring and treatment plant performance reports (Radian, 2000b, 2000c, 2000d, and 2000g – 2000p), excess treatment plant effluent from TP-1 has historically been discharged into SWMU 4 and the unlined sewage lagoon, located east of SWMU 4 along the northern Depot boundary (Figure 1.4). Limited discharge to the stormwater pond is permitted under the order. Water discharged into the sewage lagoons or stormwater ponds evaporates or percolates into shallow groundwater. The only off-Depot outlet for surface water at DDJC-Tracy is via pumping from the stormwater retention pond to a local irrigation canal. This discharge is regulated under a general NPDES permit (State Water Resources Control Board, 1997).

Because treatment plant effluent is discharged to groundwater (directly or via percolation), the highest potential beneficial use of groundwater serves as basis for selection of federal and state MCLs and RWQCB criteria as the standards for discharge of treated effluent. Therefore, the effluent discharge requirements for the identified groundwater COCs are the same as the OU1 ACLs (Table 4.1). However, the WDR order also sets discharge criteria for pH and several chemicals for which ACLs are not established in the RODs. Effluent pH must be maintained within the range of 6.5 to 8.5 standard units. Other current TP effluent discharge standards are listed in Table 3.3.

TABLE 3.3
EFFLUENT DISCHARGE STANDARDS FOR TREATED WATER[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Constituent	Daily Maximum Concentration (µg/L)[b/]	Monthly Median Concentration (µg/L)
Carbon Tetrachloride	0.5	0.5
Chloroform	5.0	0.5
1,1-Dichoroethene	5.0	0.5
Tetrachloroethene	5.0	0.5
Trichloroethene	5.0	0.5
Total VOCs [c/]	5.0	1.0
Chlordane	0.25	0.104
Dieldrin	0.1	<0.05
4,4-DDD	1.0 [d/]	0.15
4,4-DDE	1.0 [d/]	0.1
4,4-DDT	1.0 [d/]	0.1
Monuron	2.0	1.0 [e/]
Diuron	2.0	1.0 [e/]
Chromium (total)	50	<50

[a/] Discharge limitations for treated groundwater are established in the Record of Decision and explanation of significant difference for OU1 (WCC, 1993; Montgomery Watson, 1996a) and in Waste Discharge Requirements Order 98-053 (California RWQCB, 1998a). Waste discharge requirements apply to treated waters discharged to infiltration galleries/trenches or on-Depot water impoundments with no outlet to surface waters of the state (e.g., the sewage lagoon or stormwater pond) for reintroduction to groundwater.

[b/] µg/L = micrograms per liter.

[c/] Sum of all purgeable halocarbons and aromatic hydrocarbons using US Environmental Protection Agency (USEPA) Method 8260.

[d/] Daily maximum is the sum of DDD, DDE, and DDT.

[e/] Based on USEPA Method E632 detection limit.

3.1.4 SVE System Air Emissions Requirements

SVE systems are designed to remove volatile constituents from vadose-zone soils, and as a consequence of their operation, such systems generate a vapor-phase effluent stream containing volatilized contaminants. In California, SVE effluent streams (and groundwater air-stripper emissions) are subject to regulation under the Clean Air Act, as amended, RCRA, California statutes, and local Air Pollution Control District (APCD) regulations. At DDJC-Tracy, air-discharge regulation is under the supervision of the SJVUAPCD, and operation of vapor-treatment systems must be in accordance with rules promulgated by this agency. The District does not have prohibitory rules that would apply to remedial activities at DDJC-Tracy; however, certain provisions in SJVUAPCD

Rules 2201, 4651, and 4661 may apply to SVE air emissions generated during soil remediation at the Depot.

Rule 2201, the New and Modified Stationary Source Review Rule, regulates nonvehicular sources of air contaminants in California. The local APCD establishes allowable emissions limits. According to Rule 2201, a vapor effluent stream must be treated prior to discharge to the atmosphere, using best-available control technology (BACT), if emissions of a regulated air contaminant exceed 2 pounds per day (lbs/day).

Rule 4651 regulates VOC emissions from soil decontamination activities. According to Rule 4651, treatment methods for contaminated soil (e.g., SVE systems) will incorporate a VOC collection and control system. However, remediation of contaminated soil at sites affected by accidental spillage of less than one barrel (42 gallons) of liquids containing VOCs is not subject to the requirements of Rule 4651.

Rule 4661 regulates VOC emissions resulting from use or spillage of organic solvents. TCE and similar other solvent constituents are defined to be photochemically reactive solvents, and as such VOC emissions from these substances (possibly including SVE remediation activities at DDJC-Tracy) are regulated in accordance with the requirements of Rule 4661. An operator discharging more than 40 pounds of VOC emissions per day from a source operation is required to install and operate a VOC emissions control device having an overall capture and control efficiency of at least 85 percent. PCE is defined (Rules 4661 and 1020) as "not a VOC."

3.2 REVIEW OF SWMU 4 SEDIMENT REMEDIAL DECISIONS

As noted above, the framework of environmental regulation in recent years has evolved from strict application of numerical standards (e.g., ARARs) to the application of risk-based standards after careful consideration of site-specific factors and potential use of resources, including land and water. The re-evaluation of sediment cleanup goals at SWMU 4, the stormwater retention pond (Figure 1.3), using site-specific bioassay data is one such example of a risk-based approach to remediation at DDJC-Tracy.

The Comprehensive ROD (Radian, 1998a) proposes a sediment-removal remedy for SWMU 4. Based on the findings of the ecological risk assessment that was performed for SWMU 4 during the comprehensive RI/FS (Montgomery Watson, 1997), DDT, dieldrin, lead, and selenium in sediment were found to have the potential to induce adverse effects in wildlife that could use the pond for foraging. The original risk assessment conclusions were based on conservative exposure assumptions (e.g., exposure to maximum detected COC concentrations in sediment at the ephemeral stormwater pond on a year-round basis) for representative plant and animal species, and on literature-based toxicity and bioaccumulation data (Montgomery Watson, 1997). Preliminary risk-based sediment cleanup goals proposed in the FS were included in the ROD. However, the ROD acknowledged data gaps that contributed to uncertainties in the conclusions of the risk assessment, and recommended additional sampling to reduce those uncertainties. Resulting site-specific cleanup goals would then be incorporated into the remedy via a ROD ESD (Radian, 1998a).

From July 1998 through April 2000, Radian (2000f) collected sediment, surface water, plant, invertebrate, and fish samples from SWMU 4 to develop site-specific data to better

characterize potential risks to ecological receptors at the site. Samples were analyzed for DDT, DDD, DDE, PCBs, lead, and selenium. These data then were used in a new baseline ecological risk assessment (BERA) to reduce uncertainties associated with the 1997 risk assessment (Radian, 2000f; URS, 2001). As part of this RPO evaluation, Parsons ES reviewed the draft BERA and provided comments to Radian in a memorandum (Gordon, 2000); comments were incorporated into the final BERA report.

Using site-specific bioaccumulation data from the biota samples, and applying more realistic exposure assumptions for the representative receptors, Radian (2000f) concluded that contaminants in pond sediment do not pose unacceptable risks to ecological receptors. State and USEPA Region 9 regulators have reviewed the revised final BERA (URS, 2001) and have concurred with the findings of no significant risk from site sediments. Because there is no significant risk, the risk-based cleanup goals listed for sediment in the ROD no longer apply at SWMU 4. Therefore, URS is preparing an ESD to the Comprehensive ROD (Radian, 1998a) that will replace the sediment removal action with institutional controls and monitoring as the remedy for SWMU 4. Elimination of this removal action from the DDJC-Tracy CERCLA cleanup program should result in a cost saving of approximately $855,500 for SWMU 4 (Radian, 1998a).

3.3 SITE-SPECIFIC SOIL CLEANUP GOALS FOR SITES 1, 66, AND 68

Groundwater contamination at DDJC-Tracy is being remediated using a combination of ETI systems and MNA, in accordance with the requirements of the OU1 ROD (WCC, 1993; Montgomery Watson, 1996a). The DDJC-Tracy Comprehensive ROD specifies 350 ppbv of TCE and 780 ppbv of PCE as those concentrations in soil vapor that will prevent migration of these COCs to groundwater in the saturated zone at concentrations exceeding the ACLs (Radian, 1998a). Radian (2000a) has designed SVE systems for SWMU 1/Area 2 (former sewage lagoon and drum storage area), DSERTS 66 (asphalt-equipment cleaning area), and DSERTS 68 (former Area 3 drum storage area) to remediate soils in the vadose zone to meet the soil-vapor cleanup criteria. As specified in the Comprehensive Site-Wide ROD (Radian, 1998a), the objective of the SVE systems is to prevent further degradation of groundwater quality resulting from continued migration of PCE and TCE from vadose-zone soils to groundwater at dissolved concentrations exceeding the ROD-specified ACLs for these chemicals.

The soil-vapor cleanup levels of 350 ppbv for TCE and 780 ppbv for PCE apparently were derived on the basis of Henry's Law, which describes the concentration of a substance dissolved in the aqueous phase at equilibrium with its vapor phase (Appendix C). Several assumptions are necessary if vapor-phase concentrations of PCE and TCE, in equilibrium with ACL concentrations of 5 μg/L of each constituent dissolved in water, are to be established as cleanup standards for these constituents in soil vapor:

1. Soil vapor containing TCE at a concentration of 350 ppbv, or PCE at a concentration of 780 ppbv, is in direct contact with the underlying water table, and must remain in contact until equilibrium concentrations are established.

2. Soil vapor containing TCE at a concentration of 350 ppbv, or PCE at a concentration of 780 ppbv, is in direct contact with the water table across the entire affected area, and movement of groundwater into or out of the affected area does not occur. This assumption disallows the possibility that dilution of

groundwater contaminated with TCE or PCE could reduce the concentrations of those constituents to levels below ACLs.

3. Upward migration of vapor-phase TCE or PCE toward the atmosphere (and away from the water table) does not occur. This is equivalent to stating that the concentrations of TCE or PCE are uniform throughout the full thickness of the vadose zone, and remain constant through time.

4. If TCE or PCE in soil vapor is not in direct contact with groundwater in the saturated zone, but is in contact only with soil water in the unsaturated zone at some distance above the water table, equilibrium conditions will be established between TCE or PCE in the vapor phase and TCE or PCE dissolved in soil water. Constituents dissolved in soil water will then migrate to the water table below the contaminated soil vapor with no attenuation occurring.

During several soil-vapor investigations at SWMU 1 and DSERTS 66 and 68, TCE and PCE have been detected at concentrations that exceed the soil-vapor cleanup standards for these VOCs in fewer than half of soil-vapor samples collected near the water table. Upward migration of these constituents in soil vapor is known to occur (TCE and TPE are volatile chemicals); and several different attenuation mechanisms, including volatilization, sorption to soil, dilution, dispersion, and chemical or biological degradation, are capable of acting to reduce the mobility or concentrations of chemicals in the subsurface environment (USEPA, 1998). In light of these observations, the assumptions used to establish the ROD cleanup standards for TCE and PCE in soil vapor appear to be unnecessarily conservative. Accordingly, the soil-vapor cleanup standards were reviewed, considering the current understanding of site-specific conditions in the subsurface at DDJC-Tracy, to evaluate whether more realistic cleanup standards for TCE and PCE in soil vapor could be developed that would still be protective of underlying groundwater.

Site-specific information was used to evaluate the potential for migration of TCE and PCE downward through the vadose zone to the water table, in order to predict the maximum concentrations of these VOCs that could remain in the vadose zone at each of the three sites without causing further migration at concentrations that would exceed the ROD ACLs (Appendix C). The results of this evaluation then were used to calculate the concentrations of TCE and PCE in the vapor phase in equilibrium with the maximum concentrations of VOCs that could remain in the soil column within the vadose zone. These calculated vapor-phase concentrations of TCE and PCE represent convenient screening-level indicators of cleanup criteria for TCE and PCE in soil at the three sites. If vapor-phase concentrations of a particular volatile constituent exceed the screening-level soil-vapor cleanup criterion for that constituent, then it is likely that the concentrations of that constituent, in the sorbed, dissolved, and vapor phases in the vadose zone, are sufficiently elevated that the constituent will continue to migrate to the groundwater table at concentrations that would exceed the ACL for that constituent. Conversely, if vapor-phase concentrations of a VOC are below the screening-level soil-vapor cleanup criterion for that constituent, then continued migration of that constituent to the groundwater table at concentrations that would exceed the MCL is unlikely to occur.

Because the vadose zone at DDJC-Tracy is unsaturated (i.e., pore spaces are not completely filled with water), an analytical solution to the one-dimensional (1-D), unsaturated-soil transport equation (Jury *et al*., 1983a and 1983b) was used to evaluate the potential migration of VOCs in the subsurface (Appendix C). Using the "Jury model", chemical migration in the aqueous phase can be examined, and because the soil column simulated by the model contains some proportion of air in the pore spaces, vapor-phase transport also is accounted for. The solution to the equations describing 1-D, unsaturated transport (Jury *et al*., 1983a) is in the form of a partitioning model that distributes a chemical species in equilibrium among three of its possible phases (dissolved in the aqueous phase, sorbed to soil, and in soil vapor) in accordance with its chemical properties and local conditions in the subsurface. Radian (2000a) used the 2-D VapourT numerical transport model to develop design parameters for the SVE systems model. However, those modeling results were not used to develop site-specific cleanup goals.

In applying the Jury model (Appendix C), the initial concentrations TCE and PCE in the simulated vadose zone at each of the three SVE sites were adjusted until the maximum concentration of TCE or PCE calculated to arrive at the water table through the entire simulated time period never exceeded the ACL for that chemical. Those initial concentrations represent the maximum concentrations of TCE and PCE that could remain in the vadose zone at a particular site without representing a threat to groundwater quality (Table 3.4, Column 3). The vapor-phase concentrations of TCE and PCE in equilibrium with the maximum allowable sorbed and dissolved concentrations in the vadose zone were then calculated using the Jury model. These vapor-phase concentrations are equivalent to screening-level soil cleanup criteria (Table 3.4, Column 4) in that they can serve to indicate whether TCE or PCE remaining in soil in the vadose zone is present at concentrations that could eventually cause chemical migration to the water table at concentrations that would exceed the ACL in groundwater (Table 3.4, Column 5).

The simulation results indicate that if the vapor-phase concentration of PCE in soil vapor at SWMU1/Area 2 is reduced to 940 ppbv, and the vapor-phase concentration of TCE in soil vapor at SWMU1/Area 2 is reduced to 640 ppbv, these VOCs are not likely to continue to migrate from the vadose zone to the water table at concentrations that exceed their respective ACLs (Table 3.4). The results of simulations also were used to derive screening-level soil cleanup criteria for TCE and PCE in soil vapor at the other two SVE sites at DDJC-Tracy (Table 3.4).

At such time as the results of soil-vapor monitoring indicate that the concentrations of TCE and PCE in soil vapor at a specific SVE monitoring point no longer exceed vapor-phase soil cleanup criteria, the vapor-extraction system in that area could be shut down because the VOC mass remaining in that soil volume would be unlikely to represent a continued potential threat to groundwater. Soil-vapor monitoring should be continued for a period of time following system shut-down to evaluate whether the concentrations of TCE or PCE in soil vapor increase, as volatile constituents sorbed to soil or within the soil matrix diffuse into the soil pore spaces (the "rebound" effect). In some cases, VOC concentrations will continue to rebound above soil vapor criteria during equilibrium (shut-down) testing. In such cases, an approach similar to the SVE Termination or Optimization Process (STOP) protocol (Castle Air Force Base [AFB], 1999), currently being applied at several Air Force installations in California, should be pursued to weigh the relative costs/benefits of continued operation of the SVE system with marginal

TABLE 3.4
SITE-SPECIFIC SOIL CLEANUP CRITERIA BASED ON CONTAMINANT CONCENTRATIONS IN SOIL VAPOR
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Chemical of Concern [b/]	Maximum Concentrations Remaining in Vadose-Zone Soils[a/]		Maximum Dissolved Concentration Migrating to Groundwater at the Water Table (µg/L)[e/]
		Sorbed Concentration (µg/kg) [c/]	Resulting Equilibrium Concentration in Soil Vapor/ Soil Cleanup Criterion (ppbv) [d/]	
SWMU 1/ Area 2	PCE	32	940	5
	TCE	13	640	5
DSERTS 66 (Area 1)	PCE	43	870	5
	TCE	18	590	5
DSERTS 68 (Area 3)	PCE	51	910	5
	TCE	22	620	5

a/ Maximum sorbed chemical concentrations are those concentrations in the vadose zone, under the conditions described, that will produce a concentration of the chemical in groundwater at the water table that does not exceed the aquifer cleanup level for that chemical.

b/ Identified as groundwater chemicals of concern in the Operable Unit 1 Record of Decision (WCC, 1993; Montgomery Watson, 1996a).

c/ µg/kg = micrograms per kilogram.

d/ ppbv = parts per billion, by volume.

e/ µg/L = micrograms per liter.

extraction rates and high unit costs for VOC mass removal. URS has indicated that once COC concentrations in soil vapors reach asymptotic levels during SVE, the STOP protocol will be applied at DDJC-Tracy sites undergoing SVE remediation. At such time, if COC concentrations stabilize at levels that exceed the ROD cleanup criteria, it would be appropriate to develop site-specific cleanup goals in concert with the regulatory remedial project managers for DDJC-Tracy.

SECTION 4

REMEDIAL SYSTEMS EVALUATION

Ultimately, the effectiveness of a remediation system is judged by evaluating how well it achieves its objectives, and the efficiency of the system is considered to be optimal if it is effectively achieving its objectives at the lowest total cost, and/or in the shortest period of time. The RAOs for the SVE and groundwater ETI systems were established in the RODs (WCC, 1993; Montgomery Watson, 1996a; Radian, 1998a). Because the effectiveness and efficiency of a remediation system are directly related to its ability to achieve RAOs, the degree to which these objectives are met can be used as a measure of system performance. However, SVE systems at DDJC-Tracy were not yet in service at the time this RPO evaluation was conducted, and the integrated groundwater ETI system has not been fully operational during its 2-year performance period. Consequently, absolute criteria for evaluating long-term system performance are not available. Therefore, this RPO Phase II evaluation addresses the overall design and potential effectiveness and efficiency of the SVE systems that are being installed at SWMU 1 and DSERTS 66 and 68; and examines the overall design and preliminarily assesses the effectiveness of the groundwater ETI system and associated monitoring program. Based on these Phase II evaluations, recommendations to reduce OM&M costs are developed, and opportunities for renegotiation of site-specific soil cleanup goals (i.e., performance criteria) and enhancing the effectiveness of the groundwater remedy and monitoring program are identified.

4.1 SOIL-VAPOR EXTRACTION SYSTEM EVALUATION

SVE systems are being constructed at SWMU 1, DSERTS 66, and DSERTS 68 in order to remediate soils by removing CAHs (primarily PCE and TCE) from the vadose zone. The following subsections describe the remedial design of the SVE systems and present an evaluation of the potential effectiveness and efficiency of the SVE systems currently being installed.

The primary RAO of the SVE systems being installed at SWMU 1 and DSERTS 66 and DSERTS 68 is to reduce the concentrations of PCE and TCE in the vadose zone at these locations. The cleanup goals reviewed in Section 3 are intended to represent levels that will prevent further degradation of groundwater quality that could result from continued migration of PCE and TCE from vadose-zone soils to groundwater at dissolved concentrations exceeding the ACLs for PCE and TCE. Protection of groundwater quality is therefore the basis for requiring removal of CAH from vadose-zone soils at the three sites. The soil-vapor cleanup levels of 350 ppbv of TCE in soil vapor and 780 ppbv of PCE apparently were derived on the basis of Henry's Law, which describes the concentration of a substance dissolved in the aqueous phase at equilibrium with its vapor phase (Section 3.3; Appendix C).

The Comprehensive ROD for DDJC-Tracy (Radian, 1998a) specifies that the RAOs for vadose-zone cleanup will be considered to have been achieved when the following conditions have been met:

- The concentrations of PCE and TCE in soil vapor are equal to or less than the cleanup standards for each COC. (Presumably, this condition applies to every point in the vadose zone at each site; and vapor-phase concentrations at each site would be evaluated by collecting soil-vapor samples at a number of VMPs.)

- It can be demonstrated that no PCE or TCE remaining in the vadose zone at each site will migrate to the groundwater table at concentrations that exceed ACLs for PCE and TCE.

- The mass of PCE and TCE in the vadose zone has been removed to the extent technically and economically feasible. If ACL concentrations have not been achieved in groundwater beneath an SVE site, consideration of technical and economic feasibility will include the following factors, at a minimum:

  a) Evaluation of the total cost and duration of continued operation of the SVE systems that would be necessary to achieve ACL concentrations in groundwater underlying the vadose zone at the site.

  b) Evaluation of the total cost and duration of continued groundwater ETI to meet ACL concentrations in groundwater at the site, in the absence of continued SVE operation.

  c) Evaluation of the incremental cost of continued operation of the SVE system at the site. "Incremental cost" will be estimated as the cost per pound of additional COC mass removed from the site.

The ROD permits the SVE systems at DDJC-Tracy to be operated in cycles (i.e., temporarily shut down for a period of time, and then re-started), in order to optimize CAH removal rates, or to evaluate the attainment of vadose-zone cleanup criteria.

4.1.1 Summary of Design Elements of SVE Systems

Current plans (Radian, 2000a) call for installation of vapor extraction wells (VEWs) in areas where the concentrations of PCE and TCE in soil vapor exceed soil-vapor cleanup levels. Individual SVE wells were designed using information about the permeability of local soil to air, and estimated radii of influence (ROIs) obtained during SVE pilot testing in January, 1999 (Radian, 2000a). SVE wells are being installed at each site in an array that will allow a vacuum to be applied (at the VEWs) throughout the entire volume of affected soil. Soil-vapor monitoring points (VMPs) will be installed near the perimeter of each affected soil volume, within the ROI of each VEW field, and near hot spots (Radian, 2000a). Details of the proposed SVE and monitoring systems are summarized for each of the three sites below.

4.1.1.1 SWMU 1/Area 2

During Radian's (2000a) 1998 CPT investigation, two sub-areas at SWMU 1/Area 2 were identified, within which COC concentrations in soil-vapor samples exceeded the ROD-specified cleanup criteria for soil vapor. Detected concentrations of COCs in soil

vapor extended from depths of about 6.5 feet bgs to a point just above the water table, at a depth of approximately 16 feet bgs. Because the two sub-areas of vadose-zone contamination in SWMU 1/Area 2 are separated by some distance, a separate SVE wellfield will be required to remediate each of the two sub-areas. Each wellfield will consist of several SVE wells, with wellheads connected by a manifold (a single "circuit") to a hookup in a location central to the SVE wells. The design of the hookup enables the wellfield to be operated using a single, trailer-mounted treatment unit (see Section 4.1.1.4).

The remedial design for SWMU 1/Area 2 calls for installation of 14 VMPs and 7 SVE wells on two extraction circuits (Table 4.1), with a design extraction-well flow rate of 15.5 standard cubic feet per minute (scfm) (Table 4.2). The design total vapor-extraction rate for the two circuits is 107 scfm, with influent concentrations of TCE at system startup estimated to be 20,000 ppbv, and influent concentrations of PCE estimated to be at or below detection limits (Radian, 2000a, Appendix G). The total of direct and indirect capital costs for the SVE system at SWMU 1/Area 2 was estimated (Radian, 1998a) to be approximately $266,100 (in 1998 dollars) (Table 4.3).

Based on soil-vapor concentration data collected during the 1998 CPT investigation, Radian (2000a) estimated that approximately 1.0 pound of PCE and 1.6 pounds of TCE mass remain in the vadose zone at SWMU 1/Area 2 (Table 4.4). Considering the volume of soil at SWMU 1/Area 2 that is thought to be affected by PCE and TCE in the vadose zone, this is equivalent to an average concentration of 22 micrograms per kilogram (µg/kg) of PCE, and 0.128 mg/kg of TCE remaining in vadose-zone soils at SWMU 1/Area 2. However, based on SVE system operating data collected during 1Q00, 0.09 pound of TCE had been removed from the vadose zone, and 4.4 pounds of PCE hade been recovered. The PCE mass removed exceeded the design report estimate of 1.6 pounds by a factor of 2.75.

4.1.1.2 DSERTS 66/Area 1

The area within which the 1998 concentrations of COCs detected in soil-vapor exceeded the ROD-specified cleanup criteria for soil vapor encompassed the entire vicinity of Building 237 at DSERTS 66/Area 1 (Radian, 2000a). Detected concentrations of COCs in soil vapor extended from depths of about 5 feet bgs to a point just above the water table, at a depth of approximately 15 feet bgs. Two SVE circuits will be required to effectively treat the large, irregular area of contaminated soil surrounding Building 237. The remedial design for DSERTS 66/Area 1 calls for installation of 12 VMPs and 8 SVE wells on 2 extraction circuits (Table 4.1), with a design extraction-well flow rate of 19.2 scfm (Table 4.2). The design total vapor-extraction rate for the two circuits is slightly greater than 150 scfm, with influent concentrations of TCE at system startup estimated to be 1,200 ppbv, and influent concentrations of PCE estimated to be 13,000 ppbv (Radian, 2000a, Appendix G). The total of direct and indirect capital costs for the SVE system at DSERTS 66/Area 1 was estimated (Radian, 1998a) to be approximately $139,500 (in 1998 dollars) (Table 4.3).

TABLE 4.1
SVE SYSTEM DESIGN AND CONSTRUCTION DETAILS[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Circuit Number	Number of VMPs[b/]	Number of SVE Wells	Extraction Well Screened Interval (feet bgs)[c/]	Screen Length (feet)[d/]	Design Extraction Rate per Foot of Screen (scfm)[e/]	Total Design Extraction Rate per Circuit (scfm)
SWMU 1	1	14	3	5 - 13	8	1.9	46
	2		4	5 - 13	8	1.9	61
DSERTS 66	1	12	4	5 - 13	8	2.4	77
	2		4	5 - 13	8	2.4	77
DSERTS 68	1	28	7	5 - 13	8	1.9	106
	2		6	5 - 13	8	1.9	91
	3		5	5 - 13	8	1.9	76

[a/] Design and construction details from Radian (2000a).
[b/] VMP = vapor monitoring point.
[c/] bgs = below ground surface.
[d/] ft = feet.
[e/] scfm = standard cubic feet per minute.

TABLE 4.2
SVE WELL DESIGN DETAILS[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Design Vapor-Extraction Rate (per well) (scfm)[b/]	Design Wellhead Vacuum (in Hg)[c/]	(atm)[d/]	Design Radius of Influence (feet)
SWMU 1	15.5	4	~ 0.13	65
DSERTS 66	19.2	4	~ 0.13	50
DSERTS 68	15.5	4	~ 0.13	65

[a/] Design and construction details from Radian (2000a).
[b/] scfm = standard cubic feet per minute.
[c/] in Hg = inches of mercury.
[d/] atm = atmosphere; 29.92 in Hg = 1 atm.

TABLE 4.3
ESTIMATED TOTAL COSTS TO ACHIEVE CLEANUP GOALS[a/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Estimated Direct and Indirect Capital Costs [b/]	Estimated Annual OM&M Costs [c/]	Projected Range of Cleanup Times (days) [d/]	Projected Range of Costs for GAC [e/]	Estimated Range of Total Costs per Site	Estimated Range of Unit Costs per Site ($/lb COC) [f/]
SWMU 1	$266,100	$8,000	179 - 714	$1,800 - $7,400	$272,000 - $290,000	$105,000 - $112,000
DSERTS 66	$139,500	$8,000	76 - 304	$1,600 - $6,400	$143,000 - $153,000	$27,500 - $29,400
DSERTS 68	$241,500	$8,000	268 - 1,071	$26,800 - $107,000	$274,000 - $372,000	$4,300 - $5,800

[a/] Cleanup goals established for PCE and TCE in soil in terms of vapor-phase concentrations (Section 3.3).

[b/] Direct and indirect capital costs for SVE systems estimated by Radian (1998a), in constant (1998) U.S. dollars.

[c/] OM&M = operations, maintenance and monitoring (excluding granular activated carbon). Estimated annual OM&M cost for a single SVE system is $24,000, prorated among three systems; in constant (1998) U.S. dollars.

[d/] Range of cleanup times projected by Radian (2000a).

[e/] GAC = granular activated carbon, used to remove chemicals of concern (COCs) from SVE effluent vapor stream. Estimated cost for GAC is about $2.00 per pound.

[f/] $/lb COC = unit cost per pound of chemical of concern (PCE and TCE) removed from each site.

TABLE 4.4
ESTIMATED MASS OF COCs IN VADOSE ZONE AND PROJECTED TIMES TO ACHIEVE CLEANUP GOALS[/]
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Volume of Soil Containing COCs[a/]		Mass of COCs [a/]		Average Total Concentrations of COCs[b/]		Projected Range of Cleanup Times [c/] (days)
	PCE (ft^3)[d/]	TCE (ft^3)	PCE (lbs)[e/]	TCE (lbs)	PCE (µg/kg)[f/]	TCE (µg/kg)	
SWMU 1	483,300	131,900	1.0	1.6	22	128	179 - 714
DSERTS 66	243,100	324,000	3.4	1.8	148	59	76 - 304
DSERTS 68	2,287,000	746,400	39.4	24.7	186	357	268 - 1,071

[a/] Mass of chemicals of concern (COCs) in vadose-zone soils and volumes of soil that contain COCs were estimated by Radian (2000a).

[b/] Average concentration of COCs in an area is the mass of COCs in all phases (sorbed to soil, dissolved in soil water, and as a vapor) divided by the mass of the affected volume of soil, with the result converted to micrograms per kilogram. Unit weight of soil in each area from Radian (2000a).

[c/] Time to achieve ROD cleanup goals as projected by Radian (2000a). Cleanup goals are established for PCE and TCE in soil in terms of vapor-phase concentrations (Section 3.3).

[d/] ft^3 = cubic feet.

[e/] lbs = pounds.

[f/] µg/kg = micrograms per kilogram.

Based on soil-vapor concentration data collected during the 1998 CPT investigation, Radian (2000a) estimated that approximately 3.4 pounds of PCE and 1.8 pounds of TCE

mass remain in the vadose zone at DSERTS 66/Area 1 (Table 4.4). Considering the volume of soil at this site that is thought to be affected by PCE and TCE in the vadose zone, this is equivalent to an average concentration of 148 µ/kg of PCE, and 59 µg/kg of TCE remaining in vadose-zone soils at DSERTS 66/Area 1.

4.1.1.3 DSERTS 68/Area 3

The area at DSERTS 68/Area 3 within which the concentrations of COCs in soil-vapor exceeded the ROD-specified cleanup criteria for soil vapor encompassed an area 750 feet long by about 325 feet wide (Radian, 2000a). Detected concentrations of COCs in soil vapor extended from depths of about 5 feet bgs to a point just above the water table, at a depth of approximately 16 feet bgs. Three SVE circuits will be required to treat the large irregular area of contaminated soil at DSERTS 68/Area 3. The remedial design for this site calls for installation of 28 VMPs and 18 SVE wells on 3 extraction circuits (Table 4.1), with a design extraction-well flow rate of 15.5 scfm (Table 4.2). The design total vapor-extraction rate for the three circuits is slightly greater than 275 scfm, with influent concentrations of TCE at system startup estimated .to be 35,000 ppbv, and influent concentrations of PCE estimated to be 49,000 ppbv (Radian, 2000a, Appendix G). The total of direct and indirect capital costs for the SVE system at DSERTS 68/Area 3 was estimated (Radian, 1998a) to be approximately $241,500 (in 1998 dollars) (Table 4.3).

Based on soil-vapor concentration data collected during the 1998 CPT investigation, Radian (2000a) estimated that approximately 39.4 pounds of PCE and 24.7 pounds of TCE mass remain in the vadose zone at DSERTS 68/Area 3 (Table 4.4). Considering the volume of soil at DSERTS 68/Area 3 that is thought to be affected by PCE and TCE in the vadose zone, this is equivalent to an average concentration of 186 µg/kg of PCE, and 357 µg/kg of TCE remaining in vadose-zone soils at DSERTS 68/Area 3.

4.1.1.4 Vapor Treatment Unit and Operational Considerations

At each site proposed for SVE treatment, the multiple SVE well circuits will be connected to a single manifold, so that any or all of the circuits at a particular site can be operated using a single treatment unit (Radian, 2000a). The proposed treatment unit is trailer-mounted for mobility, and consists of a high-vacuum blower assembly, a moisture separator, a heat exchanger, and two GAC filtration units to remove VOCs from the effluent vapor stream prior to discharge to the atmosphere. The manifold valves were designed so that individual circuits can be cycled (periodically shut down for a period of time and then re-started).

In operation, the trailer-mounted blower and treatment system will be connected to the manifold at a particular site and placed in active service for a period of time ranging from 30 to about 60 days (Radian, 2000a). At the end of that period, the blower and treatment unit will be shut down, disconnected from the manifold, and transported to another SVE site, where the procedure will be repeated. Operating an SVE system in cycles can provide several benefits, including the option of incorporating small blower units and off-gas treatment systems into the design; lower energy costs, because the system is not in continuous operation; and capital cost savings, because a mobile unit, operated in cycles, can be used to service multiple sites. In addition, vapor-phase concentrations of COCs in the subsurface may increase during periods of system shut-down (the “rebound” effect).

This can result in higher VOC concentrations influent to the system during periods of operation, thereby improving system efficiency (Sterrett, 1993).

4.1.2 Projected SVE System Performance

Operational and cost factors considered during the evaluation of an operating SVE remediation system typically include (Johnson *et al.*, 1990a and 1990b; USEPA, 1994b):

- Current and historic concentrations of contaminants in extracted vapor;
- Current and historic rates of removal of contaminant mass;
- Changes in contaminant concentrations and mass-removal rate through time; and
- Total and incremental costs through time.

During the period that Parsons ES was conducting this RPO evaluation, the SVE systems at DDJC-Tracy had not yet been placed in service. Accordingly, it was not possible to apply standard techniques to the evaluation of the systems. Rather, several elements of the SVE system design were examined to assess whether the proposed systems address conditions at SWMU 1 and DSERTS 66 and DSERTS 68 to a degree adequate to achieve RAOs for vadose-zone soils. Design elements that were evaluated included source-area delineation and areas of influence of the SVE systems; projected effectiveness of emission controls; and projected cleanup times and cumulative costs.

4.1.2.1 Source-Area Delineation and Areas of Influence of SVE Systems

The site-specific ROI of individual VEWs is an important parameter in the design of an SVE system (Johnson *et al.*, 1990b; Sterrett, 1993). The *design ROI* is the maximum radial distance from a VEW, operating at its design vacuum and flow rate, at which a measurable pressure difference occurs, as a result of the well operation. Vapor and vapor-phase COCs in the subsurface within the ROI of the well are induced to move toward the operating well as a consequence of the pressure gradients existing within the volume encompassed by the ROI (the *zone of influence*).

In a typical SVE well field, extraction wells are installed within, and surrounding, the volume of soil contaminated with VOCs, and are located so that the volumes encompassed by the ROIs of individual wells overlap to some extent (Sterrett, 1993), and so that the entire volume of contaminated soil is contained within the composite zone of influence of the entire well field. In this situation, when the system is in operation, soil vapor at every point within the volume of contaminated soil will move toward a well under the influence of the pressure gradients induced by the extraction wells. As vapor moves through the volume of contaminated soil toward SVE wells, it is replaced by cleaner air moving at slow rates from surrounding, uncontaminated soil, and by air moving downward into the vadose zone from the atmosphere (Johnson, 1990b; USEPA, 1994b). An SVE well field is appropriately designed if measurable pressure gradients can be established throughout the entire volume of contaminated soil when the SVE system is in operation; and is optimized when this is achieved with the fewest number of wells, operating at the lowest total extraction rate.

Because of the limitations on remediation imposed by the ROI of SVE wells, adequate delineation of VOC sources and characterization of the extent of VOCs in the subsurface is a necessary precursor to the design of a successful SVE system. The extent of VOC contamination in the vadose zone at SWMU 1/Area 2, DSERTS 66/Area 1, and DSERTS 68/Area 3 has been evaluated during the course of several investigations (Montgomery Watson, 1996b; Radian, 2000a) by collection of soil samples from soil borings and CPT points and using soil-vapor sampling techniques (Section 2.3.1.1). The extent of PCE, as defined by the 780-ppbv PCE isoconcentration contour, and TCE, as defined by the 350-ppv TCE isoconcentration contour, appear to have been adequately characterized in soil vapor at SWMU 1/Area 2 (Radian, 2000a).

Characterization of the extent of PCE and TCE in the subsurface at DSERTS 66/Area 1 (Radian, 2000a) is less certain (in particular, south and east of Building 237), because of the spatial separation of the CPT soil-vapor sampling points (on the order of 50 feet), and because the results of earlier investigations (e.g., Montgomery Watson, 1996b) do not appear to have been integrated into the interpretation of existing VOC concentration data. The spatial separation of soil-vapor sampling points at DSERTS 66/Area 1 is approximately the same as the design ROI of SVE wells to be installed at the site (Table 4.2). If the extent of PCE and TCE in soil at DSERTS 66/Area 1 has not been sufficiently characterized, it is possible that some volume of soil, containing PCE or TCE at levels that exceed RAO concentrations, could remain unaffected by SVE remediation.

The extent of PCE and TCE in the subsurface at DSERTS 68/Area 3 (Radian, 2000a) also is uncertain (in particular, northeast of the facility boundary, in the vicinity of monitoring well LM032AU), because of the spatial separation of the CPT soil-vapor sampling points, which ranged to more than 100 feet, or nearly twice the design ROI of SVE wells to be installed at DSERTS 68/Area 3 (Table 4.2). Additional characterization of the extent of PCE and TCE in soil and groundwater at DSERTS 68/Area 3 was one of the objectives of field activities completed in conjunction with this RPO evaluation (Section 2.3.1.2).

Possible well-field configurations were examined at each of the three sites scheduled for remediation using SVE. Assuming that the extent of soil contamination has been adequately characterized at each site (as presented by Radian [2000a]), and that the design ROIs (Table 4.2) can be achieved, the well fields proposed appear to be adequate to induce vapor movement through the entire volumes of contaminated soil at each of the sites, on the basis of the criteria described above. The adequacy of site characterization, and the operational characteristics of the SVE well fields, should be assessed by periodic monitoring, once the systems are in operation.

4.1.2.2 Projected Effectiveness of Emission Controls

Vapor-phase emissions of VOCs from the SVE systems at DDJC-Tracy apparently cannot exceed a total mass of 2 pounds per day (lbs/day), in accordance with the requirements of SJVUAPCD Rule 2201, the ROD-specified ARAR dealing with allowable air emissions from the systems (Radian, 1998a). The requirements of Rule 4651, which regulates VOC emissions from soil decontamination activities, may not be applicable to SVE system operation at DDJC-Tracy because remediation of contaminated soil at sites affected by accidental spillage of less than 42 gallons of liquids containing VOCs is exempt under the rule. A total mass of about 44 pounds of PCE and 28 pounds

of TCE is estimated to remain in vadose-zone soils at the three DDJC-Tracy sites (Table 4.4). Using the densities of PCE and TCE (1.464 grams per cubic centimeter [g/cm^3] and 1.623 g/cm^3, respectively; Table C.1, Appendix C), the total volumes of PCE and TCE in the vadose zone at the three SVE sites are estimated to be about 3.3 gallons and 2.3 gallons, respectively. Accordingly, the requirements of Rule 4651 do not appear to apply to SVE remediation activities at DDJC-Tracy.

The maximum rate of vapor-phase COC mass removal projected to occur at any of the SVE sites is about 7 lbs/day, which may be realized during the initial system startup and prove-out period for Circuit No. 1 at DSERTS 68/Area 3. The GAC treatment system is projected in design documents (Radian, 2000a, Appendix G) to be capable of removing 90 percent of influent COC mass from the vapor stream, prior to discharge to the atmosphere. During system operation, elevated humidity in the extracted soil vapor may reduce the projected removal efficiencies, because water vapor in soil vapor will interfere with the sorptive capacity of the carbon (USEPA, 1994b). Nevertheless, in the worst case (Circuit No. 1 at DSERTS 68/Area 3), probably less than 1 lb/day of COC mass will be discharged to the atmosphere. Discharges to the atmosphere from all other locations will probably not exceed 0.2 lb/day of vapor-phase COC mass. Therefore, treatment of the effluent vapor stream using GAC filters should result in acceptable levels of COC emissions from the SVE systems.

In fact, after system prove-out and the initial phase of operations, the concentrations of vapor-phase COCs in the vapor stream are expected to decline rapidly, and direct discharge of untreated vapor-phase effluent from all three circuits at DSERTS 68/Area 3 operating simultaneously probably would not introduce more than 2 lbs/day of COC mass to the atmosphere. Because the SVE blower and treatment system has been designed to operate at only a single site at any given time, discharge from DSERTS 68/Area 3 represents the maximum amount of COC mass that could be introduced to the atmosphere during SVE operations at DDJC-Tracy. Therefore, GAC treatment of extracted soil vapor may not be necessary, following system prove-out and initial operation. This possibility could be evaluated during the prove-out period for the SVE systems, by periodically collecting and analyzing samples of the extracted vapor from the influent line to the treatment system.

As a GAC treatment system is used, the VOC removal efficiency of the activated carbon gradually decreases, as volatile chemicals sorb to the carbon (USEPA, 1994b). After some period of operation, the GAC must be replaced or regenerated to restore its ability to remove VOCs from the vapor stream. The trailer-mounted SVE blower and treatment system is designed to incorporate twin GAC canisters, each containing 400 pounds of activated carbon (Radian, 2000a). Using estimates of VOC mass loading in the vapor streams influent to the GAC canisters, Radian (2000a, Appendix G) calculated the length of time that a single GAC canister could remain in service at each SVE site before requiring replacement/regeneration. A single carbon canister can be used for a period of 77 days in the SVE system at SWMU 1/Area 2, 38 days in the SVE system at DSERTS 66/Area 1, or 8 days in the SVE system at DSERTS 68/Area 3.

4.1.2.3 Projected Cleanup Times and Cumulative Costs

In conjunction with system design, Radian (2000a) estimated ranges of time that might be required to achieve RAOs for soil vapor at each of the SVE sites. Radian (2000a)

calculated a travel time for movement of vapor through a distance equal to the radius of influence of an individual SVE well to estimate a pore-volume exchange rate at each site, and then assumed that movement of between 50 and 200 pore volumes of air through the affected areas would be required to achieve soil-vapor RAOs. On the basis of these calculations, Radian (2000a) estimated that a period of time ranging from 179 days to 714 days would be required to achieve RAOs for soil vapor at SWMU 1/Area 2; 76 days to 304 days would be required to achieve RAOs for soil vapor at DSERTS 66/Area 1; and 268 days to 1,071 days would be required to achieve RAOs for soil vapor at DSERTS 68/Area 3 (Table 4.4). If these projections are accurate, and if GAC treatment of extracted vapor is necessary, the GAC canisters used in the SVE vapor-treatment system will require replacement/regeneration from at least twice (DSERTS 66/Area 1) to possibly more than 130 times (DSERTS 68/Area 3). Commercial GAC currently costs approximately $2 per pound (or about $800 for each 400-pound canister). This suggests that GAC treatment costs may represent a significant part of long-term operations costs, if the SVE systems remain operational for long periods of time (Table 4.3).

Based on experience in designing, installing, and operating numerous SVE systems, Parsons ES estimates that annual OM&M costs (excluding GAC) for the three SVE sites would be approximately $24,000 (or $8,000 per site, if the total OM&M costs are evenly prorated equally among the three sites). The total cost required to achieve RAOs for soil at each site is the sum of the direct and indirect capital costs of system installation at the site, together with the OM&M and GAC costs through the period required for system operation. If the projected lengths of the time periods required to achieve RAOs are correct, then the total costs of SVE remediation are estimated to range from about $143,000 (DSERTS 66/Area 2) to more than $370,000 (SWMU 1/Area 2) (Table 4.3). These correspond to costs per pound of COC (TCE + PCE) removed from the vadose zone ranging from about $4,300 (DSERTS 68/Area 3) to more than $100,000 (SWMU 1/Area 2). The excessive unit cost for SVE remediation at SWMU 1/Area 2 is a consequence of the significant capital cost of the system ($266,100) and the low COC mass (less than 3 pounds of total CAH in soil at the site).

The technique of using calculated vapor travel times and pore-volume exchange rates to estimate the length of time required to achieve RAOs at each site apparently relied on an assumption that soil in the vadose zone approximately comprises a homogeneous porous medium (Radian, 2000a, Appendix G). Actual SVE sites are not so ideal, and in field situations, a contaminant may become trapped within fine-grained, low-permeability materials that are surrounded by sandy soils of higher permeability. In this situation, induced vapor flow moves around the lower-permeability contaminated zone, and the venting mass-removal rate becomes limited by the rate of vapor-phase chemical diffusion from the low-permeability zone into the moving vapor stream (Johnson *et al.*, 1990a). Mass removal from heterogeneous materials of varying permeability is therefore nearly always slower than the rate of mass removal from homogeneous, permeable materials, and is expressed in terms of venting efficiency (the ratio of the rate of mass removal from a heterogeneous system to the rate of mass removal from a homogeneous system).

Soils in the subsurface at DDJC-Tracy are heterogeneous, and consist of relatively permeable zones of sandy (occasionally gravelly) layers, interbedded with lower-permeability silt and clay strata (Section 2.2.2). Therefore, rates of venting mass removal probably will rapidly become limited by the rate of chemical diffusion, and it is unlikely that RAOs for soil will be achieved within the time periods predicted (Table 4.4).

Analytical methods developed by Johnson *et al.* (1990a) were used, together with the chemical properties of PCE and TCE, and site-specific soil properties, to estimate the venting efficiencies that might be achieved at each of the three SVE sites. Estimated venting efficiencies ranged from about 1 percent (for PCE at SWMU 1/Area 2) to about 6 percent (for TCE at DSERTS 68/Area 3). This suggests that the periods of time required to achieve RAOs for soil at DDJC-Tracy could be anywhere from 17 to 100 times longer than have been estimated using the assumption that soil at DDJC-Tracy is a homogeneous porous medium (Radian, 2000a). The OM&M costs, GAC costs, and total costs for SVE remediation also would be correspondingly greater.

4.1.3 Potential System Enhancements and Associated Cost Savings

As is apparent from the preceding discussion, some degree of uncertainty is associated with aspects of the design and operation of SVE systems to remediate soil at DDJC-Tracy. In particular, the degree to which COC mass removal may be limited by vapor-phase chemical diffusion will not be known until the SVE systems have been in operation for some time. Accordingly, current projections regarding the length of time required to achieve RAOs for volatile COCs in soil must be regarded as speculative.

Nevertheless, the RPO evaluation of the SVE systems planned for installation at DDJC-Tracy has identified several elements of system design and operation that may enable the systems to be operated more effectively, more cost-effectively, or more efficiently. Design and operational elements that could be altered to enhance the effectiveness of the SVE systems are associated with source-area delineation and adjustments to SVE well locations; emission controls; and implementation of passive soil venting to supplement active SVE treatment. Additional efficiencies could be realized if the recommended system enhancements were to be implemented in conjunction with regulatory changes to the RAOs for CAH in soil vapor, described in Section 3.3. Although not all the beneficial effects of SVE system enhancement can be quantified, their implementation should result in reduced OM&M costs, a decrease in the time required to achieve RAOs for CAH in soil, or both. Any reduction in the operational life of the SVE systems, in turn, is likely to generate cost savings.

4.1.3.1 Source Area Delineation and SVE Well Locations

Adoption of alternative, site-specific RAOs for concentrations of CAH in the ranges of 870 to 940 ppbv for PCE and 590 to 640 ppbv for TCE in soil vapor (see Section 3.3) would reduce the volumes of soil requiring SVE remediation at each of the three SVE sites. In conjunction with additional characterization of COC source areas, this could enable those limited volumes of soil containing COCs at concentrations representing a potential threat to groundwater to be delineated. These soil hot spots could then be targeted for SVE remediation, which probably could be accomplished using systems smaller than those currently designed.

For example, Parsons ES estimates that adoption of alternative, site-specific RAOs for PCE and TCE in soil vapor (940 ppbv and 640 ppbv, respectively; Table 3.4) at SWMU 1/Area 2 would reduce the volume of soil requiring remediation to an extent that a 5-well system, rather than the current 7-well design, would be adequate to achieve RAOs. Lower capital costs would be required to install the smaller system, and lower OM&M costs would be associated with its operation. If the estimated total direct and indirect

capital costs for a 7-well system at SWMU 1/Area 2 ($266,100; Table 4.3) are prorated for a 5-well system, the total direct and indirect capital costs for the 5-well system are estimated to be about $190,000. This represents a capital cost savings of about $76,000 over the 7-well system.

Similarly, if site-specific RAOs for PCE and TCE in soil vapor (870 ppbv and 590 ppbv, respectively; Table 3.4) were to be adopted at DSERTS 66/Area 1, a 5-well system, rather than the current 8-well design, may be adequate to achieve RAOs. Installation of a smaller system at DSERTS 66/Area 1 could result in capital cost savings on the order of $52,000. Adoption of site-specific RAOs for PCE and TCE in soil vapor (910 ppbv and 620 ppbv, respectively) at DSERTS 68/Area 3 might also enable a smaller SVE system to be installed and operated. However, because the extent of PCE and TCE in the subsurface at DSERTS 68/Area 3 is uncertain (Section 4.1.2.1), the design characteristics of an SVE system that would be adequate to achieve RAOs for CAH in soil vapor at this site are unknown.

4.1.3.2 Emission Controls

The daily maximum COC mass discharge allowed under SJVUAPCD regulations is 2 lbs/day. The results of influent vapor-stream loading calculations completed by Radian (2000a, Appendix G) indicate that during system prove-out and initial operations, the SVE system operating at DSERTS 68/Area 3 (the site with the highest anticipated COC concentrations in extracted vapors) could produce a maximum of about 7 lbs/day of vapor-phase COC mass. Therefore, treatment of extracted vapors using GAC may be necessary during the early phase of system operations. However, as COC concentrations are expected to quickly decline following SVE startup at all three sites, it may be possible to eliminate treatment of extracted vapors after some initial period of system operation. Once SVE monitoring data indicate that the VOC mass in the treatment-system influent vapor streams is less than the allowed 2 lbs/day at each site, direct discharge of untreated vapor-phase effluent from SVE operations at DDJC-Tracy would be acceptable under the APCD regulations, and the GAC treatment system could be removed from the SVE blower unit. This possibility should be evaluated during the prove-out period for the SVE systems by collecting and analyzing samples of the extracted vapors at each site from the influent lines to the treatment system.

Once COC vapor concentrations fall within regulatory emissions requirements, elimination of GAC treatment of the SVE vapor effluent stream could generate substantial cost savings over the operational life of the SVE systems. Assuming that the systems will operate at the three sites through the longer operational periods projected by Radian (2000a) (714 days at SWMU 1, 304 days at DSERTS 66, and 1,071 days at DSERTS 68), elimination of GAC treatment could result in total cost savings of more than $120,000 (Table 4.3, Column 5).

4.1.3.3 Passive Soil Venting

SVE systems at DDJC-Tracy are planned to be operated in cycles, so that the trailer-mounted SVE blower and treatment system will be active at only one of the three SVE sites at any given time. This method of operation presents an opportunity to implement passive SVE treatment technology at the two inactive SVE sites, concurrent with active SVE treatment proceeding at the other site.

Theory of Passive Venting Treatment Process

All venting systems rely on the preferential partitioning (as indicated by the Henry's Law constant; Lyman *et al.*, 1990) of VOCs to the vapor phase from the dissolved or solid phases (in soil water or adsorbed to soil particles). Active venting systems require that air be moved through soil, *in situ* or *ex situ*, by means of fans or blowers, connected to wells or vent lines (Brown *et al.*, 1991; Gross *et al*, 1992; Johnson *et al.*, 1990a and 1990b). Passive systems, in contrast, utilize pressure differences between interstitial air/vapor in soil pore spaces, and the atmosphere, to induce a flow of air and vapor from soil into the vent wells or lines, which discharge to the atmosphere. Because removal of vapor-phase chemicals from soil pore spaces increases the chemical concentration gradient between the sorbed and vapor-phase chemicals, this will promote the further partitioning of chemicals from the adsorbed phase to the vapor phase, with subsequent removal via the venting process (Gross *et al.*, 1992).

Alternatively, if atmospheric pressure exceeds the interstitial vapor/air pressure in the soil pore spaces, fresh air will move from the atmosphere into the soil, diluting chemicals in the vapor phase and causing additional partitioning of chemicals from the sorbed to the vapor phase (again as a consequence of the increased chemical concentration gradients), for subsequent flushing from the system (Rossabi *et al.*, 1993; Weeks, 1994). In addition, if the volume of contaminated soil is covered by an impermeable membrane (e.g., asphalt pavement), the removal efficiency of the venting system should be enhanced (Peters *et al.*, 1994).

Conceptual Implementation of Passive Soil Venting at DDJC-Tracy

Successful volatilization of chemicals from soil depends primarily on the properties of the chemicals to be removed, and to a lesser extent on the grain size, mineralogy, air permeability, and moisture content of the soil (Lyman *et al.*, 1990; Johnson *et al.*, 1990). The COCs in soil at DDJC-Tracy (PCE and TCE) have relatively low boiling points (190 degrees Fahrenheit [°F] for TCE, and 250°F for PCE) (Montgomery and Welkom, 1990) and relatively high Henry's Law constants (0.009 atmosphere–cubic meters per mole [atm-m^3/mol] for TCE, and 0.027 atm-m^3/mol for PCE; Appendix C, Table C.1), indicating that active or passive venting techniques can be successful in removing these chemicals from the vadose zone. In fact, passive venting techniques have been used successfully to remove PCE and TCE from soils similar in character to the soils at DDJC-Tracy (Sulborski *et al.*, in press).

Analytical methods developed by Johnson *et al.* (1990a) were used to estimate the vapor-flow rates and resulting mass-removal rate if the proposed SVE systems were to be used for passive venting during inactive periods. Using the properties of the VOCs in soil (PCE and TCE), and the properties of the soils at the three sites, Parsons calculated that if a differential pressure of only 0.005 atm were established between the atmosphere and interstitial air in soil within the vadose zone, a flow rate of approximately 1.5 scfm per well, or greater, would be produced (compare with design flow rates of active SVE wells ranging from about 15 to 19 scfm; Table 4.2). This corresponds to a vapor-flow velocity of approximately 0.003 feet per minute at a radius of 10 feet from the well, as compared with vapor-flow velocities of about 0.03 feet per minute estimated for the current well designs.

Under optimum conditions, the VOC mass removal rate is approximately proportional to the vapor-flow velocity induced by the well (Johnson *et al.*, 1990a). Thus, the mass removal rate of a continuously-operating passive SVE system would be approximately one-tenth the mass removal rate of a continuously-operating active SVE system. However, if the active SVE systems, as designed, were to be modified to allow passive venting to occur during inactive periods, mass removal would continue even though the system was not in active operation, and the length of time required to achieve RAOs in soil at the three sites could be reduced, perhaps by as much as 10 percent. Assuming that the systems would be in active operation at the three sites through the longer operational periods projected by Radian (2000a) (714 days at SWMU 1, 304 days at DSERTS 66, and 1,071 days at DSERTS 68), a 10 percent reduction in operational time that might occur as a consequence of implementing passive venting could result in a 10-percent cost savings for OM&M (about $5,000; Table 4.3, Columns 3 and 4). If GAC treatment of the vapor stream effluent from active SVE systems is not eliminated, a 10-percent reduction in operational time for the active SVE systems would also generate substantial savings in GAC costs (about $12,000).

Only minor modifications would be required to adapt the SVE systems for periodic use as passive venting systems. During periods of inactivity at an SVE site, a valve or vent in the manifold, or at individual wellheads, could be left open to the atmosphere, thereby allowing free exchange of air and vapor between the atmosphere and the SVE well system. A modification of this type could be implemented at little or no additional cost. However, because manifolds are installed below grade at the three DDJC-Tracy sites, piping modifications would be required to ensure that vapors are not vented into subgrade vaults. Assuming above-grade discharge, treatment of the passively extracted effluent vapor stream would not be necessary, because VOC mass discharge from a passive venting system to the atmosphere would be much less than mass discharge from an active SVE system, and would be considerably less than the 2-pound daily maximum mass of COCs allowed by SJVUAPCD regulations (Section 4.1.2.2).

Because it is not possible to calculate the rate of additional mass removal that would results from implementation of a passive-venting remediation strategy, the potential cost savings associated with passive venting cannot be quantified. However, any enhancement to the SVE remediation systems that reduces the length of time required to achieve RAOs will have associated cost savings.

4.2 EVALUATION OF GROUNDWATER REMEDIAL SYSTEM

This section describes the groundwater ETI system operating at DDJC-Tracy and, based on FY99 operating data, assesses the performance of the extraction wells, treatment systems, and infiltration system. The effectiveness of the system to date is reviewed, opportunities for optimization are developed, and potential cost savings are examined.

4.2.1 Current Groundwater ETI System Operations

Montgomery Watson began operating a five-well IRM system in November 1992. After several system modifications, an expanded IRM treatment system was designated as Treatment Plant 1 (TP-1). Operation of the integrated, full-scale, 1,300-gpm ETI system (TP-I and TP-2) began in November 1998, when TP-2 was brought on line. The layout of the full-scale groundwater ETI system, as configured in 1999, is shown on

Figure 1.4 (Radian, 1999a). The system has yet to attain steady-state operating conditions.

TP-1 includes a single, packed-column, air stripper having a capacity of 500 gpm, and currently is configured to receive flow from 15 extraction wells (EW001AU through EW012AU, EW033AU, EW035AU, and EW037AU), having a combined design pumping capacity of 410 gpm (Radian, 2000c). As indicated in Table 4.5, four of the TP-1 wells (EW001AU, EW033AU, EW035AU, and EW037AU) have never been operational. Of these, EW001AU has been recommended for abandonment, and a sixteenth well, EW036AU, was abandoned in August 1999 (Radian, 2000c). Seven of the operational TP-1 wells are screened in the Above Upper (AU)/Upper horizons, three are screened in the Upper (A) horizon, and one is screened in the Middle (B) horizon (Radian, 2000c). Well EW005AUA is screened in two discrete intervals of the Above Upper/Upper horizons. Two infiltration galleries (IG-1 and CD-1) receive TP-1 effluent. The locations of TP-1 and its associated infiltration galleries and extraction wells are shown on Figure 1.4. From October 1, 1998 through September 30, 1999 (fiscal year 1999 [FY99]), 9 of the 11 operational extraction wells were operated at an average combined pumping rate of 162 gpm (Table 4.5). In addition to the four wells that have never been in service, wells EW005AUA and EW009BA were inactive during FY99, and EW007A and EW009B were inactive during FY00 (Table 4.5).

TP-2, located on the Tracy Annex (Figure 1.4), includes a single, packed-column 800-gpm air stripper that currently treats water extracted from 20 wells having a combined design pumping capacity of 617 gpm (Table 4.5). As indicated in Table 4.5, two TP-2 wells are screened in the Above Upper horizon, nine are screened in the Upper horizon, six are screened in the Middle horizon, and three are screened in the Lower horizon. Twelve TP-2 wells (EW015A through EW022A, EW024B, EW029B, EW030C and EW031C) each have two separate screened intervals within the indicated horizons (Radian, 2000c). All 20 TP-2 extraction wells were operational during FY99, though several experienced shutdowns during FY00 (Table 4.5). Treated TP-2 effluent is discharged to eight infiltration galleries, five (IG-2 through IG-6) along the southeastern Annex boundary, and three (IG-7 through IG-9) in the northwestern part of the Annex. The TP-2 system layout is shown on Figure 1.4.

In addition to the TPs, which treat groundwater contaminated with VOCs, four extraction wells located in areas with pesticide contamination also have liquid-phase GAC canisters installed at the wellhead to remove pesticides before water is routed to the air strippers. GAC treatment units currently are mounted at wells EW002AU and EW005AU, which are tied into TP-1, and EW021A and EW022A, which are tied into TP-2. Wellhead GAC treatment at five new extraction wells (EW040AU through EW044AU) was scheduled to begin during 2001. However, results of recent pump tests at some of these wells suggest that they may need to be redesigned to be effective for mass removal of dieldrin.

Average annual groundwater extraction rates per well for FY97 through FY00 are presented in Table 4.5. Total average annual flow rates to TP-1 and TP-2 in FY99 were 162 and 528 gpm, respectively (Kvaerner Environmental, 1998j, 1999a through 1999k). For FY00, average flow rates of 84 gpm (TP-1) and 275 gpm (TP-2) were estimated based on performance data available for the first 11 months of the fiscal year (Kvaerner Environmental, 1999l; Radian, 2000g through 2000p).

TABLE 4.5
AVERAGE ANNUAL GROUNDWATER EXTRACTION RATES (FY97 - FY00)
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

TP-1 Average Extraction Rates (gallons per minute)[a/]

Flow Basis	EW001AU[b/]	EW002AU	EW003A	EW004AU	EW005AU	EW006AU	EW007A	EW008A	EW009B	EW010AU	EW011AU	EW012AU	EW033AU[b/]	EW035AU[b/]	EW037AU[b/]	TP-1
Design Rate [c/]	NA [d/]	40	25	25	40	40	40	40	40	40	40	40	NA	NA	NA	410
FY97 [e/]	0	35	26	0	0	34	16	18	30	0	19	36	0	0	0	214 [f/]
FY98	0	50	32	0	0	45	17	18	0	0	28	29	0	0	0	219
FY99	0	31	23	7	0	28	3	5	0	8	3	54	0	0	0	162
FY00	0	14	3	23	3	3	0	13	0	1	8	16	0	0	0	84 [g/]

TP-2 Average Extraction Rates (gallons per minute)[a/]

Flow Basis	EW013C	EW014A	EW015A	EW016A	EW017A	EW018A	EW019A	EW020A	EW021A	EW022A	EW024B	EW025B	EW026B	EW027B	EW028B	EW029B	EW030C	EW031C	EW032AU	EW034AU	TP-2
Design Rate [c/]	40	40	40	40	40	40	40	40	40	10	9	8.5	40	40	40	40	40	19.5	5	5	617
FY99	46	13	26	53	64	17	52	33	11	2	4	2	37	41	57	21	22	6	7	14	528 [h/]
FY00	33	2	4	29	25	14	31	19	1	1	5	1	32	8	35	14	4	2	10	5	275 [g/]

[a/] Extraction rates presented in this table are based on data presented in groundwater treatment plant monthly performance monitoring reports (Kvaerner Davy, 1997a-1997h; Kvaerner Environmental, 1998a-1998j and 1999a-1999l; Radian, 2000h-2000o).

[b/] TP-1 wells EW001AU, EW033AU, EW035AU, and EW037AU have never been operational. TP-1 well EW036AU never operated and was abandoned in 1999; therefore, this well is excluded from the table.

[c/] Design flow rates are the planned discharge rates (Radian, 2000c).

[d/] NA = not available.

[e/] FY = fiscal year. FYs run from October 1st thru September 30th of the following year.

[f/] FY97 average extraction rate is extrapolated for the 12-month fiscal year based on TP-1 data collected from January 1997 through September 1997.

[g/] FY00 average extraction rate is extrapolated for the 12-month fiscal year based on data collected from October 1999 through August 2000.

[h/] FY99 average extraction rate is extrapolated for the 12-month fiscal year based on TP-2 data collected from November 1998 through September 1999.

4.2.2 Extraction System Assessment

The effectiveness of the groundwater ETI systems at OU1, and of the individual extraction wells in the TP-1 and TP-2 systems, was evaluated in terms of the two complementary RAOs specified in the RODs (WCC, 1993; Montgomery Watson, 1996a; Radian, 1998a): 1) COC mass removal (as represented by PCE and TCE) to ROD-specified ACLs, and 2) plume containment (see Section 3.1).

The ETI system has experienced numerous operational problems since startup. System shutdowns have been attributed to maintenance (e.g., filter replacement and de-scaling), power outages, training, mechanical problems (e.g., frozen lines and pump replacements), effluent discharge capacity constraints, and computer communication system failures (Parsons ES, 2000a). Extended shutdown periods have been recorded for extraction wells EW004AU, EW005AUA, EW008A, EW009B, EW010AU, and EW011AU due to mechanical problems (Kvaerner Davy, 1997a through 1997h; Kvaerner Environmental, 1998a through 1998j, and 1999a through 1999l). Wells EW001AU (recommended for abandonment) and EW036AU (abandoned in 1999) are permanently out of service, and wells EW033AU, EW035AU, and EW037AU have never been operated (Table 4.5). Because the ETI system is not fully operational, results of this evaluation should be considered preliminary for the system as a whole, and for partially operational extraction wells.

4.2.2.1 Extraction System Operating Efficiency

Because of continuing mechanical and system problems, periods of operation for the extraction wells were less than optimal during FY99, as indicated in Table 4.5. Of the 9 TP-1 wells that were operated during that period, 7 wells operated 37 percent of the time or less (EW002AU, EW003, EW004AU, EW006AU, EW007A, EW008A, and EW011AU), 1 well operated 54 percent of the time (EW010AU), and 1 well operated 90 percent of the time (EW012AU). During FY99, 8 of the 20 TP-2 extractions wells operated more than 90 percent of the time (EW013C, EW014A, EW015A, EW016A, EW017A, EW019A, EW028B, and EW029B), 5 wells operated 65 to 77 percent of the time (EW018A, EW020A, EW021A, EW026B, and EW034AU), 4 wells were operational 40 to 60 percent of the time (EW024B, EW027B, EW030C, and EW032AU), and 3 wells (EW022A, EW025B, and EW031C) operated less than 32 percent of the time (Kvaerner Environmental, 1998j and 1999a through 1999k).

A similar performance pattern was observed from October 1999 through August 2000 (Kvaerner Environmental, 1999l; Radian, 2000g through 2000p). TP-1 wells EW003AU and EW006AU were out of service for 4 to 6 months, well EW010AU was out of service for 9 months, and wells EW007A and EW009B were not operated at all. Several TP-2 wells also were out of service during the first 11 months of FY00: wells EW015A, EW022A, EW025B (for 5 months); EW032AU and EW034AU (for 1 month); and EW014A, EW021A, EW027B, EW030C, and EW031C (for 10 of the 11 months). The average pumping rates achieved during FY00 reflect extraction efficiencies of less than 20 percent of the planned pumping rates for TP-1, and no more than 45 percent for TP-2 (Table 4.5). Reduced pumping efficiencies adversely affect estimates of the time required to achieve ROD ACLs for OU1 COCs, and imply increased OM&M costs to service wells that are experiencing shut downs.

4.2.2.2 Treatment Plant Utilization

Extraction system inefficiencies also directly impact treatment plant operating efficiencies. The total average FY99 influent flow rates were 162 gpm for the TP-1 extraction system and 528 gpm for TP-2 (Table 4.5). For that performance period, TP-1 operated at about 32 percent of its 500-gpm treatment capacity, and TP-2 operated at about 66 percent of its 800-gpm capacity. Integrated treatment system efficiency was about 53 percent during FY99.

Average influent flow rates from TP-1 and TP-2 extraction wells during FY00 were estimated using the 11 months of data available for this RPO evaluation. TP-1 and TP-2 average influent flows were estimated at 84 gpm and 275 gpm, respectively (Table 4.5). These flow rates are equivalent to about 17-percent (TP-1) and 34-percent (TP-2) utilization (relative to design capacities), or about 28-percent utilization for the integrated OU1 system. The effectiveness of the treatment plants for removing VOCs is evaluated in Section 4.2.3.

4.2.2.3 Plume Capture

The groundwater ETI system was designed to remove COC mass and, in concert with hydraulic barriers formed near the northern and southern infiltration galleries, to limit further plume migration. Results of qualitative capture-zone analyses performed by Radian (2000c) were reviewed to evaluate plume capture and hydraulic control for selected extraction wells. As specified in the ROD, the extraction well system was designed to remediate contaminant hot spots, attain ACLs throughout OU1, and minimize plume migration and contaminant transport off-Depot/Annex.

Based on extraction well locations relative to COC plumes, emphasis has been placed on remediating hot spots near former source areas on the Depot and in the western parts of the Annex, and on limiting plume migration along the northwestern Depot boundary and along Banta Road (Figures 1.4 and 2.15 through 2.19). Review of historical contaminant concentration data for wells near source-area hot spots suggest that the extraction system has been generally effective at reducing contaminant concentrations in targeted source areas (e.g., see Figures 2.15 through 2.18). However, the current well/screen configurations are not particularly effective for capturing the COC plumes downgradient from the on-Depot source areas.

Although the active extraction wells located along the northern boundary of DDJC-Tracy (wells EW002AU through EW009B, Figure 1.4) may be containing the portions of the westernmost CAH plumes that remain on the Depot, these PCE and TCE plumes had already migrated onto the Annex by the time these wells were installed (Figure 2.15). To contain the parts of the plumes beneath the Annex, emphasis should be placed on the extraction wells located near the leading edge of the westernmost plume (i.e., wells EW021A, EW026B, and EW030C).

The extraction wells along Banta Road (wells EW014A through EW020A, EW024B, and EW025B) are intended to intercept COCs migrating toward the eastern Annex boundary, and to limit migration of contaminants onto private land to the east. Because characterization of COCs in groundwater east of Banta Road is incomplete, and because the TP-2 extraction wells in this area have not been pumping for an extended period of

time, the effectiveness of these wells for plume containment is unclear. However, the northern wells (EW014A through EW018A, Figure 1.4) are located outside (north of) the observed TCE plume as defined by concentrations at or above the ACL (Figure 2.18). Based on this observation, operation of the more southerly wells (EW019A, EW020A, EW024B, and EW025B) may be relatively more important for containing the dissolved CAH plume on the Annex than the northern wells.

These observations are reflected in the results of Radian's (2000c) capture-zone analyses for 3Q99. Plume capture of the westernmost TCE (Figure 2.10) plume ranged from 70 to 100 percent from the Above Upper horizon through the Lower horizon. Capture of the eastern TCE plume (as interpreted on Figure 2.10) ranged from no capture in the Middle horizon to about 73 percent in the Upper horizon (Radian, 2000c). Similar capture patterns apply for the PCE plume (Figure 2.11).

Radian's (2000c) capture-zone analysis results indicate that neither the western nor eastern TCE plume (Figure 2.10) is being fully captured in the upper saturated zones, either on the Depot or beneath the Annex. Figures 2.18 and 2.19 suggest that COC plumes at concentrations greater than the ACLs extend downgradient from extraction wells located along the northern Depot boundary, in the Annex, and east of Banta Road. The observed plume-capture patterns can be attributed to a combination of incomplete characterization of the leading edges of the PCE/TCE plume originating at DSERTS 68 and the TCE plume present east of Banta Road (see Section 2.3); ineffective extraction well placement; and inefficient extraction system operations.

An assessment of the consequences of incomplete plume capture over time in terms of plume stability, expansion onto private land, or contraction cannot be undertaken because the leading edges of the easternmost COC plumes have not been delineated or monitored. For example, because historical data for dissolved TCE east of Banta Road, and characterization of the leading edge of this "plume," are incomplete, it is not possible to determine if TCE is migrating off-Annex in this area, or if contamination present east of the Annex pre-dates the 1998 startup of the extraction wells along Banta Road (either through migration from DDJC-Tracy sources or releases from an off-Depot source).

The effectiveness of the hydraulic barriers to plume migration, which were designed to be created by infiltration of treated groundwater at the northern and southern IGs (Figure 1.4), is unclear. Plume interpretations through time (e.g., Figures 2.10 and 2.11) suggest that the COC plumes have not migrated close enough to the IGs to be significantly affected by changes in the potentiometric groundwater surface induced by groundwater injection. Moreover, the poor and temporally erratic performance of the IGs, and their short period of operation, preclude assessment of the potential for plume containment/deflection as a result of changes in hydraulic gradients near the IGs (see Section 4.2.4).

Based on available data, progress toward achieving the plume-containment RAO cannot be evaluated downgradient from the Annex, and the effects of the ETI system on continued COC migration are unclear. However, because the ESD to the OU1 ROD allows for remediation by natural attenuation of portions of the TCE plume that extend east of Banta Road (Montgomery Watson, 1996a), it can be inferred that the containment RAO is being achieved if on-Annex contamination is no longer contributing to off-Annex TCE contamination. Therefore, the focus of future capture-zone analyses over the near

term will be most productive for extraction wells within the remaining hot spots, where "capture" translates into meaningful mass-removal rates and measurable improvements in groundwater quality; at the leading edge of the westernmost CAH plume; and at the eastern Annex boundary where COC concentrations exceed the ACLs. Analysis of plume capture by existing wells along the northern Depot boundary likely will not provide useful information for assessing ROD compliance, as the plumes extend beyond this point, and COC concentrations at these wells are declining. An exception occurs in the vicinity of DSERTS 68 (Area 3), where PCE and TCE concentrations at the source are high, and where the core of the plume may remain on the Depot. Currently there is no extraction well at this source area, and well EW034AU appears to be capturing only a portion of the downgradient extension of this plume (Figure 2.12).

4.2.2.4 COC Mass-Removal Rates

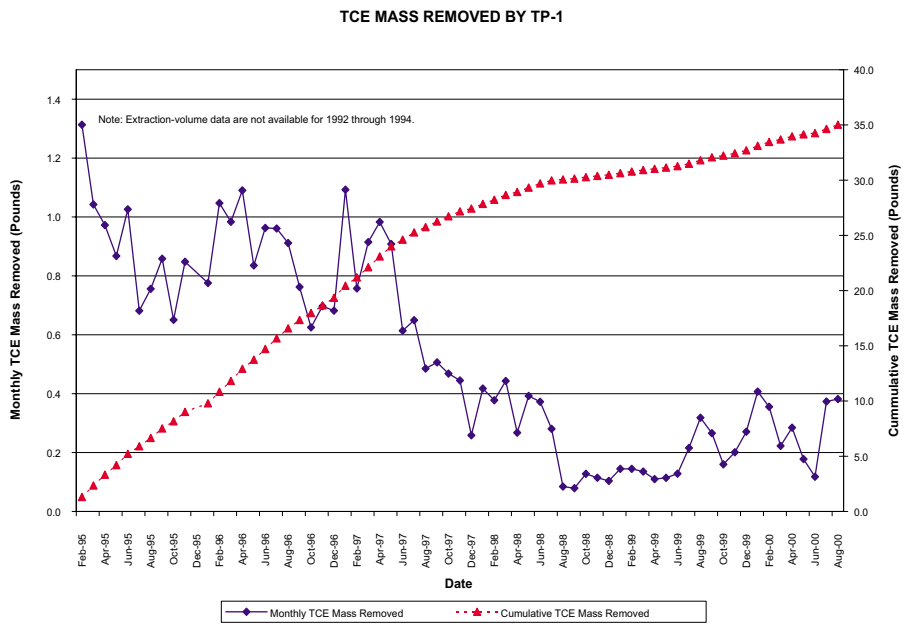
TCE, PCE, and total VOC mass-removal rates from February 1995 through August 2000 were calculated as part of this RPO evaluation. TP-1 and TP-2 mass-removal rates were estimated based on monthly groundwater influent concentrations and groundwater extraction data for each plant. Removal rates for the period from IRM system startup in 1992 through January 1995 could not be calculated directly because extraction-volume data for the IRM (TP-1) were not available. Therefore, removal rates for this time period were extrapolated from available data, as explained below.

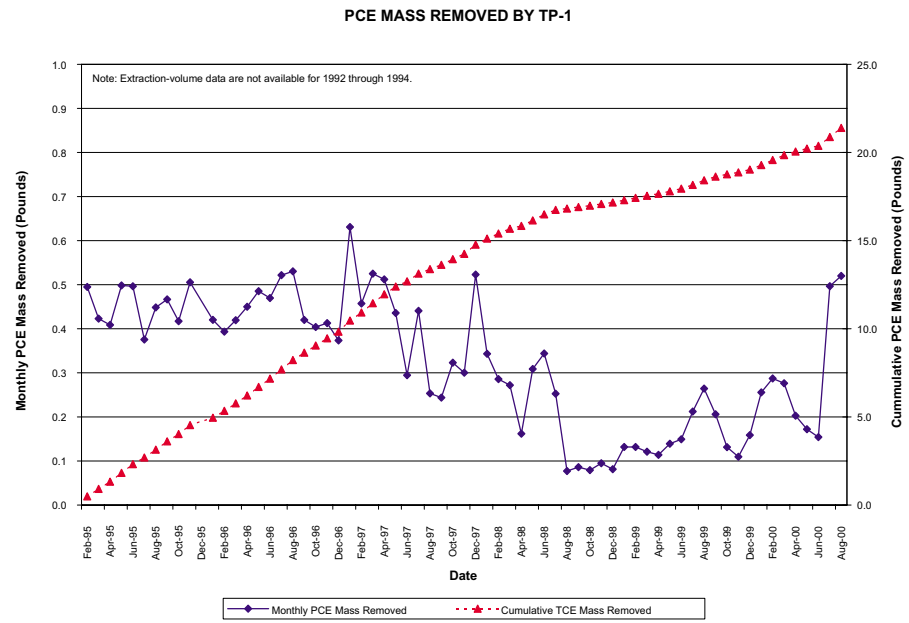
TP-1 Mass Removal

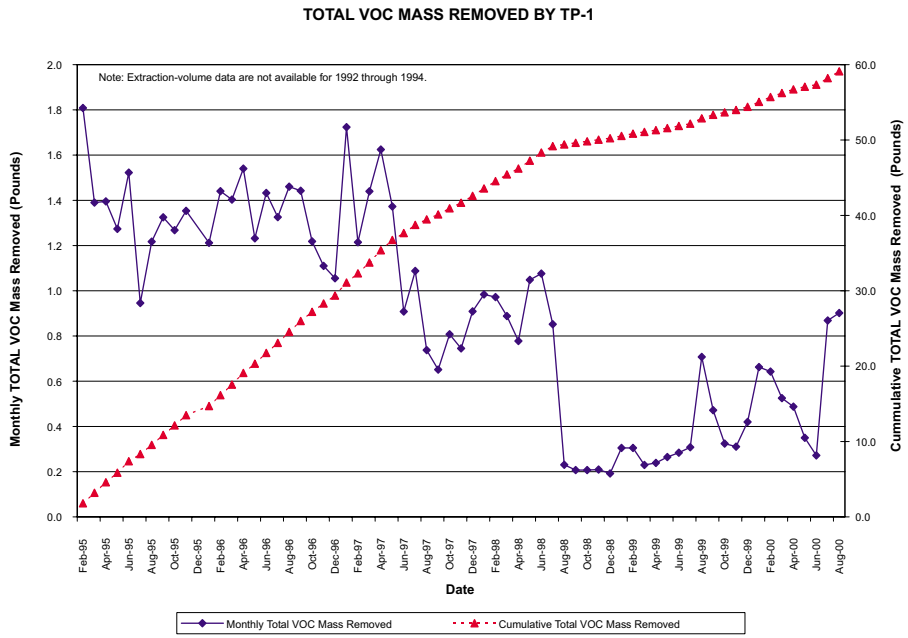
TP-1 monthly COC mass-removal rates from February 1995 through August 2000 ranged from 0.1 pound (lb) to 1.3 lbs for TCE and from 0.08 to 0.64 lbs for PCE (Figure 4.1). The highest mass-removal rates occurred early during IRM/TP-1 system operation (1995 through 1997), and are reflective of effective initial targeting of COC hot spots. Since 1997, TCE and PCE mass-removal rates have decreased significantly. The maximum TP-1 monthly removal rates for TCE and PCE during FY99 and FY00 were 0.43 lb and 0.52 lb, respectively (Figure 4.1).

As a result of stabilizing influent COC concentrations, monthly COC removal rates for TP-1 since 1997 have become increasingly dependent on extracted groundwater volumes (Figure 4.2), rather than on influent COC concentrations. For example, the average TCE influent concentration at TP-1 during FY99 was 4.2 µg/L, with a maximum weekly concentration of 6.8 µg/L, and a maximum monthly average of 6.5 µg/L (Figure 4.3). The average TP-1 PCE influent concentration was 4.3 µg/L, with a maximum weekly concentration of 5.8 µg/L, and a maximum monthly concentration of 4.8 µg/L. The ACLs for both TCE and PCE are 5 µg/L (Table 3.1).

Figure 4.1 also shows the cumulative TCE and PCE mass removed at TP-1 from February 1995 through August 2000. TP-1 removed approximately 35 lbs of TCE and 21 lbs of PCE during this period. In addition, the system removed about 2 lbs of 1,1-DCE and other VOCs. Assuming that the average mass removal rate achieved from February 1995 through February 1997 also can be applied to the period from IRM system startup and prove-out in November 1992 through January 1995 (Montgomery Watson, 1996a), removal of an additional 20 lbs of TCE, 10 lbs of PCE, and 0.5 lb of other VOCs can be extrapolated for the first 2 years of IRM operation. This extrapolation likely is conservative (i.e., the estimated mass removed is high) because operation of the IRM







Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\GW mass removal tables.xls\sitewide mass removed chart

FIGURE 4.1

VOC MASS REMOVAL TREATMENT PLANT 1

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyF.cdr p4 bbs 5/11/01

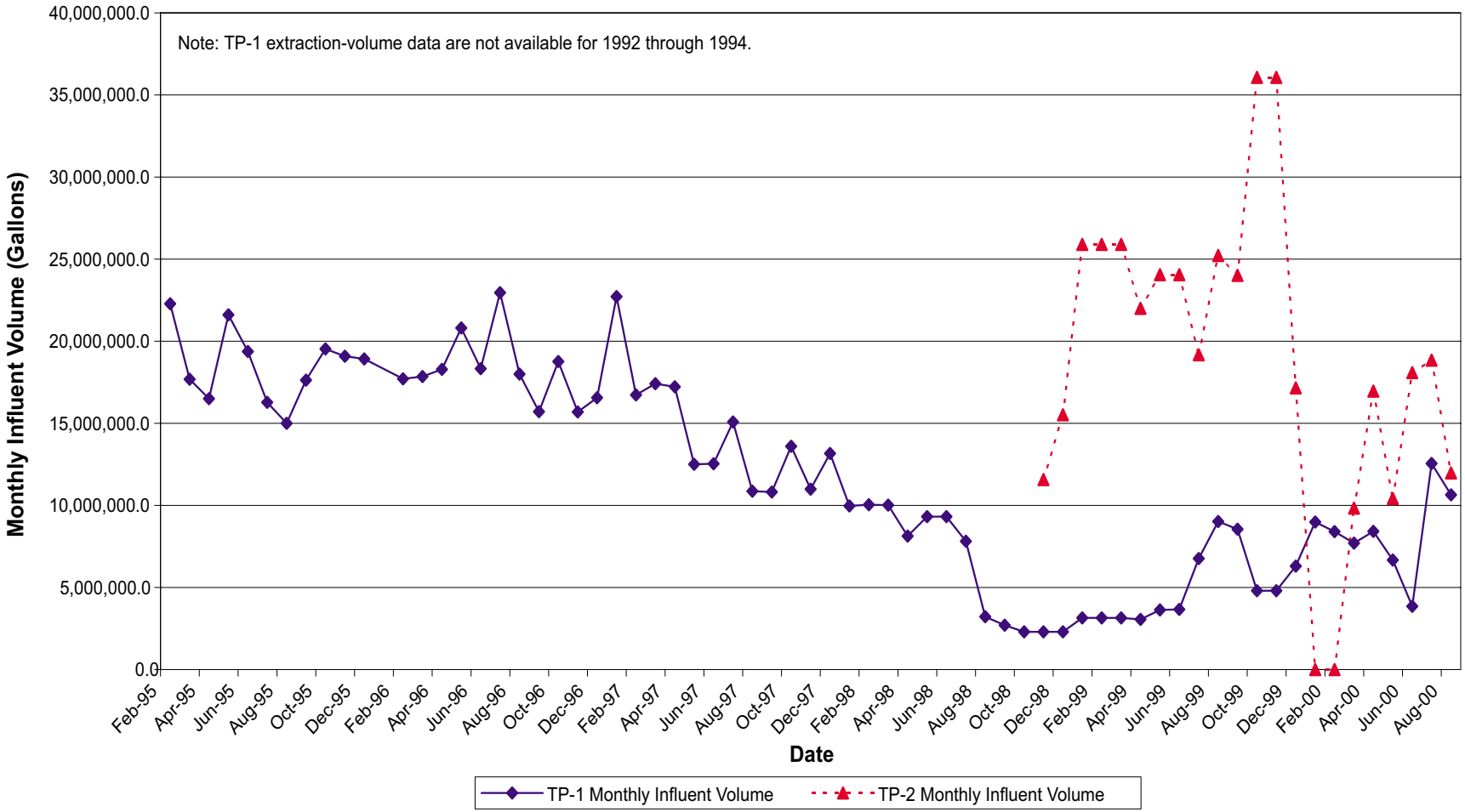


FIGURE 4.2

MONTHLY INFLUENT VOLUMES AT TP-1 AND TP-2

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\TP_data.xls\Influent Volumes

draw\TracyH.cdr p5 bbs 5/11/01

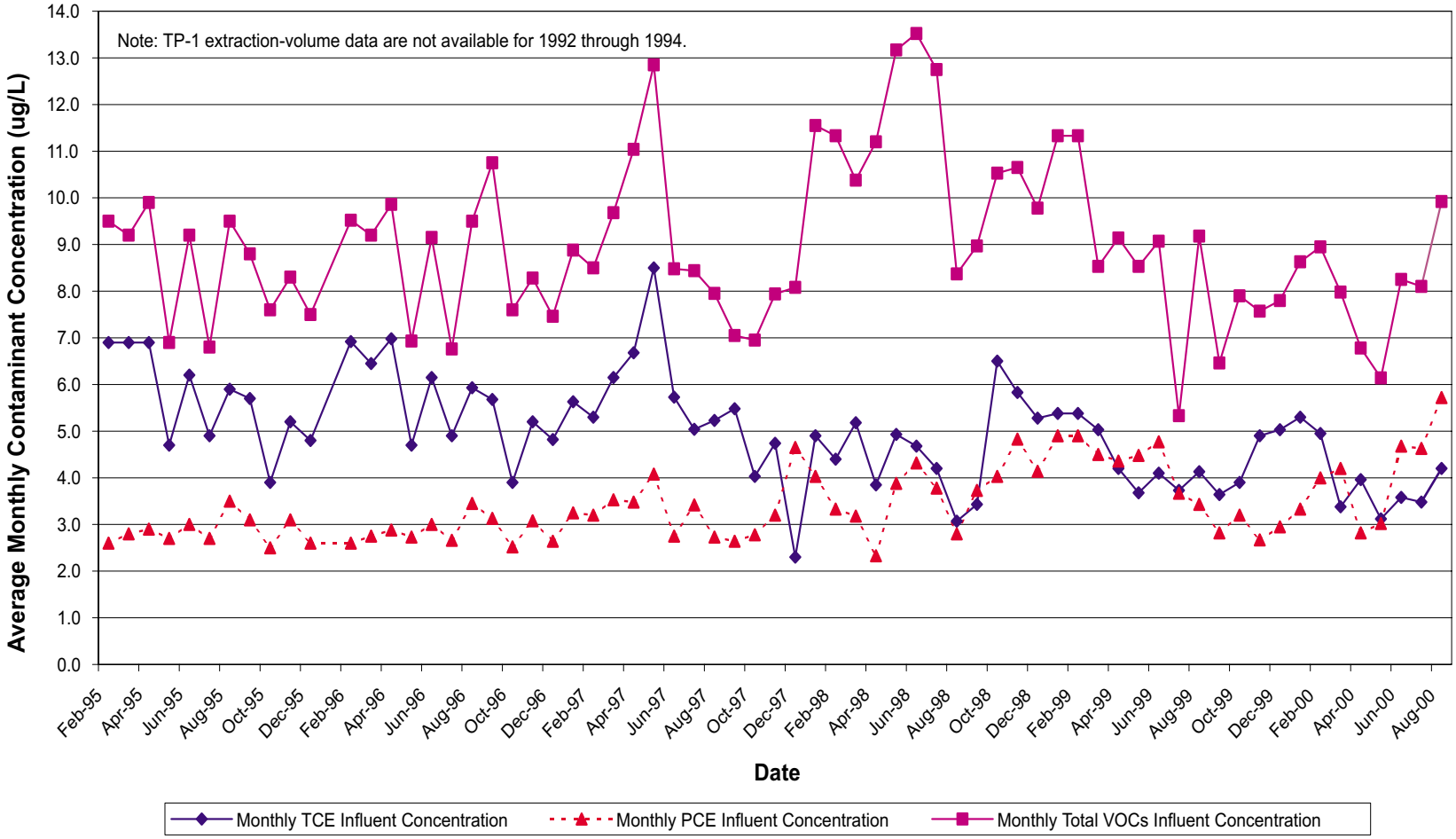


FIGURE 4.3

INFLUENT VOC CONCENTRATIONS AT TP-1

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\TP_data.xls\GWTP-1 Graph

draw\TracyH.cdr p3 bbs 5/11/01

system was discontinuous from startup through November 1994 (Montgomery Watson, 1996a), and fewer wells were operating during that time period. Based on this extrapolation, total TCE and PCE mass removed by TP-1 from startup through August 2000 is estimated at 55 and 31 lbs, respectively (Figure 4.1).

TP-2 Mass Removal

TCE and PCE mass-removal rates also were calculated for TP-2 from startup in November 1998 through August 2000 (Figure 4.4). TCE removal rates have varied from 0.5 to 2.7 lbs per month when the plant was operating. Lower mass-removal rates were obtained for PCE (0.1 to 1.2 lbs per month) during the same time period. The significant drop in removal rates that occurred during the first 8 months of 2000 (Figure 4.4) is largely attributable to limited operation of many of the TP-2 extractions wells during this period (see Section 4.2.2.1).

Because of greater extracted groundwater volumes (Table 4.5 and Figure 4.2) and higher influent concentrations (*cf.* Figures 4.3 and 4.5), more TCE mass is being removed by TP-2 than by TP-1. TP-2 wells extracted 3.25 times the groundwater volume of TP-1 wells during FY99 (Table 4.5 and Figure 4.2). During the same time period, the average monthly TCE influent concentration at TP-2 was 7.6 µg/L (*vs.* 4.4 µg/L at TP-1), with a maximum weekly concentration of 12 µg/L (*vs.* 6.8 µg/L at TP-1). Average monthly influent PCE concentrations were lower at TP-2 (2.7 µg/L) than at TP-1 (4.3 µg/L), though maximum weekly influent PCE concentrations at both plants were comparable (5.9 µg/L at TP-2 and 5.8 µg/L at TP-1). The maximum monthly averages for TCE and PCE influent concentrations were 10.7 µg/L and 15.5 µg/L, respectively (Figure 4.5).

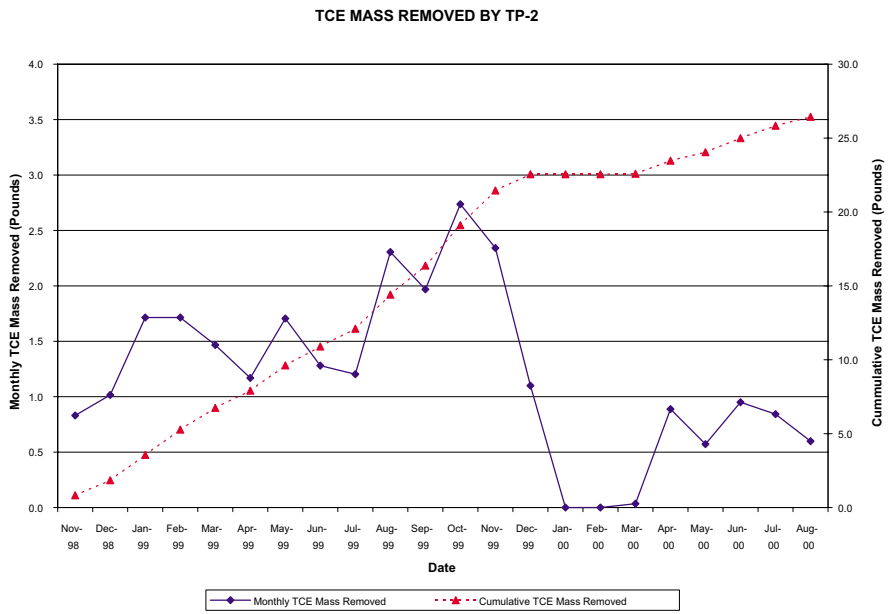
From startup in November 1998 through August 2000, approximately 26 lbs of TCE and 10 lbs of PCE were removed at TP-2 (Figure 4.4). As noted, the higher PCE mass-removal rates attained at TP-2 are a result of higher groundwater extraction volumes (Figure 4.2). The total VOC mass removal for TP-2 also is shown on Figure 4.4.

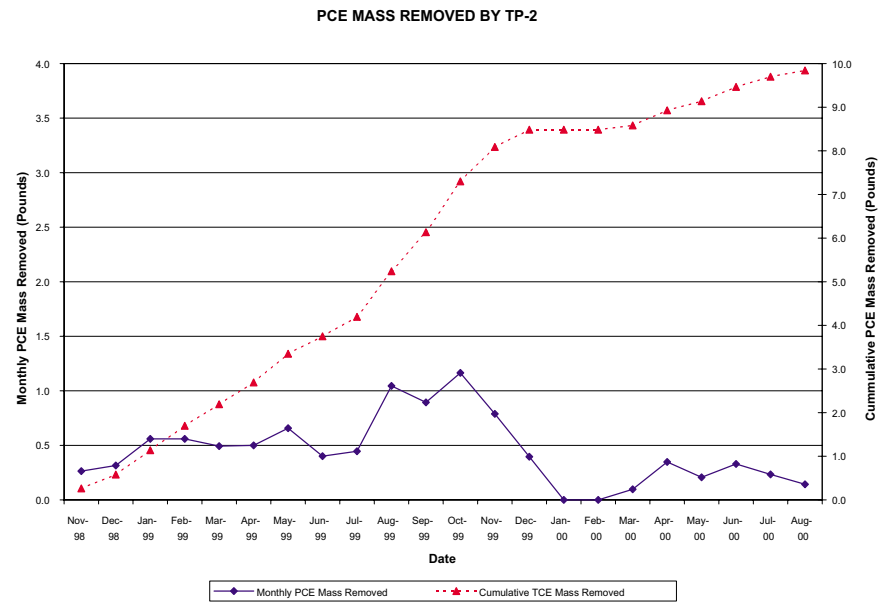
Integrated OU1 System Mass Removal

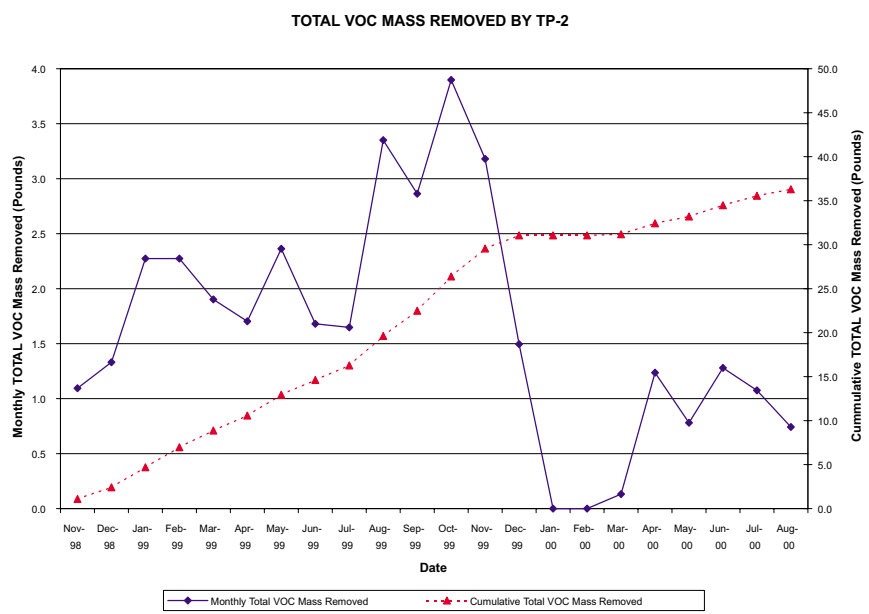
The integrated OU1 ETI system (TP-1 + TP-2) removed a total VOC mass of about 94 lbs from February 1995 through August 2000 (Figure 4.6). Of this total mass, about 65 percent (61 lbs) was TCE, about 33 percent (31 lbs) was PCE, and about 2 percent (2 lbs) was other VOCs. As explained above, it was estimated that the system removed 20 lbs of TCE and 10 lbs of PCE from 1992 through January 1995. Consequently, a total of about 122 lbs of COCs (approximately 81 lbs TCE and 41 lbs PCE) were removed from OU1 groundwater from November 1992 through August 2000.

Mass Removal By Extraction Well

TCE and PCE mass-removal rates also were calculated for each extraction well for FY99 (4Q98 through 3Q99). This time period provides most complete data on pumping rates (Figure 4.7) and COC concentrations (Figure 4.8 and Appendix D, Tables D.1 through D.3) available during this RPO evaluation. The integrated OU1 system removed a total of about 20 lbs of TCE and 9 lbs of PCE during this time period. The greatest well-specific TCE mass removals (1 lb or greater) occurred at wells EW012AU, EW019A, EW020A, EW026B, EW027B, EW028B, and EW034AU. These seven wells







Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\GW mass removal tables.xls

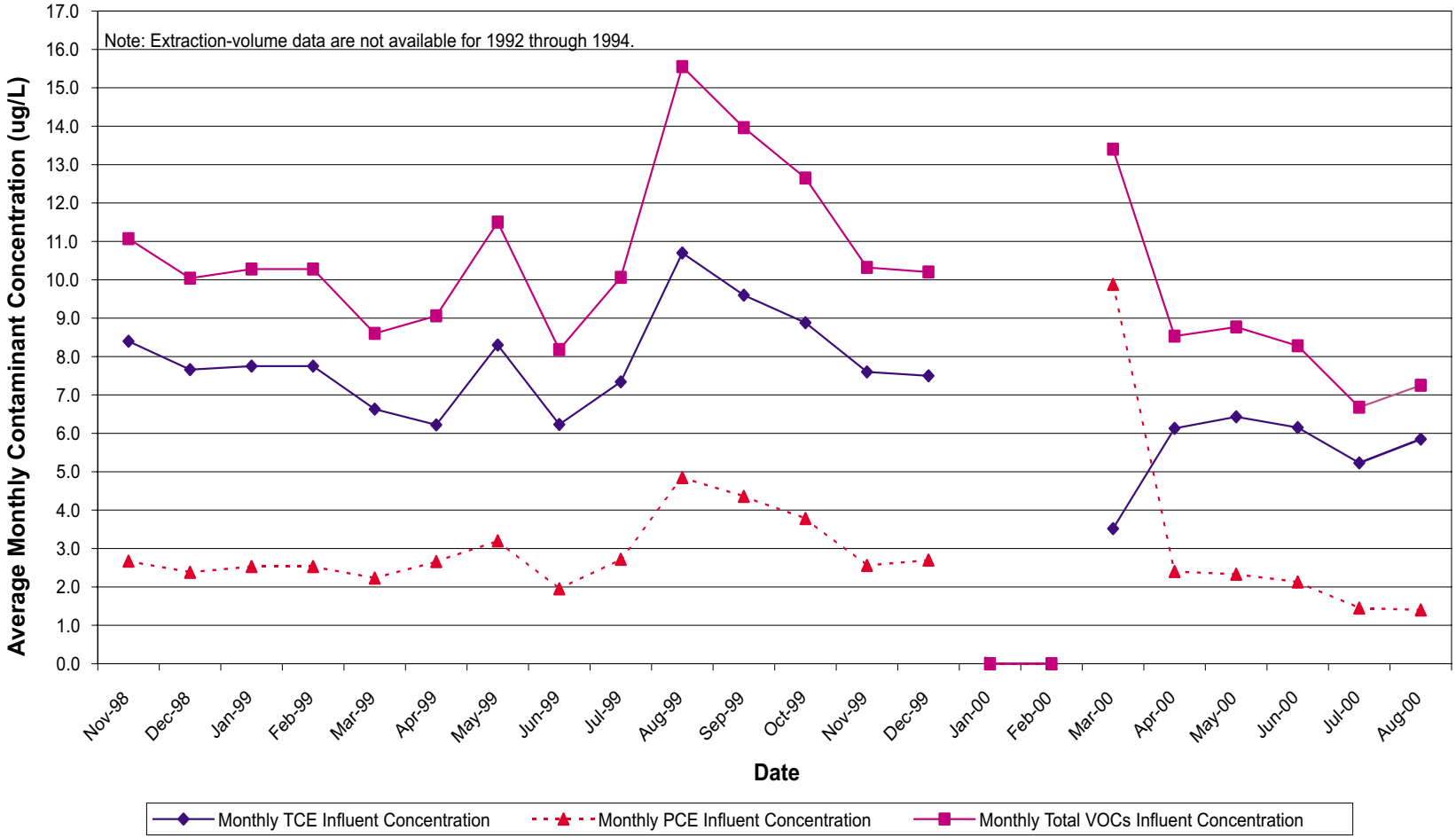
FIGURE 4.4

VOC MASS REMOVAL TREATMENT PLANT 2

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyF.cdr p5 bbs 5/11/01



Note: TP-2 was shut down during January and February 2000.

FIGURE 4.5

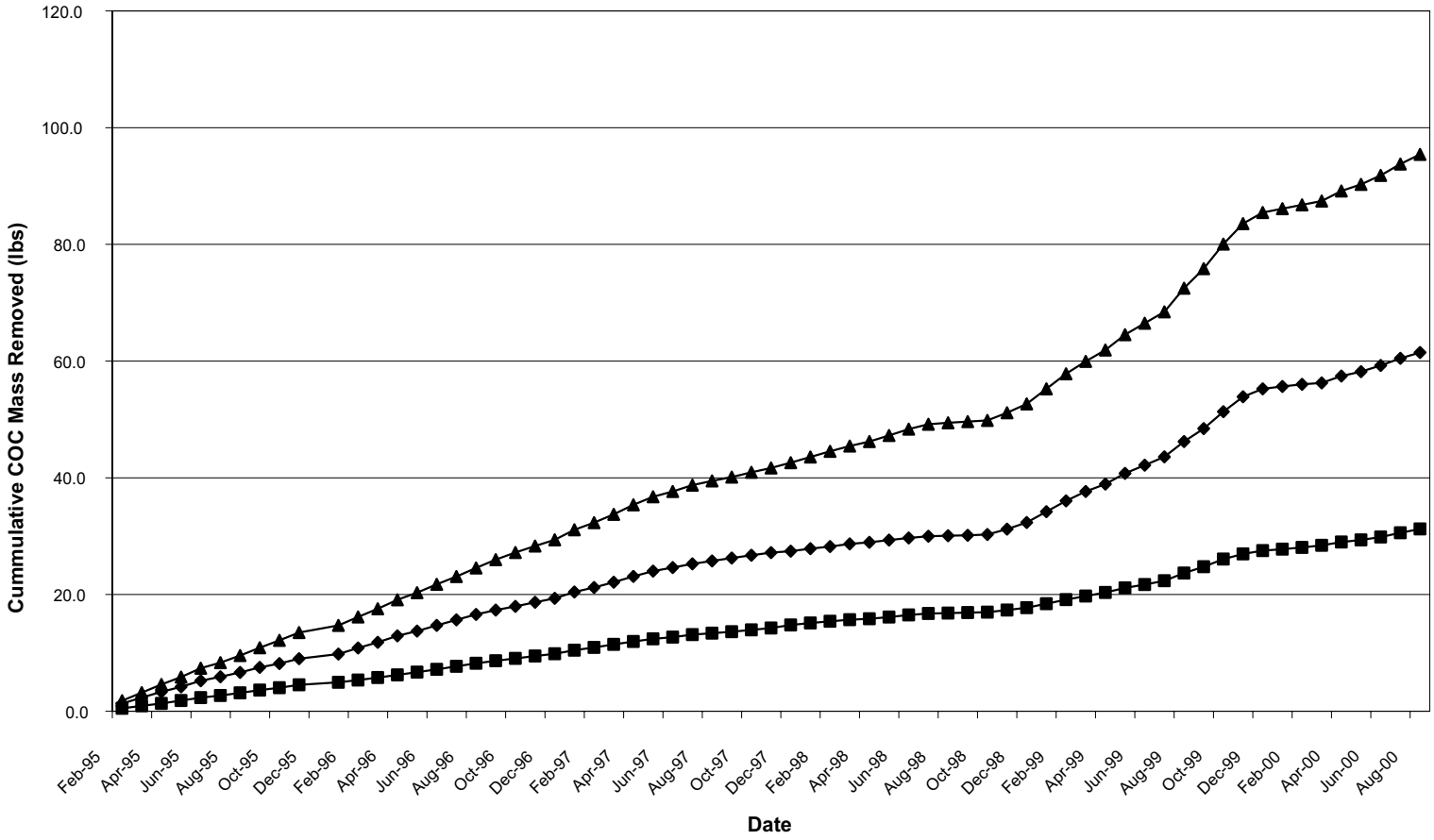
INFLUENT VOC CONCENTRATIONS AT TP-2

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\TP_data.xls\GWTP-2 Graph

draw\TracyH.cdr p4 bbs 5/11/01



Note: Extraction volume data are not available for 1992 through 1994.

TCE Mass Removal | PCE Mass Removal | Total VOC Mass Removal

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\GW mass removal tables.xls\sitewide mass removed chart

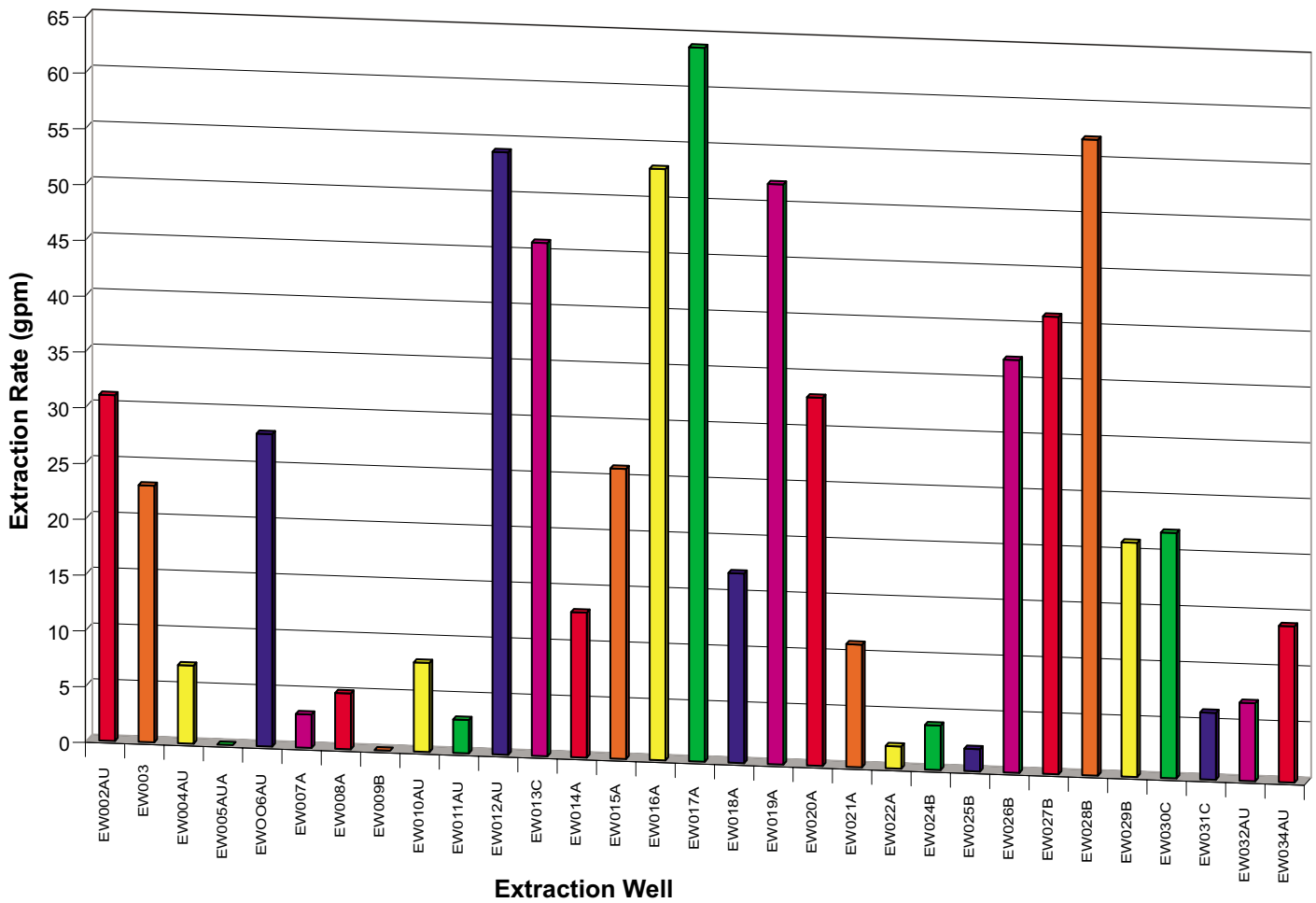
FIGURE 4.6

CUMULATIVE MASS REMOVAL TREATMENT PLANTS 1 AND 2

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyF.cdr p3 bbs 5/11/001



Note: Wells EW001AU, EW033AU, EW035AU, and EW037AU were out of service; well EW036AU has been abandoned.

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\well spec EXT Rates

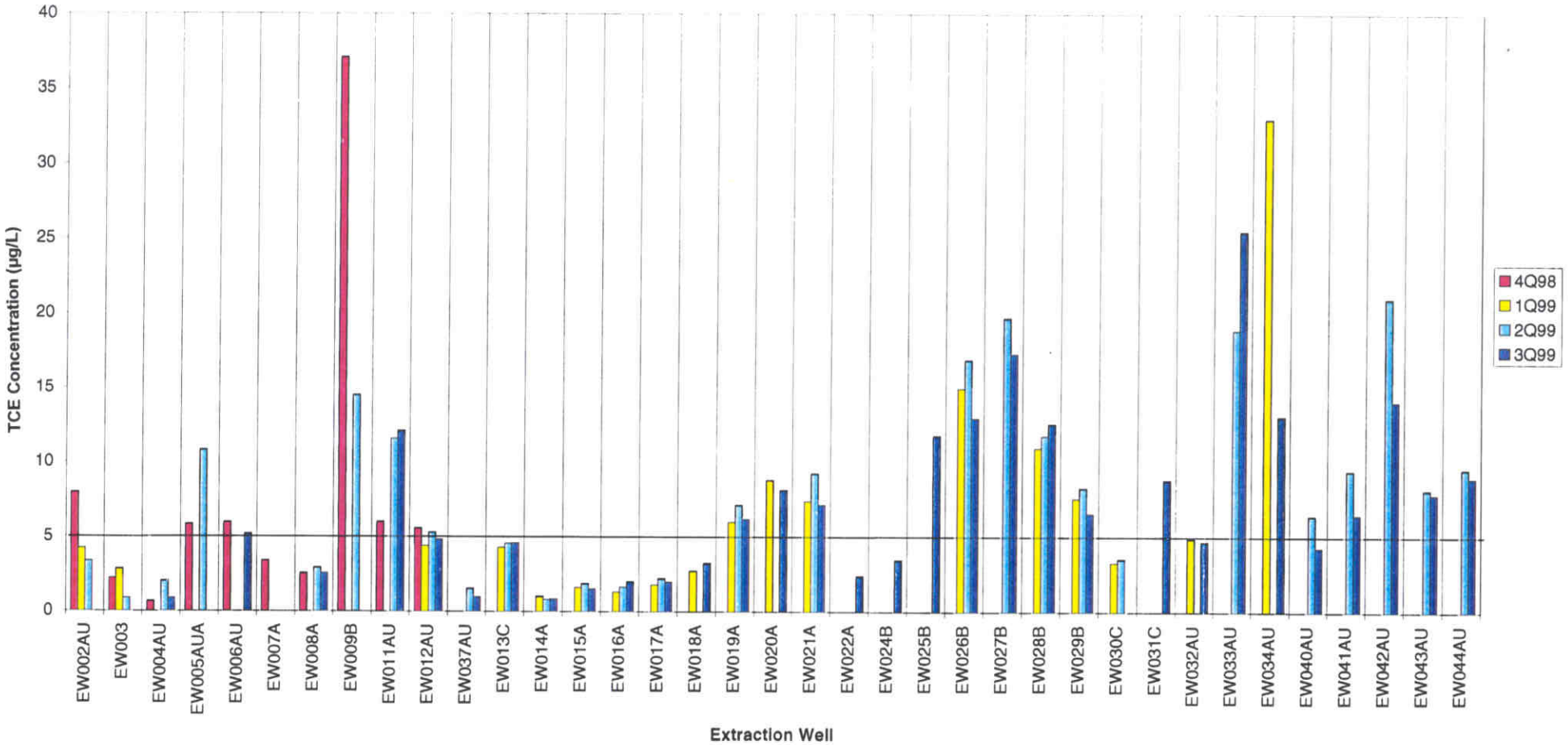
FIGURE 4.7

AVERAGE ANNUAL WELL-SPECIFIC EXTRACTION RATES (4Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\TracyH.cdr p1 bbs 5/11/01



Source: Radian, 2000b.

draw\TracyD.cdr nap p9 pup 1/8/01

FIGURE 4.8

TCE CONCENTRATIONS BY WELL (4Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

account for about 72 percent (about 14.2 lbs) of the TCE mass removed (Figure 4.9). These wells operated at a combined average FY99 flow rate of 288 gpm (Table 4.5), for a total extraction volume of approximately 151,372,800 gallons during FY99 (Table D.4, Appendix D). Based on monitoring data, wells EW005AUA and EW009B also had TCE concentrations above the ACL, but neither well was in operation during FY99.

Additional TCE mass was removed from wells at which average concentrations were below the ACL (Table D.2, Appendix D). Wells EW003AU, EW004AU, EW007A, EW008A, EW10AU, EW013C, EW014A, EW015A, EW016A, EW017A, EW018A, EW022A, EW024B, EW030C, and EW032AU removed 2.9 lbs TCE, which accounts for nearly 15 percent of the TCE mass removed. These wells pumped at an average combined rate of 300 gpm (Table 4.5), for a total extraction volume of about 157,680,000 gallons in FY99. The remaining wells (EW002AU, EW006AU, EW011AU, EW021A, EW025B, EW029B, and EW031C) accounted for 2.6 lbs (about 13 percent) of the TCE mass removed. These wells pumped at an average combined rate of 102 gpm, for a total FY99 volume of about 53,511,200 gallons (Table 4.5 and Table D.4, Appendix D).

The largest relative amount (about 7.64 lbs, or about 84 percent) of PCE mass was removed by wells EW002AU, EW012AU, EW021A, EW026B, EW027B, EW028B, and EW034AU (Figure 4.10). With exception of EW028B, all of these wells had average PCE concentrations above the ACL. These seven wells operated at a combined average flow rate of 245 gpm in FY99 (Table 4.5), for a total extraction volume of approximately 111,952,800 gallons (Table D.4, Appendix D). Fourteen other extraction wells with PCE concentrations below the ACL (EW003AU, EW004AU, EW008A, EW10AU, EW013C, EW014A, EW015A, EW016A, EW017A, EW018A, EW022A, EW024B, EW030C, EW032AU) removed 0.74 lb (8.1 percent) of the PCE mass. These 14 wells pumped at an average combined flow rate of 300 gpm, and removed about 157,680,000 gallons of groundwater (Table D.4, Appendix D). The average PCE concentration at well EW007AU, which was not pumped during FY99, was below its ACL. Wells EW006AU, EW011AU, EW019A, EW020A, EW025B, EW029B, and EW031C removed 0.72 lb PCE (7.9 percent). These five wells pumped at an average combined rate of 145 gpm (Table 4.5), and removed approximately 76,212,000 gallons. These five wells also had PCE concentrations below the ACL, though their average TCE concentrations were above the ACL (Table D.1, Appendix D). Note that wells EW005AU and EW009B, which exhibited average PCE and TCE concentrations above the 5-µg/L ACL, were not operating during FY99 (Table 4.5).

Based upon the information presented, about 39 percent of the groundwater pumped by the OU1 integrated ETI system during FY99 did not need to be pumped for treatment of COCs. A comparison of relative-percent TCE and PCE mass removal by well (Figures 4.9 and 4.10) confirms these findings. Based on COC concentrations and FY99 well operations, Figures 4.11 and 4.12 show hypothetical well-specific groundwater extraction volumes required to remove 1 lb of TCE and 1 lb of PCE, respectively, from the aquifer. As can be seen on these figures, mass-removal efficiency is extremely low for wells with concentrations below the ACLs (i.e., wells that do not need to be pumped for COC mass removal). Such low mass-removal rates are to be expected for wells installed primarily for plume containment. For example, Banta Road well EW014A would need to pump about 135 million gallons per year of groundwater to recover 1 lb of TCE mass (Figure 4.11). Similar conclusions apply to PCE mass-removal rates, as

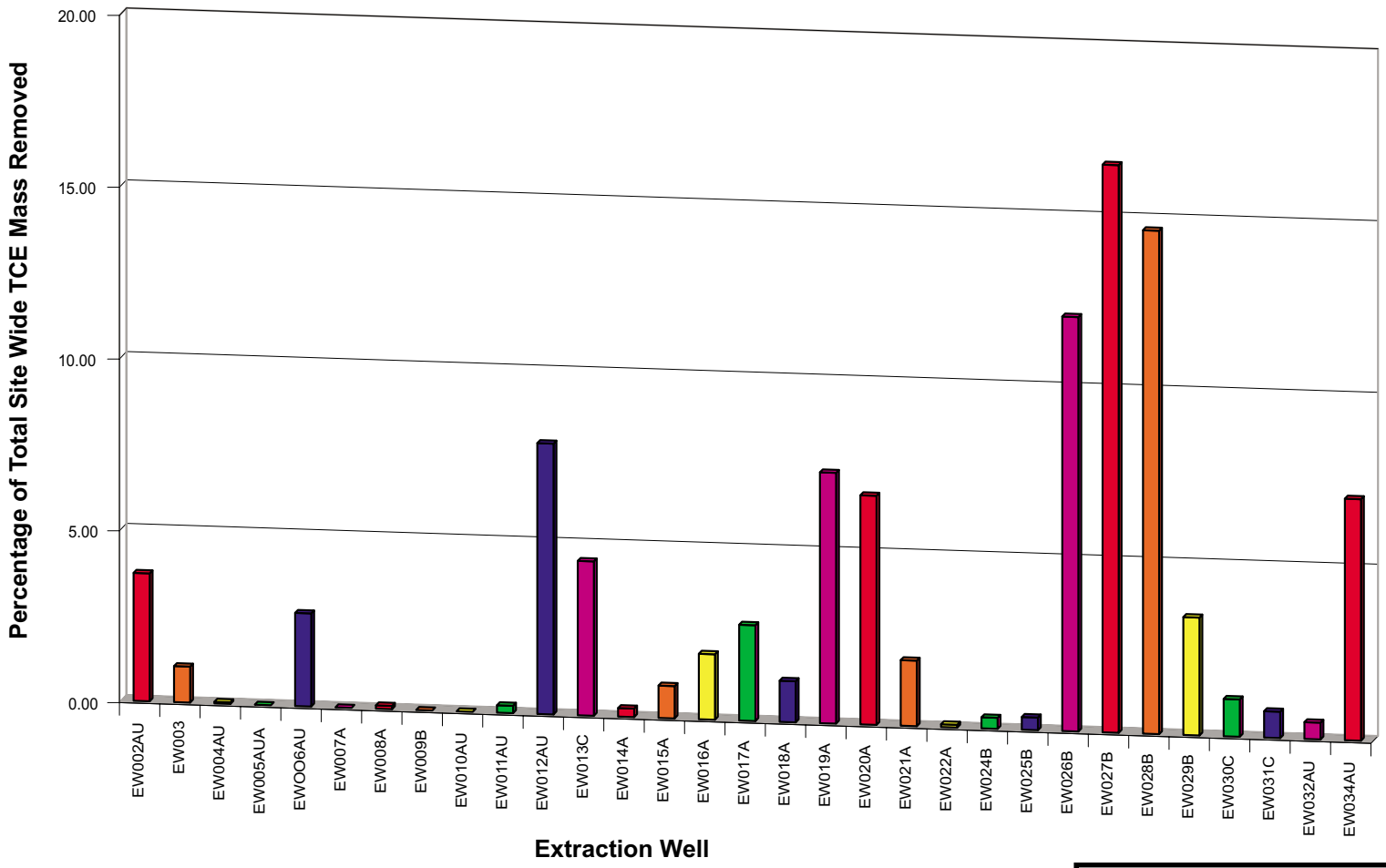


FIGURE 4.9

RELATIVE TCE MASS REMOVAL BY WELL (4Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\well spec TCE

draw\TracyF.cdr p2 bbs 5/11/01

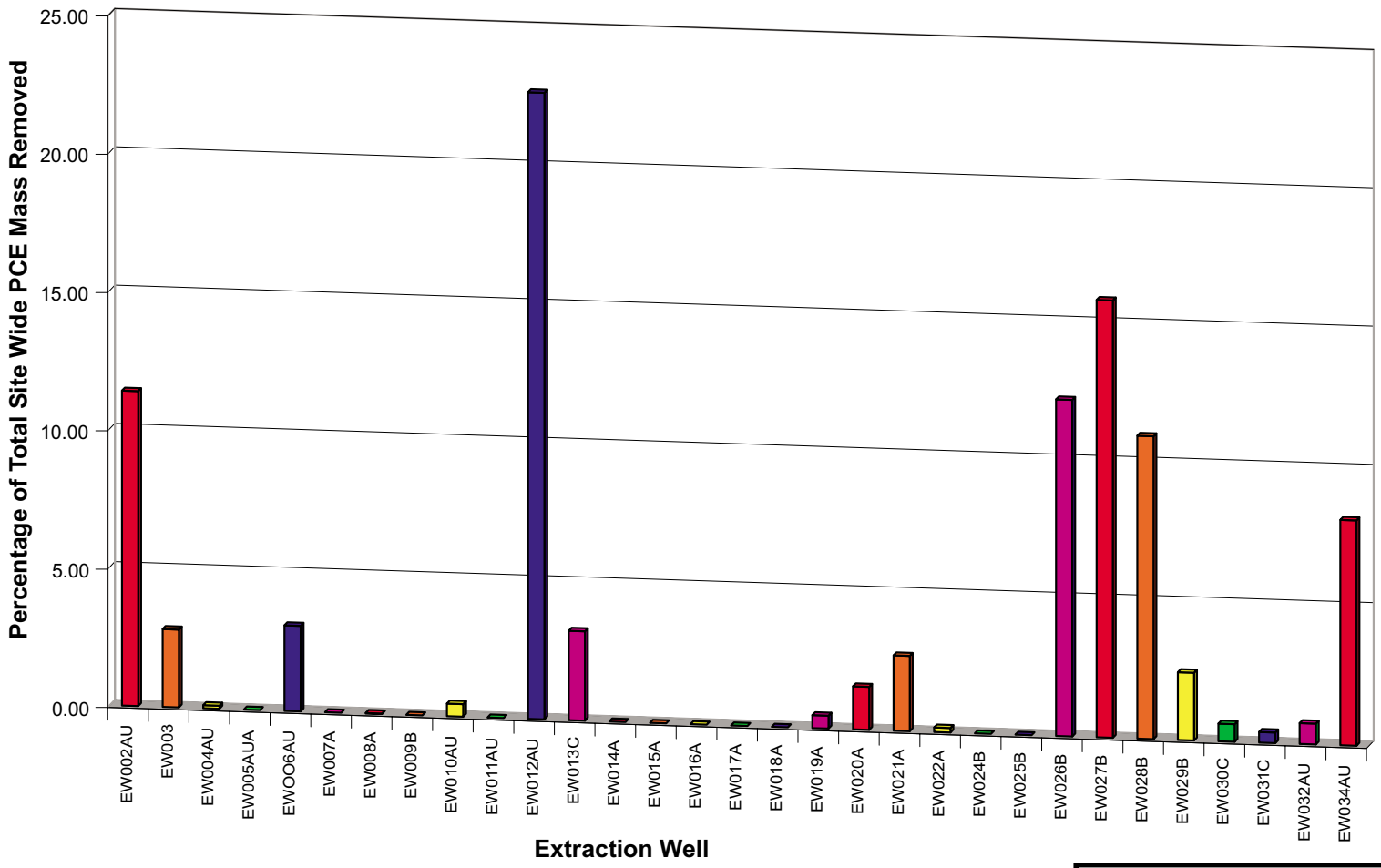


FIGURE 4.10

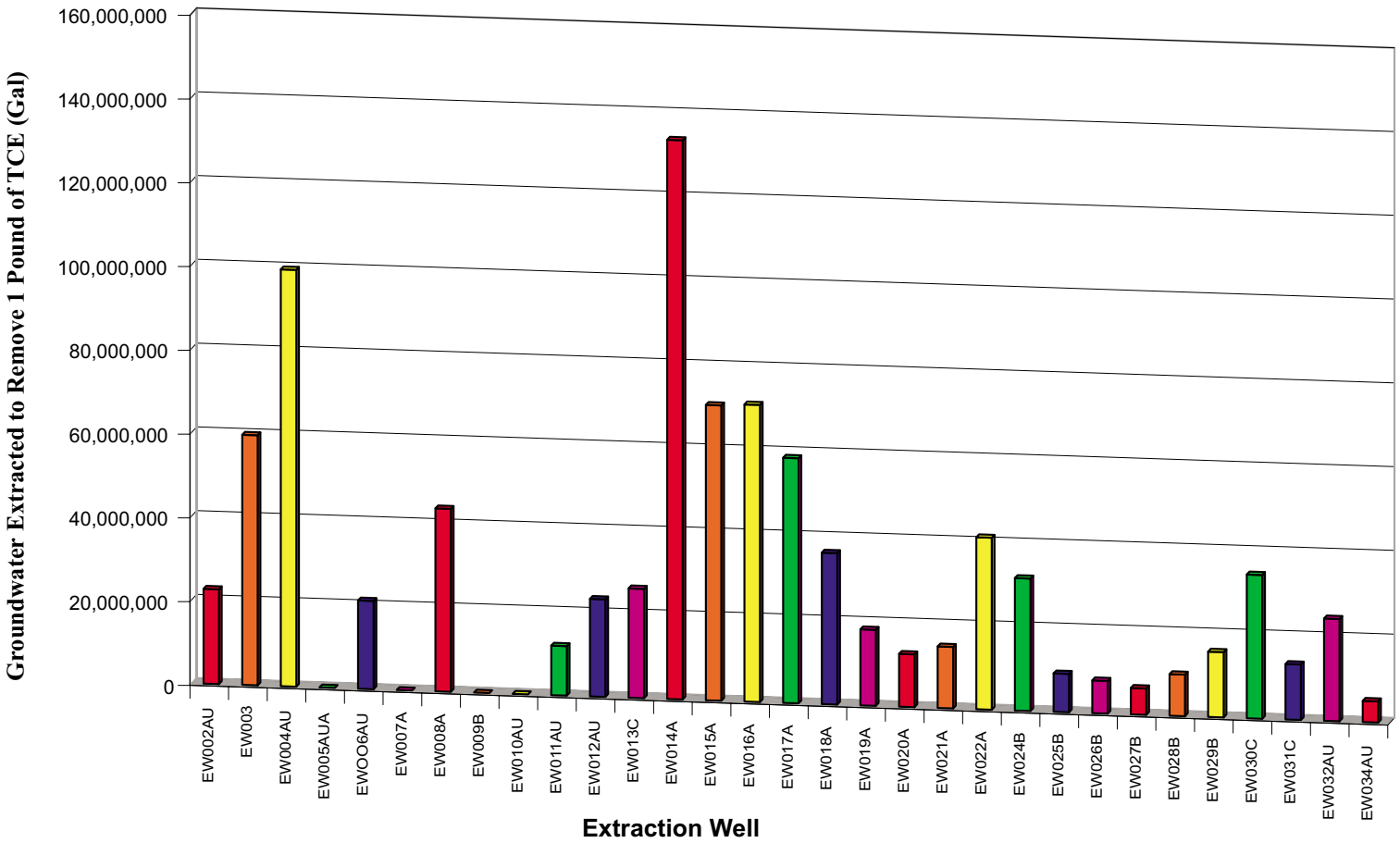
RELATIVE PCE MASS REMOVAL BY WELL (4Q98-3Q99)

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\well spec PCE

draw\TracyF.cdr p1 bbs 5/11/01



Note: Based on extraction rates and TCE concentrations for FY99 (4Q98-3Q99).

FIGURE 4.11

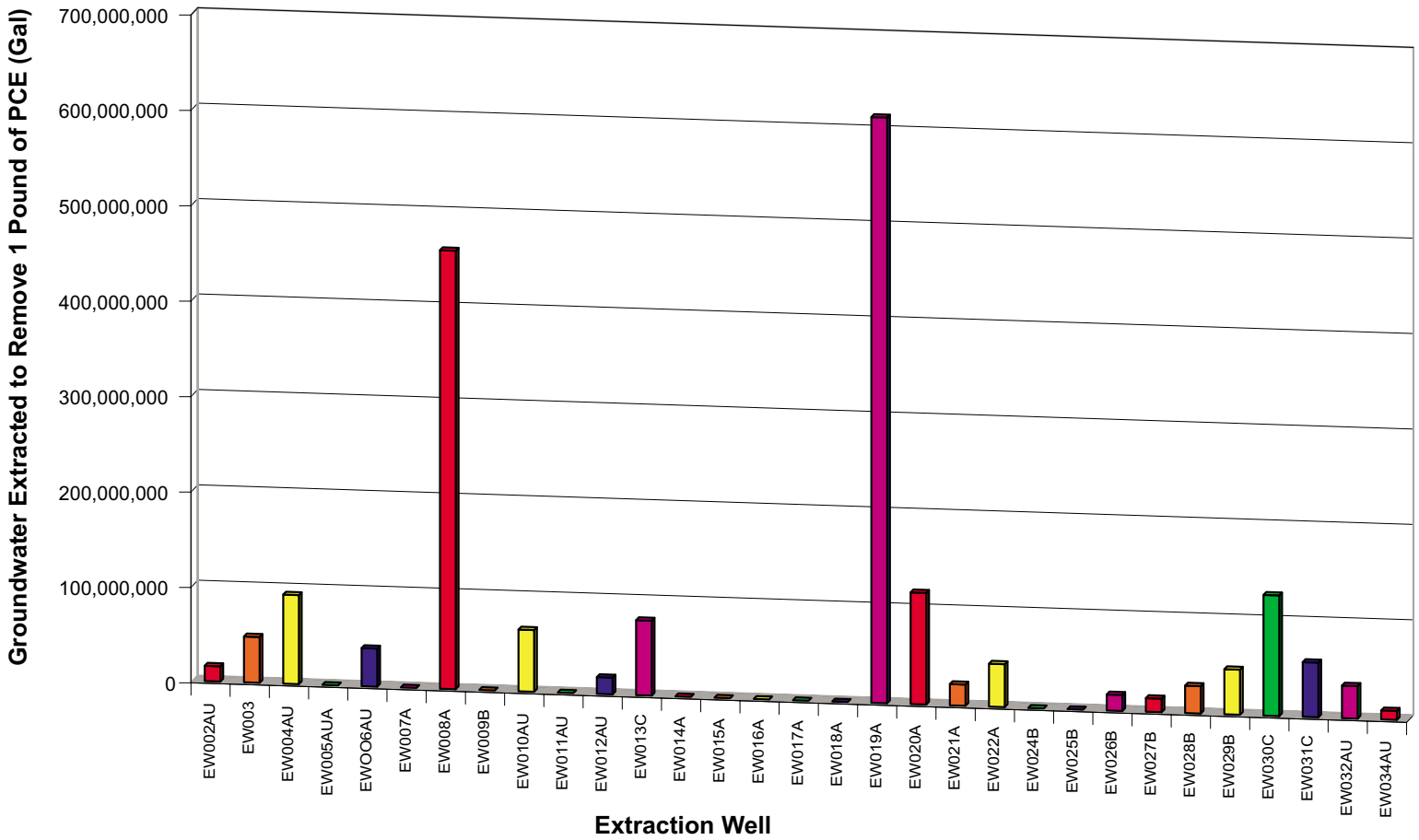
ESTIMATED WELL-SPECIFIC GROUNDWATER EXTRACTION VOLUMES REQUIRED TO REMOVE 1 POUND OF TCE

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\well spec gw extract (TCE)

draw\TracyJ.cdr p1 bbs 5/11/01



Note: Based on extraction rates and PCE concentrations for FY99 (4Q98-3Q99).

FIGURE 4.12

ESTIMATED WELL-SPECIFIC GROUNDWATER EXTRACTION VOLUMES REQUIRED TO REMOVE 1 POUND OF PCE

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\well spec gw extract (PCE)

draw\TracyJ.cdr p2 bbs 5/11/01

shown on Figure 4.12. However, because PCE concentrations in the aquifer are lower on average than TCE concentrations (Tables D.1 and D.2, Appendix D), the volumes of groundwater extracted for PCE mass recovery would be greater.

4.2.2.5 Extraction System Optimization Opportunities

The operational histories, VOC concentrations, and mass-removal rates for all extraction wells were analyzed as part of this RPO evaluation in order to identify optimization opportunities for the TP-1 and TP-2 extraction systems. Average pumping rates for FY99 are provided by well on Figure 4.7, and historical COC concentrations are provided in Appendix D.

Based on review of historical COC concentrations (1993 to 2000) and pumping data for all extraction wells, the following conclusions can be drawn:

1. COC (i.e., PCE, TCE, 1,1-DCE, and dieldrin) concentrations have not exceeded the ACLs during any monitoring event at extraction wells EW008A, EW010AU, EW013C, EW014A, EW015A, EW016A, EW017A, EW018A, EW022A, EW024B, EW030C, EW032AU, and EW037AU (Appendix D). At well EW007A, COC concentrations have not exceeded ACLs since 1Q97 (Appendix D). With the exception of EW037AU, which has never been operational, all of these wells were pumped during FY99 (Table 4.5). Therefore, the 12 operating wells are pumping groundwater that already meets the ROD ACLs and does not require treatment. Moreover, well EW0022A is fitted with a point-of-extraction GAC canister for treatment of pesticides, but dieldrin has not been detected in the effluent from this well (Appendix D, Table D.3). (Note: It was assumed that monitoring data for wells equipped with dedicated wellhead GAC treatment units are reflective of COC concentrations in well effluent before it passes through the GAC unit.) Radian (2000c) has recommended that EW008A, located along the northern boundary of DDJC-Tracy (Figure 1.4), be shut down.

   As noted in Section 4.2.2.3, extraction wells located close to the downgradient edges of the COC plumes are more important for plume containment than for mass removal. Because the easternmost extent of the TCE plume has not been fully characterized, the effectiveness of the downgradient wells situated along Banta Road (i.e., EW014A through EW020A, EW024B, and EW025B) for limiting off-Annex plume migration cannot be fully assessed. However, wells EW014A through EW018A (Figure 1.4) appear to be located north of the COC plume flowpath, as defined by the distribution of TCE and PCE at concentrations above the ACLs (Figure 2.18 and 2.19). Rebound testing could be conducted at these five Banta Road extraction wells to better assess their effectiveness in limiting migration of CAHs off-Annex.

   COC concentrations at downgradient wells EW030C and EW024B (Figure 1.4) are below the ACLs. Well EW030C has two 10-foot screens in the deeper portion of the aquifer (Lower horizon), and well EW024B has two 5-foot screens in the middle portion of the aquifer (Middle horizon). Both of these wells are located adjacent to shallower-saturated-zone wells (i.e.,

EW021A/EW026B and EW020A, respectively; Figure 1.4) where COC concentrations exceed the ACLs. Therefore, careful assessment of monitoring data for the deeper wells is needed to assess their value for plume containment, to evaluate potential dilution of COC concentrations due to pumping from two intervals, and also to ensure that pumping in the deeper zones is not inducing downward migration of contamination from shallower saturated intervals. Rebound monitoring in each of the screened intervals at these wells is recommended.

2. At least one COC has been detected above the ACL during all monitoring events at wells EW005AUA, EW009B, EW020A, EW026B, EW027B, EW028B, EW029B, EW031C, EW033AU, and EW034AU (Appendix D, Tables D.1 through D.3). Other extraction wells in which one or more of the COCs has exceeded its ACL in a majority of samples collected during LTM include EW002AU, EW003A, EW004AU, EW006AU, EW011AU, EW012AU, EW019A, EW021A, and EW025B (Appendix D). Pesticides are being treated at wells EW002AU, EW005AUA, and EW021A via wellhead GAC units. However, because dieldrin concentrations have been below the ACL at EW005AUA since 4Q99, and at EW021A since monitoring began in 1Q99, wellhead treatment for pesticides may be unnecessary. As shown in Table 4.5, wells EW009B and EW033AU are not in service. Extraction of groundwater from the 17 operational wells should continue for mass removal of COCs (and for plume containment at downgradient wells EW025B and EW026B; Figure 1.4), and if feasible, resumption of pumping should be considered for wells EW009B and EW033AU.

Eventual shut down of the 13 operating wells listed in Item 1, above, could result in a potential reduction in OU1 ETI system extraction volumes of up to 141,912,000 gallons per year (based on the average FY99 combined pumping rate of 270 gpm) (Table 4.5 and Figure 4.7). As noted above, groundwater extracted from these wells is being treated unnecessarily because COC concentrations are below the ACLs. If these wells could be shut down, the resulting potential flow-rate reduction would be equivalent to about 39 percent of the average total volume pumped by the OU1 system during FY99.

Currently, the OU1 extraction system is not fully optimized for COC mass removal. The extraction wells with COC concentrations consistently below the ACLs (Item 1, above), removed only 2.9 lbs (14.8 percent) of TCE and 0.7 lb (8.1 percent) of PCE while pumping about 40 percent the total groundwater extracted during FY99. This is equivalent to 54 million gallons per year of groundwater extracted for each pound of TCE mass removed, and 312.1 million gallons of groundwater extracted per year per pound of PCE removed. For the rest of the system, extraction of 12.2 and 24.5 million gallons per year would be needed to remove 1 lb of TCE and PCE, respectively. This shows that the mass-removal efficiency for extraction wells with COC concentrations above the ACLs is approximately 4.5 (TCE) to 8.7 (PCE) times the efficiency achieved by extraction wells located in more dilute portions of the COC plumes (i.e., where ACLs are not exceeded).

Therefore, wells EW007A EW008A, EW010AU, EW013C, EW014A, EW015A, EW016A, EW017A, EW018A, EW0022A, EW024B, EW030C, and EW037AU should be considered for rebound testing and/or shutdown (see Section 5.3). The rate of COC mass removal (i.e., progress toward meeting ROD ACLs) in some areas could be

increased by adding extractions wells at source zones or along plume flow paths. For example, a new well targeting the shallow saturated zone could be located within the groundwater hot spot associated with the CAH source area at DSERTS 68 (Figures 2.18 and 2.19) to accelerate remediation of this plume (see Section 5.3).

4.2.2.6 Schedule to Complete Groundwater Remediation

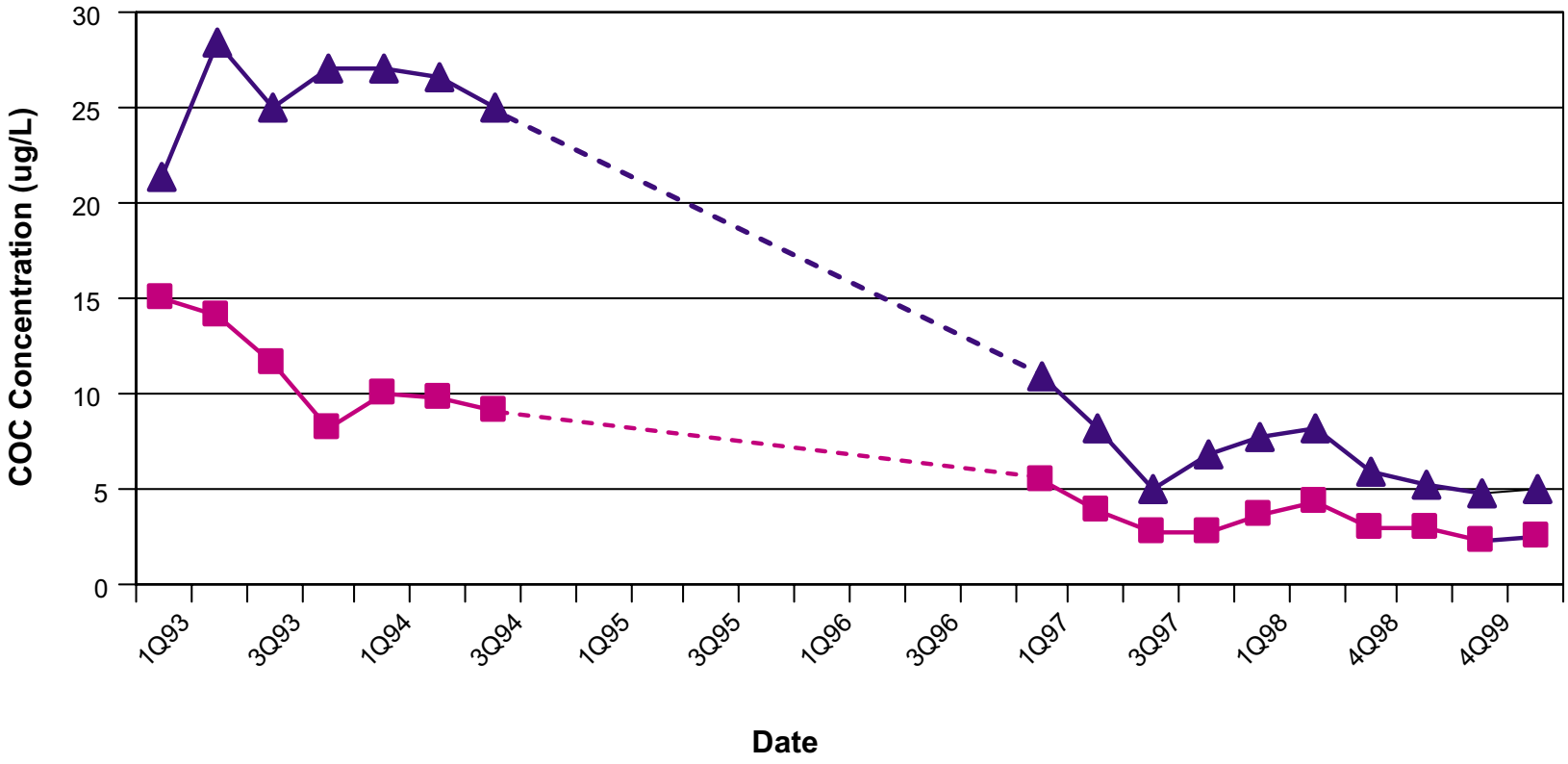
Parsons ES is not aware of any estimates of the VOC mass originally present in groundwater at DDJC-Tracy or the Annex. Therefore, in lieu of multi-year performance data for most extraction wells, the schedule to complete (STC) groundwater remediation under current operational scenarios and mass-removal rate cannot be estimated. Any attempt to quantify the VOC mass dissolved in groundwater at the site would be incomplete because not all plume areas have been fully delineated. The Comprehensive ROD (Radian, 1998a) estimated that restoration of OU1 groundwater to PCE and TCE ACLs would require 30 years of integrated ETI system operation from the startup of TP-2. Cleanup of dieldrin was estimated to require at least 50 years. Because the IRM/TP-1 system had been operating for approximately 6 years at the time that TP-2 came on line, the total time to achieve ACLs for the VOCs would be about 36 years, with remediation to be completed by approximately 2028.

Although data deficiencies preclude a meaningful projection of the remaining time required to achieve ACLs, available data suggest that COC concentrations have stabilized at or below the ACLs in response to ETI at some extraction wells. By way of example, PCE and TCE concentrations from 1Q93 through 4Q99 were plotted for extraction well EW006AU (Figure 4.13), which has a relatively long operating life, and is located in close proximity to other Above Upper extraction wells along the northern Depot boundary (Figure 1.4). Although performance data for EW006AU are not available for a 2-year period, Figure 4.13 suggests that TCE and PCE concentrations at the well continued to decline through 3Q97, after which concentrations appear to stabilize near the ACLs.

For comparison purposes, graphs for wells EW011AU, EW012AU, EW028B, EW032AU, and EW034AU are shown on Figure 4.14. These wells have been in operation for 2 to 4 years, and concentrations trends are not clearly established. It is expected that over time, concentrations of COCs at these extractions wells, and therefore the rates of VOC mass removal, will decline, eventually reaching static levels. However, some rebounding of COC concentrations can be expected after groundwater extraction ceases. Such an effect can be seen on the graph for well EW011AU (Figure 4.14), where higher COC concentrations were observed after 4Q98 through 4Q99, during which time the well was not pumped due to mechanical problems (Kvaerner Environmental, 1998j and 1999a through 1999l). Therefore, additional treatment time may be required after the ACLs have been met in extracted groundwater.

4.2.2.7 Cost Analysis

The net present value (NPV) of capital and OM&M costs from IRM system installation through the end of 1997 were estimated at approximately $9,500,000 for TP-1 alone (Radian, 1998a). While it is suspected that this estimate is conservative (i.e., low), actual capital and OM&M cost data were not available for this RPO evaluation. The NPV of capital and OM&M costs from 1998 through attainment of remediation goals



TCE Concentration

PCE Concentration

(Dashed where inferred)

FIGURE 4.13

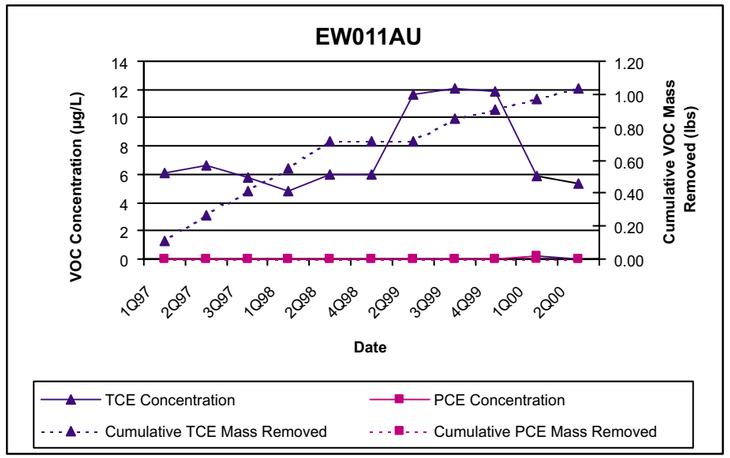
COC CONCENTRATIONS THROUGH TIME AT EW006AU

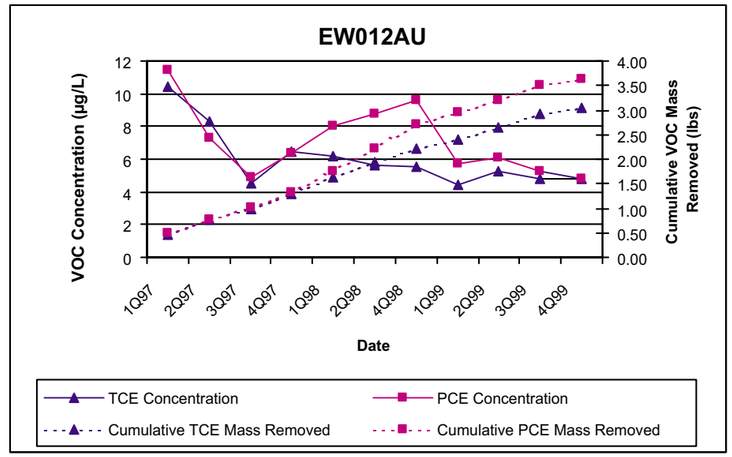
Remedial Process Optimization
DDJC - Tracy, California

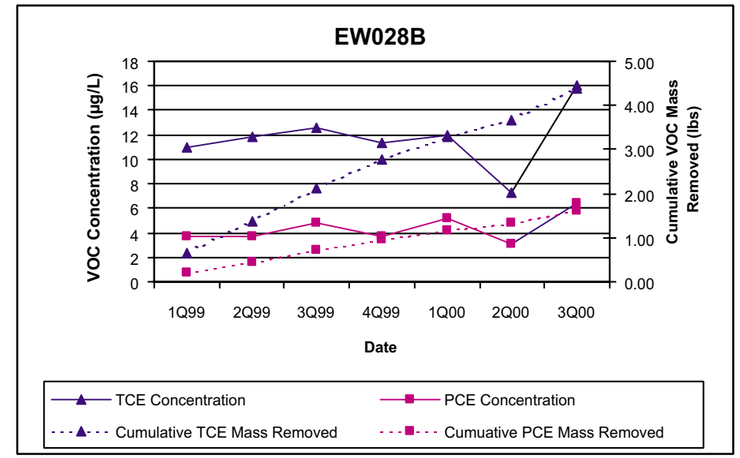
PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

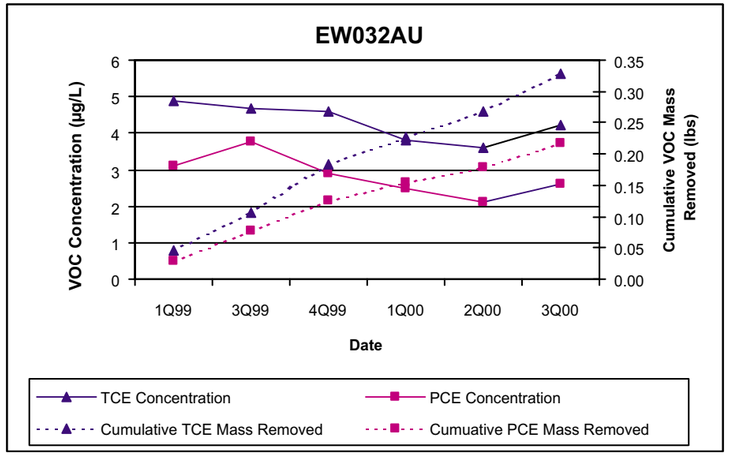
Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls\EW6AU

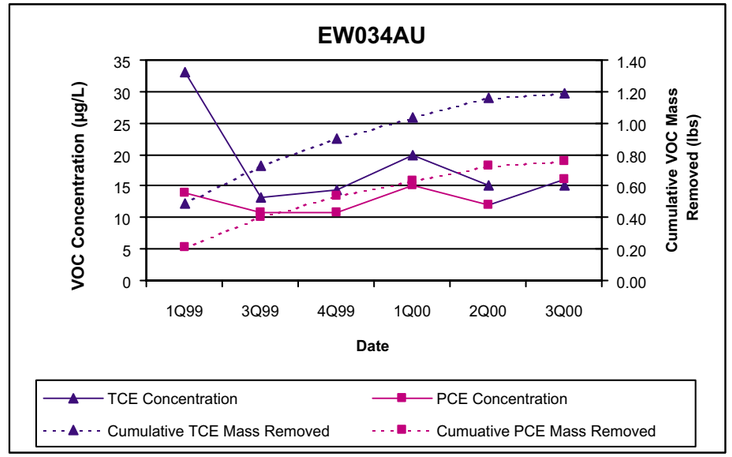
draw\TracyH.cdr p2 bbs 5/11/01











Note: Quarters for which COC concentration data are not available are excluded from the plots.

FIGURE 4.14

COC CONCENTRATIONS AND MASS REMOVAL FOR SELECTED EXTRACTION WELLS

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\well spec mass removal.xls

draw\TracyE.cdr pg1 bbs 5/11/01

was projected to be approximately $12,037,500 (Radian, 1998a). Of this amount, the capital costs for installation of TP-2, additional extraction wells, and IG-2 through IG-9, were estimated at approximately $3,324,400 (1998 dollars), excluding costs for installation of well-head GAC units for pesticide treatment (Radian, 1998a). Based on these data, the estimated annual OM&M cost for VOC removal for the integrated OU1 ETI system at DDJC-Tracy was estimated to be $206,270 (Table 4.6), and the total estimated OM&M cost for the OU1 system from 1998 to date (3 years of operation) was $618,810. Because data are unavailable, additional capital costs (e.g., for additional extraction wells) and extraordinary maintenance/repair costs were ignored. The total estimated cost to date (through 2000) for construction and OM&M of the groundwater ETI system for VOC removal/containment is approximately $13.4 million (Table 4.6).

The COC mass removed from 1992 through 2000 was estimated to be about 122 lbs (approximately 81 lbs TCE and 41 lbs PCE) (see Section 4.2.2.4), for a total cost per pound of COCs (as PCE and TCE) removed to date of $110,190 (Table 4.6). For cost-analysis purposes, the relatively insignificant removal of other VOCs was ignored. The current rate of COC mass removal, estimated from FY99 data, is about 29 lbs per year (about 20 lbs TCE and 9 lbs PCE) (Appendix D). This rate of COC mass removal was achieved by pumping at an average total flow rate of 690 gpm and treating approximately 362.6 million gallons of groundwater during FY99 (Table 4.6 and Appendix D). Conservatively assuming that the ROD-estimated annual OM&M cost of $206,270 for VOC treatment is accurate (see Section 4.2.3 for comparative monitoring cost estimate), it cost about $7,165 per lb of COC (PCE + TCE) mass removed in FY1999.

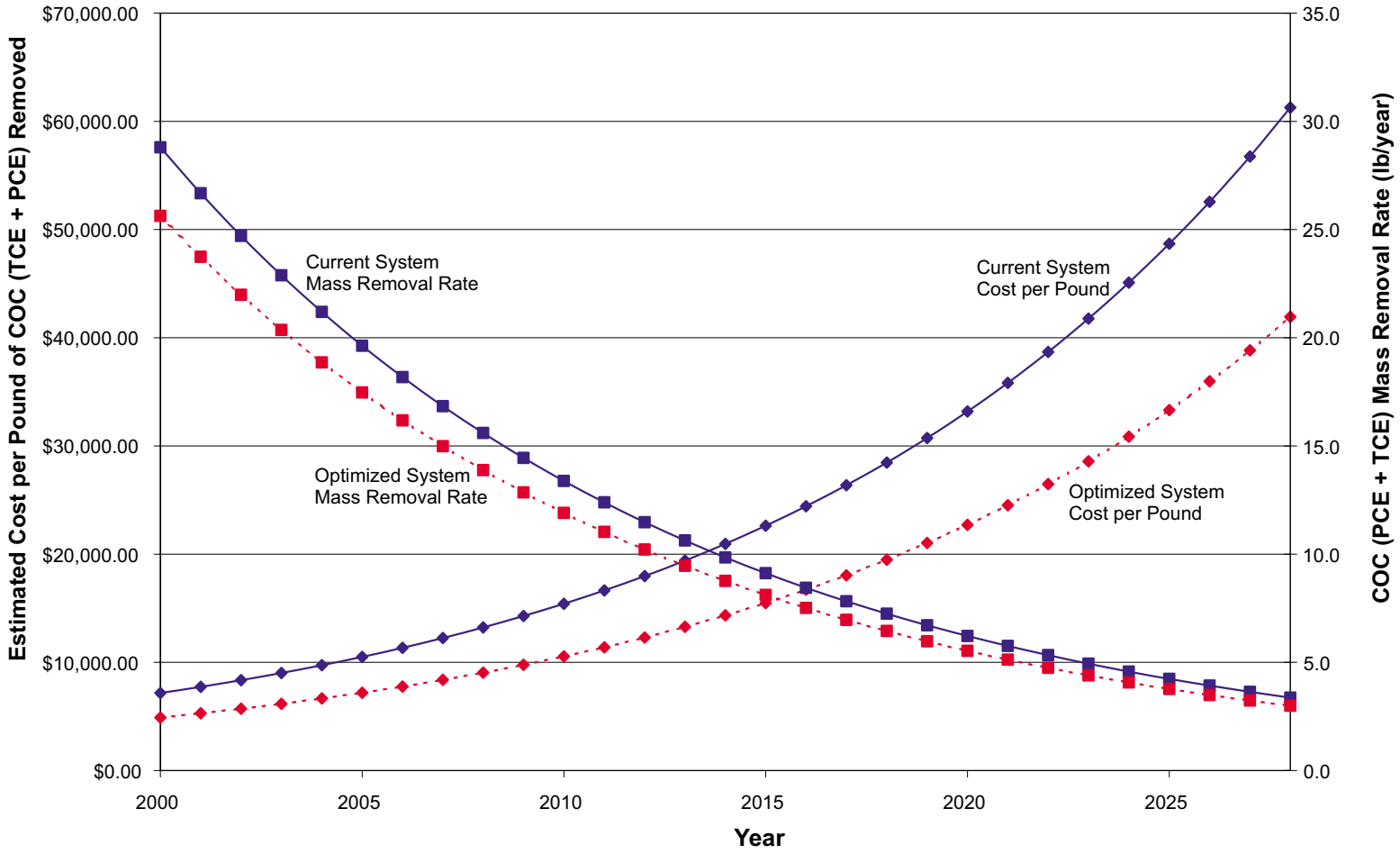
Hypothetically, if the current rate of TCE and PCE mass removal could be sustained through year 2028 (the estimated cleanup time specified in ROD), an additional COC mass of about 806 lbs could be removed from OU1 groundwater under FY99 pumping conditions. In reality, COC mass-removal rates will decline through time as concentrations in groundwater decrease due to pumping and attenuation. The TCE and PCE concentration data for extraction well EW006AU were used to estimate the rate at which mass-removal rate could be expected to decline from 2001 through 2028 (Appendix D, Figure D.1). Well EW006AU has a relatively long operating life (Figure 4.13), and the concentrations of PCE and TCE detected at this well in 1993 (27 µg/L TCE and 15 µg/L PCE) are comparable to the highest COC concentrations measured at operating extraction wells in 3Q00 (24 µg/L TCE and 16 µg/L PCE; Tables D.1 and D.2, Appendix D). Therefore, it was assumed that PCE and TCE data for well EW006AU provide a reasonable approximation of declining COC mass-removal rates that could be expected in OU1 groundwater. The TCE and PCE concentration data for this well were analyzed using a first-order equation (Appendix D, Figure D.1). The decay rate was then extrapolated for the entire integrated OU1 ETI system for the remaining 28 years of the ROD-estimated cleanup time (i.e., the remaining ETI system operating period).

The projected rate of decrease in COC mass removal over time could result in a longer-than-projected remediation STC of the Upper Tulare Aquifer to ACLs, and will result in increasing costs per pound for removal of COCs to ACLs, as illustrated on Figure 4.15. Assuming that the declining mass-removal rate calculated for well EW06AU can be extrapolated to the entire OU1 system, COC mass-removal rate would decline to about 3 lbs per year by 2028. The estimated total cumulative mass of COCs to be removed from 2001 through 2028 would be about 319.2 lbs, assuming an average total

TABLE 4.6
SUMMARY OF ESTIMATED CAPITAL, OPERATION, MAINTENANCE, AND MONITORING COSTS FOR GROUNDWATER ETI SYSTEM
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Item	Cost
Estimated IRM/TP-1 Capital Costs (prior to 1998)[a/]	$9,500,000
Estimated TP-2 System Capital Costs [a/]	$3,324,400
Estimated Annual VOC OM&M Costs [a/]	$206,270
Estimated VOC OM&M Costs (1998 – 2000)	$618,810
Total Cost to Date (1992 – 2000) [b/]	$13,443,210
Mass of COCs (PCE + TCE) Removed to Date [c/]	122 lbs
Cost Per Pound of VOCs Removed to Date [d/]	$110,190
Estimated Current Annual Rate of Groundwater Extraction [e/]	362.6 million gallons
Current Rate of COC Mass removal [e/]	28.79 lbs/yr
Estimated Current Annual OM&M Cost [a/]	$206,270
Estimated Current Cost per Pound of COCs Removed per Year [a/]	$7,165
Estimated Total Mass of COCs to be Removed from 2001 through 2028 [f/]	319.2 lbs
Estimated Total COC OM&M Cost from Present through 2028 [b/]	$5,775,560
Projected Average Annual Cost Per Pound of COCs Removed in 2028 [g/]	$61,278

a/ In 1994 dollars (Radian, 1998a).
b/ Based on ROD estimated annual OM&M costs (Radian, 1998a) in 2000 dollars.
c/ Based on an estimated 41 pounds of PCE and 81 pounds of TCE removed since IRM start up.
d/ Estimated cost per pound of COC removed includes all capital and OM&M costs incurred to date (Radian, 1998a)
e/ Based on flow rates observed during fiscal year 1999 (FY99), and estimated constant FY99 mass-removal rates of 9.1 pounds per year PCE and 19.69 pounds per year TCE.
f/ Based on a first-order polynomial decay curve fit to concentration data from EW006AU (Appendix D, Figure D-1), and constant extraction at average FY99 pumping rates (Radian, 2000c).
g/ Based on a projected COC mass removal rate of 3.4 lbs per year in 2028 at an annual OM&M cost of $206,270 (2000 dollars).



Note: Current-system values are based on fiscal year 1999 operating and performance data.

FIGURE 4.15

COMPARISON OF MASS REMOVAL RATES AND COSTS FOR CURRENT AND OPTIMIZED EXTRACTION SYSTEMS

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Source: S:\ES\Remed\RPO\DDJC-Tracy\Phase2Report\conc_decay_curves.xls\cost and rate

draw\TracyH.cdr p6 bbs 5/11/01

extraction flow rate of 362.6 million gallons per year. Total OM&M costs for COC removal over the next 28 years would be about $5.8 million (Table 4.6). This estimate is conservative, as the ROD estimate for VOC OM&M is thought to be low (see Section 4.3), and the effects of inflation are excluded from the calculations. Based on the above estimates, the projected average removal cost per pound of COCs by 2028 (based on mass removal of PCE and TCE at a rate of 3.4 lbs per year in 2028) would be about $61,278, compared to the current estimated annual cost of $7,162 (Table 4.6).

If it can be assumed that OM&M costs for operating the ETI system are a function of the volume of groundwater extracted, then the potential savings of shutting down some of the extraction wells, and thereby reducing flow through the TPs to the infiltration system, can be estimated. If the 13 extraction wells identified in Item 1 of Section 4.2.2.5 as candidates for shutdown were taken off line, up to 39 percent of the total FY99 flow through the integrated ETI system could be eliminated. With 13 wells shut down, total annual flow to the treatment plants could theoretically be reduced to about 221 million gallons (Table 4.7).

Reducing the extracted volume of groundwater being treated unnecessarily by 39 percent of the FY99 total would reduce the COC (PCE + TCE) mass-removal rate by a smaller percentage through 2028. For example, in 2001, the mass-removal rate would be reduced by 3.2 lbs per year, or about 11 percent of the total COC mass removed in FY99. However, as illustrated on Figure 4.15, in 2028 the optimized ETI system would be recovering a total COC mass (3 lbs per year), which is similar to that projected (3.4 lbs per year) assuming FY99 operating conditions.

Moreover, under a reduced-volume pumping scenario, the total COC mass recovered by the end of 2028 would be about 309.7 lbs (Table 4.7) *vs*. 319.2 lbs if extracted groundwater volumes are not reduced (Table 4.6). This amount represents a reduction in recovered COC mass of only 9.5 lbs over 28 years, or about 3 percent of the projected mass to be recovered during the same time period assuming FY99 pumping conditions. OM&M costs also would decrease, as shown on Figure 4.15, and the cost per pound of COCs removed from the aquifer during the entire remediation period would be lower (Figure 4.15). For example, the cost per COC pound removed during 2001 assuming optimized system operation would be approximately $5,300 (*vs*. $7,162 in FY99), and the annual cost per pound removed by the end of 2028 would be $41,934 (*vs*. $61,278). This represents a total OM&M savings of about 32 percent over the average annual cost per pound of COCs removed during the remaining 28-years of the ROD estimated cleanup time of the system. Thus, a 39-percent reduction in volume of groundwater extracted could net annual OM&M savings of about $80,652 per year, or $2.26 million during the remaining 28 years of the ROD-estimated cleanup time for the OU1 ETI the system (Table 4.7).

Potential ancillary benefits of reducing the volume of groundwater extracted include 1) reducing the flow through the treatment plants, which could reduce current operational problems related to scaling in the air strippers and possibly allow for replacement of the strippers with GAC treatment (see Section 4.2.3); and 2) reducing effluent discharge to the capacity-limited infiltration galleries, which would improve operating efficiency for the entire ETI system by minimizing shutdowns due to IG-capacity constraints. In addition it could eliminate the need to supplement the effluent-discharge capacity of the

TABLE 4.7
SUMMARY OF ESTIMATED COSTS FOR THE OPTIMIZED GROUNDWATER ETI SYSTEM
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Item	Cost
Estimated Annual Rate of Groundwater Extraction [a/]	220.8 million gallons
Estimated Rate of COC (PCE + TCE) mass removal in Year 2001[b/]	23.7 lbs/yr
Estimated Annual OM&M Cost [c/]	$125,618
Estimated Cost per Pound of COCs Removed per Year in Year 2001[c/]	$5,300
Estimated Total Mass of COCs to be Removed from 2001 through 2028 [d/]	309.7 lbs
Estimated Total COC OM&M Cost from Present through 2028 [e/]	$3,517,316
Projected Average Annual Cost Per Pound of COCs Removed in 2028 [f/]	$41,934

a/ Based on the removal of 13 groundwater extraction wells from the ETI system well field, resulting in a system wide 39.1-percent reduction in extracted groundwater

b/ Based on flow rates observed during fiscal year 1999 (FY99) for the remaining ETI system extraction wells, and estimated FY99 mass-removal rates of 9.1 pounds per year PCE and 19.7 pounds per year TCE for the remaining ETI system extraction wells.

c/ Based on a projected COC mass-removal rate of 23.7 lbs per year in 2001 at an annual OM&M cost of $125,618 (2000 dollars).

d/ Based on a first-order polynomial decay curve fit to concentration data from EW006AU (Appendix D, Figure D.1), and constant extraction at average FY99 pumping rates (Radian, 2000c).

e/ Based on $125,618 in OM&M costs per year for 28 years.

f/ Based on a projected COC mass-removal rate of 3 lbs per year in 2028 at an annual OM&M cost of $125,618 (2000 dollars).

system through addition of an overland flow system or continued flows to the sewage or stormwater lagoons (see Section 4.2.4). Eliminating a permanent overland flow system would result in additional savings of capital and OM&M costs.

The estimated costs and savings presented in this section are based upon ROD OM&M cost estimates (Radian, 1998a) and FY99 operational data for the integrated OU1 ETI system. During FY99, some wells were not operating. If these wells are brought back online, and if new wells are installed, then the cost estimates and savings would need to be adjusted accordingly. In addition, a more accurate assessment of potential savings could be made if actual cost information were to be used. Also, note that the cost analysis in Table 4.7 does not account for savings that could be realized if the unnecessary GAC unit at well EW021A were to be removed (and possibly installed at another extraction well where pesticide concentrations are higher).

4.2.3 Groundwater Treatment System Assessment

This subsection reviews the current operations of TP-1 and TP-2 and assesses O&M for the plants. Opportunities for improving treatment plant effectiveness also are presented.

4.2.3.1 Current Operations

During the first 9 months of 2000, TP-1 operated at approximately 35 percent of its 500-gpm hydraulic capacity, and TP-2 operated at approximately 40 percent of its 800-gpm hydraulic capacity. Figure 4.2 illustrates the monthly flow rates treated at the two TP systems. As described in Section 4.2.2, treatment plant throughput historically has limited in part by the hydraulic capacity of the nine infiltration galleries. The TPs are currently underutilized due to low flow rates and low influent VOC concentrations. Due to the low influent VOC concentrations, vapor-phase carbon treatment of air-stripper emissions is no longer required at either plant.

Influent concentrations of PCE and TCE are illustrated for TP-1 and TP-2 on Figures 4.3 and 4.5, respectively. TP-1 influent concentrations of both PCE and TCE are stable, having consistently remained between 2 µg/L and 8 µg/L during the past 6 years of operation. TP-2 influent concentrations have shown a slight downward trend, with PCE concentrations remaining below 3 µg/L, and TCE remaining below 7 µg/L over the 6-month period from March through August 2000. Although optimization of extraction well pumping rates (see Section 4.2.2) could result in less dilution and some increase in influent concentrations, PCE and TCE concentrations in plant influent are expected to remain below 10 µg/L at both TPs for the remainder of ETI operations.

The treatment systems were designed to achieve 99-percent removal of VOC contaminants and to achieve the WDRs listed in Table 3.3. Low levels of pesticides are being pretreated at selected extraction wells using point-of-extraction aqueous-phase GAC cannisters. Analysis of effluent from the two treatment plants indicates that discharge standards for VOCs are being met (Radian, 2000g through 2000p).

4.2.3.2 Reliability/Maintainability Issues

Air strippers generally are reliable systems with minimum downtime for repairs. However, during FY00, TP-1 and TP-2 were operational less than 100 percent of the time (specific information on plant shutdown frequency and duration was not available). Historically, downtime has been caused by the need to remove calcium oxides from the stripping tower, pump and valve repairs, and problems with infiltration gallery capacity. Air stripping causes the release of carbon dioxide from influent groundwater, which increases pH and leads to the precipitation of calcium oxides, which foul the packing material in the stripping towers. This precipitation also increases suspended solids in the effluent, which can contribute to the fouling of downstream piping and infiltration galleries.

DDJC-Tracy's O&M (TetraTech) and environmental (URS) contractors have carefully studied the scaling problem and attempted several solutions. Efforts to reduce scale and fouling problems historically have included acid washing of infiltration gallery media, manual removal of scale from the stripping towers, and addition of carbon dioxide following air stripping to lower effluent pH, dissolve oxides, and lower the suspended solids in TP effluent discharged to the infiltration galleries. Based on discussions with TetraTech personnel during the RSV in May 2000, addition of carbon dioxide had been marginally effective (Parsons ES, 2000a).

4.2.3.3 Potential Treatment System Improvements

Although the air strippers are achieving effluent discharge standards, the air stripping systems create undesirable byproducts (scale and suspended solids) that reduce system efficiencies and increase O&M costs. Due to the current (Figures 4.3 and 4.5) and expected future low influent VOC concentrations, the air strippers will remain underutilized. Parsons ES has identified two potential treatment-process improvements that merit consideration:

- Conversion from air stripping to aqueous-phase GAC treatment for VOC treatment, and
- Use of alternative scale inhibitors.

Conversion to Activated Carbon Treatment

Although the existing air strippers provide a cost-effective technology for removing VOCs from site groundwater, the current concentrations of volatile COCs (i.e., PCE and TCE) entering the air stripper also are within the range of cost-effective removal using liquid-phase GAC. Assuming that the influent levels of PCE and TCE approach 5 µg/L in the next 2 to 3 years, and that the extracted flow rates can be reduced and maintained below 150 gpm (at either or both TPs), the economics of converting the treatment train to activated carbon should be reconsidered. For example, at a TP-1 flow rate of 150 gpm with average influent PCE and TCE concentrations of 5 µg/L, the capital cost for a full-service GAC system would be approximately $125,000, and the initial carbon would last approximately 7 years. Carbon replacement during subsequent years would cost approximately $4,000 per year (Appendix E). The extraction system evaluation (Section 4.2.2) found that up to 16 gpm (9 percent) of the total FY99 flow to TP-1 of 162 gpm

could be eliminated if the extraction well system is optimized as described. This would result in less than 150 gpm of throughput at TP-1, where average PCE and TCE concentrations have been less than 9 µg/L for the past 6 years (Figure 4.3).

The estimated costs for GAC treatment should be compared to current costs for operating and maintaining the air stripper systems. Power costs alone for the TP-1 air stripper blower have been estimated at nearly $8,000 per year (based on a 15-horsepower [hp] blower). In light of the current energy crisis in California, this estimate likely is conservative. Even if additional maintenance to remove calcium and other oxides from the stripper costs only $10,000 per year, GAC could prove to be a more cost-effective long-term treatment method for extracted groundwater at DDJC-Tracy. Table 4.8 provides an example 30-year cost comparison between air stripping and carbon for TP-1.

TABLE 4.8
COMPARISON OF COSTS FOR AIR STRIPPING AND ACTIVATED CARBON AT TP-1
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Option	Cost
Continued Air Stripping	
15-hp Blower - Annual Power	$ 8,000
Annual Tower Maintenance	10,000
Total Annual Cost:	$ 18,000
28-Year Total[a/]:	$504,000
Activated Carbon	
Install New Unit (7 yrs carbon)	$125,000
21 Years Carbon @ $4000/year	84,000
28-Year Total:	$209,000
Potential 28-Year Savings	**$295,000**

[a/] Assumed remaining operating period for the OU1 treatment systems is 28 years (Radian, 1998a). Costs are presented in constant (year 2000) dollars.

Note that this simple comparison assumes that other costs such as basic labor, monitoring, and reporting costs are equal for the air stripper and GAC. The air stripping cost does not include chemicals or the delivery system for scale inhibitors.

Due to the higher flow rates at TP-2, the initial cost for an activated carbon system and yearly carbon costs would be higher, and conversion of this plant to GAC treatment may not yet be cost-effective. However, if extraction rates remain at FY99 levels, or if optimization of the extraction system as proposed in Section 4.2.2 can achieve the projected reductions in pumping rates, all extracted groundwater could be directed to TP-2, and TP-1 could be taken off line. Such a modification would reduce treatment plant performance monitoring costs by half, and would eliminate all TP-1 OM&M costs. Once the extraction system is optimized, this RPO opportunity may merit careful evaluation.

An additional benefit of groundwater treatment using activated carbon would be a significant reduction in contact of the groundwater with air, and therefore a reduction in the consequent formation of calcium and other oxides. This benefit could reduce the need for addition of chemical scale and precipitation inhibitors, and the cost of supplying and maintaining these systems. Moreover, wellhead GAC systems for pesticides would no longer be required if flow from these wells is directed to TP-1 once the air stripper is replaced with a centralized activated-carbon treatment system. Because GAC systems generate no offgas, no VOCs could be discharged to the atmosphere. This would ensure that the vapor-phase offgas systems could remain offline permanently, and therefore should be well-received by the state environmental regulators.

Alternative Scale Inhibitors

If air stripping remains the primary treatment technology for VOCs in OU1 groundwater (e.g., at TP-2), alternatives to carbon dioxide should be considered to control scale deposits. One scale inhibitor that has worked well with air stripping systems that discharge to injection trenches is the AQUA MAG™ product sold by Carus Chemical Corporation (1-800-435-6856). This product is a liquid, inorganic phosphate complex that has proven effective at a site with calcium hardness problems. The chemical cost is approximately $40.00 per million gallons for groundwater with an assumed hardness of 200 mg/L as calcium carbonate ($CaCO_3$). AQUA MAG™ is not recommended for systems with bacterial fouling, as the phosphate can promote bacterial growth. Based on available data, biofouling is not expected to be a concern for the DDJC-Tracy TP influent.

During a 1996 pilot test of AQUA MAG™ conducted by Radian, an annual cost for addition of this scale inhibitor was estimated at $30,000. Results of the pilot test were promising, and URS is currently updating the 1996 scaling study (Sharpe, 2001).

4.2.4 Discharge System Assessment

As described in Section 4.2.1, the OU1 remedy selected in the RODs calls for discharge of treated groundwater to a series of 10 infiltration galleries installed in the shallow saturated zone (Above Upper and Upper hydrostratigraphic units) (Figure 1.4). Because the IGs have a history of hydraulic capacity problems, the WDR order (California RWQCB, 1998a) also permits discharge of treated effluent in excess of IG capacity to the stormwater retention pond (SWMU 4). In FY99, IG overflow was routed to the unlined sewage lagoon northeast of SWMU 4 during a period of construction at TP-1 (Radian, 2000c).

During FY99, approximately 265 million gallons of effluent was discharged to the IGs (about 253 million gallons) and the sewage lagoon (about 8 million gallons), with the majority of the flow (180 million gallons) disposed of in IG2 through IG6 (Figure 1.4) (Radian, 2000c). Based on average flow rates for treatment plant operations during the period from November 1999 through April 2000, Radian (2000e) projected an average treatment flow rate of 1.41 million gallons per day, or 979 gpm, at the current ETI system configuration (28 of 35 extraction wells operating). Radian also projected an increase of 525 gpm in treatment flows by late 2000 based on the planned repair of seven inoperable extraction wells and the addition of up to 13 new wells. Radian (2000e) concluded that

up to 1,504 gpm of treated effluent could require disposal under an expanded extraction system scenario.

However, as discussed in Section 4.2.2, the average annual flow rate for the integrated ETI system during FY00 was 359 gpm (84 gpm at TP-1 and 275 gpm at TP-2), and the combined average flow rate for the two TPs during FY99 was 690 gpm (Table 4.5). If the optimization plan outlined in Section 4.2.2 is implemented, the FY99 flow rate could be reduced by as much as 39 percent. Even allowing for the addition of new extraction wells (e.g., the five wells planned for pesticide extraction and a recommended well near the DSERTS 68/Area 3 source area), Radian's (2000e) projected flow volumes seem high, and total treatment plant throughput could be closer to 500 gpm.

The existing IGs have an estimated capacity (based on past performance) of 1,045 gpm (280 gpm for IG1 and CD1, 105 gpm for the northern galleries [IG7 through IG9], and 660 gpm for the southern galleries [IG2 through IG6]) (Radian, 2000e). If Radian's expanded-ETI-system operating assumptions are valid, these calculations suggest a possible shortfall in infiltration gallery capacity of about 460 gpm. Based on average FY99 and FY00 flow rates, however, IG capacity should not have been exceeded, on average, during either of the last two fiscal-year periods. Conversely, performance of the IGs deteriorated significantly during late 2000, and actual IG capacity is uncertain (Sharpe, 2001). Under the proposed optimized system scenario, total estimated flows (i.e., 420 gpm) should be well within the IG capacity estimated by Radian (2000e).

Based on their projected discharge-capacity shortfall in the DDJC-Tracy ETI system (Radian, 2000e), URS is conducting overland flow pilot tests to evaluate the potential usefulness of this alternative for discharge of treated effluent from TP-1 and TP-2. In an overland flow system, water is discharged onto the ground surface within a bermed, tilled plot, and disposed of through infiltration and evaporation. As part of this RPO Phase II evaluation, Parsons ES reviewed the results of a 33-day pilot test (Radian, 2000b) and the work plan for a scale-up, 12-month pilot test (Radian, 2000e) of this alternative effluent disposal method. The pilot studies are described briefly in the following paragraphs.

A 33-day overland flow pilot test was conducted in late 1999 using an 0.8-acre plot on the Tracy Annex for disposal of treated effluent from TP-2. During the test, approximately 1.9 million gallons of water was disposed of by directing a portion of TP-2 effluent onto the tilled surface of the test plot at a rate that prevented ponding. Groundwater levels in nearby wells was monitored, and no changes in water levels were observed. Radian (2000b) estimated a long-term disposal rate of 87 gpm per acre based on the results of the pilot test. A 1-year pilot test using an 8.0-acre plot is currently underway to evaluate seasonal effects on long-term water disposal rates and to refine the estimated per-acre disposal capacity of this method. Costs to conduct this test were estimated at $28,300 (Radian, 2000e).

While overland flow appears to provide a low-cost effluent disposal method to supplement infiltration, several concerns were raised during the initial pilot test. The most potentially serious of these relates to the quality of the treated effluent with respect to the (non-contaminant) inorganic parameters chloride and (to a lesser extent) boron. Concentrations of these constituents in the treated effluent exceeded agricultural water quality requirements (Radian, 2000b), suggesting that additional treatment might be required by the RWQCB before discharge to the ground surface would be allowed.

Alternatively, it may be possible to dedicate the overland flow plot to its remedial purpose, and to implement institutional controls to prevent future use of the land for agriculture. The long-term effects of chloride (and other inorganic compound) loading on the permeability of the soils within an overland flow plot also should be considered.

Currently, chloride and boron are not of regulatory concern because the treatment plant effluent concentrations are representative of ambient water quality in the Upper Tulare Aquifer, to which the water is returned via the IGs. Because monitoring of these constituents is not currently required under the ROD (Montgomery Watson, 1996a; Radian, 1998a) or by the WDR order (California RWQCB, 1998a), a ROD ESD and revision of the WDR order would be required to modify the OU1 remedy to include overland flow for effluent disposal. An ESD to this end currently is being pursued. Post-air-stripper (or post-GAC) treatment to remove chlorides and other inorganic constituents would create a secondary waste stream requiring disposal, and would add to OM&M costs for overland disposal. If such treatment is required, a focused FS would be needed to evaluate available treatment technologies (e.g., reverse osmosis).

The scale-up work plan (Radian, 2000e) also indicates that evapotranspiration is one mechanism of disposal for discharge effluent. However, neither the original overland flow pilot test nor the scale-up test provide for testing the use of plants to either stabilize the test plots or to accelerate rates of water disposal; rather, these tests rely on infiltration and evaporation (Radian, 2000b and 2000e). Unless elevated inorganic concentrations are addressed, use of the discharged effluent to irrigate plants may prove counterproductive.

Radian (2000b) suggests that use of overland flow plots east of IGs 7 through 9 would have the added benefit of extending the hydraulic barrier formed by the northern IGs to better deflect northward migration of the CAH plumes eastward toward the extraction well network along Banta Road (Figure 1.4). Monitoring of groundwater elevations near the 0.8-acre test plot during the initial pilot test indicated that water levels were unaffected by surface disposal of water in the plot during that 33-day test (Radian, 2000b). The effects on the 10-foot-bgs water table of long-term overland flow to a larger plot will be assessed during the 12-month scale-up testing. These data also will provide information on the impact of flood irrigation in the fields adjoining the test plot on both the water table and the infiltration rates for the test plot itself. Based on current plume migration trends, it is unclear that a hydraulic barrier east of IG9 is necessary for plume containment (see Section 2).

Based on the evaluation of the OU1 groundwater extraction system (Section 4.2.2), the need for alternative methods for disposing of treated groundwater could be reduced through reductions in the volume of groundwater extracted. Even at the average FY99 extraction-system pumping volume of 690 gpm, assuming no extraction-system optimization, the current IG system should have adequate capacity to accommodate the all treatment plant effluent. However, IG performance during the winter of 2000/2001 deteriorated significantly due to scaling (Sharpe, 2001), and IG capacity appears to be lower than predicted. Pending the outcome of the 12-month overland flow test, it may be adequate to amend the ROD and WDR order to include limited overland flow disposal as an emergency overflow system, similar to that currently allowed for the stormwater pond. The benefits of having this effluent-disposal-system redundancy would have to be weighed against the cost of maintaining and monitoring an overland flow system.

4.3 EVALUATION OF GROUNDWATER MONITORING PROGRAM

Periodic monitoring of groundwater and the groundwater ETI system is conducted at DDJC-Tracy to evaluate environmental conditions, assess compliance with remediation objectives and WDRs, track system performance, and assess the progress of remedial activities. This section reviews the current OU1 groundwater monitoring program, presents an evaluation framework to better optimize the program, reviews results of the diffusion sampler demonstration, and evaluates the performance of the incumbent analytical laboratory.

4.3.1 2000 Groundwater Monitoring Program

Currently, groundwater samples are collected from monitoring wells, extraction wells, and off-site potable water wells on a quarterly, semi-annual, or annual basis, depending on the location of the well and the purpose of monitoring (Radian, 1999a). Approximately 150 monitoring wells and 37 extraction wells are included in the groundwater monitoring program (Radian, 2000c). Groundwater samples from most monitoring wells are analyzed for VOCs and pesticides, and groundwater samples from a subset of the monitoring network are analyzed for SVOCs, metals, herbicides, dioxins/furans, simazine, and fuel hydrocarbons, in accordance with the WDR order (California RWQCB, 1998a) and the ROD (Radian, 1998a). During most of FY00, selected wells also were analyzed for geochemical indicators of natural attenuation (Radian, 1999b).

Samples are collected on a monthly basis from sampling ports at the TPs for analysis of VOCs and pesticides. These data are used to evaluate chemical mass removal and compliance with ROD/WDR effluent standards. Quarterly samples are collected from all active extraction wells and analyzed for VOCs and pesticides to evaluate the concentrations of COCs in extracted groundwater (Radian, 2000c). The monitoring program that was carried out during FY99 (i.e., October 1998 through September 1999) is summarized in the *Well Monitoring Program 1999 Annual Monitoring Report* (Radian, 2000c).

4.3.2 Overview of Monitoring Program Optimization Process

Groundwater monitoring programs have two primary objectives (USEPA, 1994a; Gibbons, 1994):

- Evaluate long-term temporal trends in contaminant concentrations at one or more points within or outside of the remediation zone, as a means of monitoring the performance of the remedial measure (*temporal evaluation*); and

- Evaluate the extent to which contaminant migration is occurring, particularly if a potential exposure point for a susceptible receptor exists (*spatial evaluation*).

The relative success of any remediation system and its components (including the monitoring network) must be judged based on its ability to achieve the stated objectives of the system. Designing an effective groundwater monitoring program involves locating monitoring points and developing a site-specific strategy for groundwater sampling and analysis that maximizes the amount of relevant information that can be obtained while

minimizing incremental costs. Relevant information is that required to effectively address the temporal and spatial objectives of monitoring. The effectiveness of a monitoring network in achieving these two primary objectives can be evaluated quantitatively using statistical techniques. In addition, there may be other important considerations associated with a particular monitoring network that are most appropriately addressed through a qualitative hydrogeologic evaluation of the network. The qualitative evaluation may consider such factors as hydrostratigraphy, locations of potential receptor exposure points with respect to a dissolved plume, and the direction(s) and rate(s) of contaminant migration. The optimal evaluation of a monitoring network should therefore be conducted in complementary stages to address each of the objectives and considerations of monitoring: a qualitative evaluation is first completed, followed by temporal and spatial evaluations. The decision tree presented on Figure 4.16 is intended to complement decision trees (e.g., for sampling frequency) that are currently used at DDJC-Tracy (Radian, 2000c).

It was beyond the scope of this RPO evaluation to perform a complete monitoring network optimization evaluation. However, this section describes a process for, and provides directions on how to implement, the evaluation. Similar evaluations at other military installations (Parsons ES, 2000c, 2000c, 2000d, and 2001) have resulted in recommendations of reducing monitoring program costs by as much as 40 percent (Parsons ES, 2000d). A decision tree is presented on Figure 4.16. The flow of the decision logic presented on this figure is designed to efficiently guide the user through a groundwater monitoring network optimization using qualitative, temporal, and spatial evaluations. The decision tree [resented on Figure 4.16 is intended to complement decision logic (e.g., for sampling frequency) that currently are used at DDJC-Tracy (Radian, 2000c).

The qualitative evaluation consists of a series of yes/no questions and is fairly self-explanatory. The temporal evaluation requires performing temporal trend analyses (e.g., regression or Mann-Kendall) on the complete data sets for each monitoring well. Results of the trend analysis are then evaluated using the decision logic presented on Figure 4.16. The spatial evaluation involves kriging the spatial distribution and relative similarity of data sets from neighboring monitoring wells. Results of the kriging analysis are then considered in the decision tree, and a final determination of whether a monitoring point should be retained, modified (e.g., through a change in sampling frequency), or removed from the monitoring program is established.

Section 4.3.2.1 describes the three steps involved in the optimization evaluation. Section 4.3.2.2 is provides a cost analysis that considers savings that could be realized if the LTM program optimization process produced results similar to those achieved for a subset of wells at DDJC-Sharpe (Parsons ES, 2001).

4.3.2.1 Monitoring Program Evaluation Process

Qualitative Hydrogeologic Evaluation

An effective monitoring program will provide information regarding plume migration and changes in chemical concentrations through time at appropriate locations, enabling decision-makers to verify that contaminants are not endangering potential receptors, and that remediation is occurring at rates sufficient to achieve RAOs. The design of the

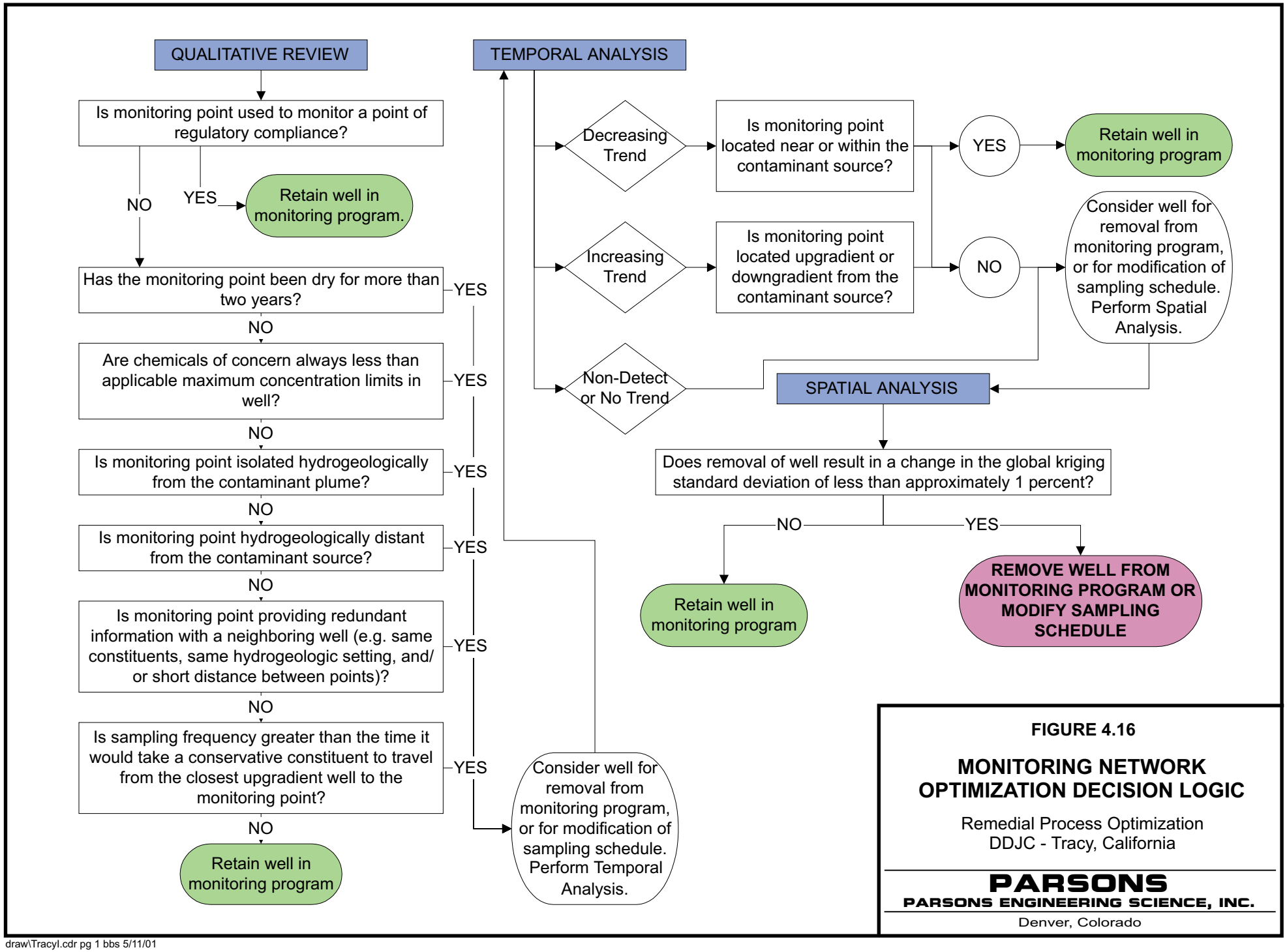


FIGURE 4.16

MONITORING NETWORK OPTIMIZATION DECISION LOGIC

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw\Tracyl.cdr pg 1 bbs 5/11/01

monitoring program should therefore include consideration of existing receptor exposure pathways, as well as exposure pathways arising from potential future use of the groundwater.

Performance monitoring wells located upgradient, within, and just downgradient from a plume provide a means of evaluating system effectiveness relative to performance criteria. Of course such well placement is dependent on adequate plume characterization. LTM at these wells also provides information about migration of the plume and temporal trends in chemical concentrations. Contingency (i.e., sentry) monitoring wells downgradient from a plume are used to ensure that the plume is not expanding past the remediation zone or containment system, and to trigger a contingency remedy if contaminants are detected.

Primary factors to consider in designing a monitoring network include:

- Types of contaminants,
- Aquifer heterogeneity,
- Distance to potential receptor exposure points,
- Groundwater seepage velocity,
- Potential surface-water impacts, and
- The effects of the remediation system.

These factors will influence the locations and spacing of monitoring points and the sampling frequency. Typically, the greater the seepage velocity and the shorter the distance to receptor exposure points, the more frequently groundwater sampling should be conducted. One of the most important objectives of LTM is to confirm that a contaminant plume is behaving as predicted. Qualitative (visual or graphical) and statistical tests can be used to evaluate plume stability. If a groundwater remediation system is effective, then over the long term, groundwater monitoring data should demonstrate clear and meaningful decreasing trends in concentrations at appropriate monitoring points.

For OU1 at DDJC-Tracy, the qualitative evaluation might include evaluating the current distribution of monitoring locations and sampling frequencies. As described in Section 2.3, delineation of the extent of dissolved contamination in OU1 groundwater is incomplete in some area (e.g., the easternmost PCE and TCE plumes). Without adequate plume characterization, it is not possible to evaluate plume stability (i.e., whether the plume is expanding, stable, or receding). URS is planning additional plume characterization off-Annex to delineate the downgradient extent of TCE east of Banta Road (Radian, 2000c). Based on the apparent distribution of TCE in this area, Parsons ES recommends that these investigations explore the potential for a secondary off-Annex source that may help explain the observed, apparently discontinuous nature of the dissolved plume in the shallow saturated zone (Sections 2.3 and 2.5).

The selection of monitoring wells to be sampled in the LTM program has been inconsistent over time (see Sections 2.4 and 2.5). When the group of wells to be sampled varies, it becomes difficult to make interpretations of plume evolution over time. A review of the plume interpretations for 3Q98 and 3Q99 presented on Figures 2.10 and 2.11 (Radian, 2000c) demonstrates this concept. As shown on Figure 2.10, the areal extents of the TCE plumes in all hydrostratigraphic horizons appear to change between 1998 and 1999, and the 3Q99 plume shown in the Upper horizon east of Banta Road was not detected in 1998. For the most part, the differences in interpreted plume configurations are due to inconsistencies in the data available for the two periods. The thematic maps presented as Figures 2.15 through 2.18 highlight the inconsistencies in VOC sampling locations over time, and allow the reviewer to take these discrepancies into account when interpreting the areal extent of the TCE plumes (see Section 2.5). A consistent approach to sampling location selection should be implemented to enable better assessment of plume extent, magnitude, and stability from year to year.

Temporal Statistical Evaluation

Temporal data (chemical concentrations measured at the same location over time) can be examined graphically or using statistical tests to evaluate plume stability. If removal or dispersion of COC mass is occurring in the subsurface as a consequence of ETI system operation or attenuation processes, these phenomena will be apparent as decreases in COC concentrations through time at a particular sampling location, as decreases in chemical concentrations with increasing distance from source areas, and/or as changes in the suite of chemicals through time or with increasing migration distance. Of course, the reliability of temporal analyses is dependent on the monitoring history for each sampling point: the longer the period of time for which data are available, the more reliable the interpretation of trends over time.

Temporal chemical-concentration data can be evaluated by plotting contaminant concentrations through time for individual monitoring wells, or by plotting contaminant concentrations versus downgradient distance from the contaminant source for several wells along the groundwater flowpath, over several monitoring events. Plotting temporal concentration data is recommended for any analysis of plume stability (Wiedemeier and Haas, 1999); however, visual interpretation of trends in plotted data is a subjective process, particularly if (as is likely) the concentration data are variable through time.

The possibility of arriving at incorrect conclusions regarding plume stability on the basis of visual examination of temporal concentration data can be reduced by examining temporal trends in chemical concentrations using various statistical procedures, including regression analyses and the Mann-Kendall test for trends. The Mann-Kendall non-parametric test (Gibbons, 1994) is well-suited for application to the evaluation of environmental data because the sample size can be small (as few as four data points), no assumptions are made regarding the underlying statistical distribution of the data, and the test can be adapted to account for seasonal variations in the data. The Mann-Kendall test statistic can be calculated at a specified level of confidence to evaluate if a temporal trend is present in contaminant concentrations detected through time in samples from an individual well. If a trend is determined to be present, a nonparametric slope of the trend line (change per unit time) can also be estimated using the test procedure. A negative slope (indicating decreasing contaminant concentrations through time) or a positive slope (increasing concentrations through time) provides statistical confirmation of temporal

trends that may have been identified visually. DDJC-Tracy routinely interprets temporal concentration trends in groundwater using the Mann-Kendall test (Radian, 2000c).

The amount of information obtained from periodic monitoring at a particular monitoring well can be evaluated by considering the location of the well within (or outside of) the contaminant plume, the location of the well with respect to potential receptor exposure points, and the presence or absence of temporal trends in contaminant concentrations in samples collected from the well. The degree to which the amount and quality of information obtainable at a particular monitoring point serves the two primary objectives of monitoring (temporal and spatial objectives) must be considered in this evaluation. For example, the continued reporting of a contaminant in groundwater at concentrations below the detection limit at a monitoring location provides no information about temporal trends in contaminant concentrations, or about the extent to which contaminant migration is occurring, unless the monitoring location lies along a groundwater flowpath between a contaminant source and a potential receptor exposure point and is intended to serve as a sentry well. Therefore, a monitoring well having a history of contaminant concentrations below detection limits may be providing no useful information, depending on its location.

A trend of increasing contaminant concentrations in groundwater at a location between a contaminant source and a potential receptor exposure point may represent information critical in evaluating whether contaminants may migrate to the exposure point, thereby completing an exposure pathway. Identification of a trend of decreasing contaminant concentrations at the same location may be useful in evaluating decreases in a plume's areal extent, but does not represent information that is critical to the protection of a potential receptor. Similarly, a trend of decreasing contaminant concentrations in groundwater near a contaminant source may represent important information regarding the progress of remediation near, and downgradient from the source, while identification of a trend of increasing contaminant concentrations at the same location does not provide as much useful information regarding contaminant conditions. By contrast, the absence of a temporal trend in contaminant concentrations at a particular location within or downgradient from a plume indicates that virtually no additional information can be obtained by continued monitoring of groundwater at that location, in that the results of continued monitoring through time are likely to fall within the historic range of concentrations that have already been detected. Continued monitoring at locations where no temporal trend in contaminant concentrations is present serves merely to confirm the results of previous monitoring activities at that location. The relative amounts of information generated by the results of temporal trend evaluation at monitoring points near, upgradient from, and downgradient from contaminant sources are presented schematically as follow:

Monitoring Point Near Contaminant Source

Relatively less information	Nondetect or no trend
↕	Increasing trend in concentrations
Relatively more information	Decreasing trend in concentrations

Monitoring Point Upgradient from Contaminant Source

Relatively less information	Nondetect or no trend
↕	Decreasing trend in concentrations
Relatively more information	Increasing trend in concentrations

Monitoring Point Downgradient from Contaminant Source

Relatively less information	Decreasing trend in concentrations
↕	Nondetect or no trend
Relatively more information	Increasing trend in concentrations

Currently, URS performs Mann-Kendall temporal analyses on data from several monitoring wells at DDJC-Tracy (Radian, 2000c). These analyses constitute a significant part of the monitoring program optimization evaluation, and will reduce the effort required to perform a comprehensive evaluation.

Spatial Statistical Evaluation

Spatial statistical techniques also can be applied to the design and evaluation of monitoring programs to assess the quality of information generated during monitoring, and to optimize monitoring networks. Geostatistics, or the theory of regionalized variables (Clark, 1987; Rock, 1988; American Society of Civil Engineers [ASCE], 1990a and 1990b), is concerned with variables that have values dependent on location and are continuous in space, but which vary in a manner too complex for simple mathematical description. The theory of regionalized variables begins from the premise that the differences in values of a spatial variable depend only on the distances between, and the relative orientations of, sampling locations -- that is, the values of a variable (e.g., concentrations of TCE) measured at two locations that are spatially "close together" will be more similar than values of that variable measured at two locations that are "far apart". If known sample values are used, the value of the variable (e.g., chemical concentrations) at any point within the sampled region can be estimated, in the process known as "kriging" (Clark, 1987; ASCE, 1990a and 1990b). An additional advantage of kriging as an estimation technique is that the standard deviations (i.e., errors) associated with the values estimated at each point in the spatial domain also are calculated during the kriging process.

Areas containing estimated concentration values having elevated standard deviations represent locations where additional information could be collected to reduce uncertainties regarding the extent of VOCs in the subsurface. This observation implies that the monitoring program could be optimized by using available information to identify those areas having the greatest associated uncertainty. Conversely, sampling points can be successively eliminated from simulations, and the standard deviations examined, to evaluate if significant loss of information (represented by increases in standard deviations) occurs as the number of sampling points is reduced. Iterative

application of geostatistical estimating techniques, using tentatively identified sampling locations, can then be used to generate a sampling program that would provide an acceptable level of uncertainty regarding chemical distribution across the area to be monitored, with the minimum possible number of samples collected.

Currently, geostatistical applications or other spatial-analysis tools are not used to evaluate the groundwater LTM program at DDJC-Tracy. Incorporation of periodic geostatistical analyses will facilitate optimization of the monitoring program. This approach recently was applied to the monitoring program for OU D at McClellan AFB (Parsons ES, 2000c) and to a subset of wells at DDJC-Sharpe (Parsons ES, 2001), with good results. The approach used in the McClellan AFB and DDJC-Sharpe RPO evaluations provides a template for possible application at DDJC-Tracy.

4.3.2.2 Cost Analysis

In the absence of actual monitoring program costs for DDJC-Tracy OU1, which were not available for this evaluation, estimated program costs, based on professional judgment, were used to prepare a cost analysis for the 2000 annual groundwater monitoring program at DDJC-Tracy. Table 4.9 summarizes:

- Analytical costs for the types of analyses performed, the number of times each analysis was performed, and the estimated cost per analysis;
- Estimated direct labor costs to perform sampling, data management, and reporting;
- Re-usable capital investment items such as bladder pumps, control boxes, and air compressors (see discussion in Section 4.3.3); and
- Other direct costs.

Because the estimates are intentionally conservative, the costs presented in Table 4.9 probably underestimate actual annual monitoring program costs.

Available database information indicates that OU1 groundwater samples were collected from a total of 78 wells in 4Q99, 114 wells in 1Q00, 72 wells in 2Q00, and 149 wells in 3Q00. A total of 413 primary and 59 quality control (QC) samples from 157 different wells were collected during that 1-year period. For the purposes of this cost analysis, the analyses proposed for the period from October 1999 through September 2000 (FY00) are assumed to represent the scope of a typical annual monitoring program (Radian, 2000c).

As shown in Table 4.9, the total annual estimated LTM program cost at DDJC-Tracy is approximately $370,000. Of this amount, approximately $210,000 is for analytical costs, $132,000 is for direct labor, $19,000 is for other direct costs, and $9,000 is for re-usable items. Note that this estimate for monitoring alone exceeds the ROD estimate for annual OM&M costs (Radian, 1998a) by more than $150,000 (see Table 4.6).

The monitoring program optimization evaluation described in Section 4.3.2 has not been performed for DDJC-Tracy OU1. Therefore, the optimization performed at DDJC-Sharpe (Parsons ES, 2001) was used to infer relative costs for comparison. Use of the

TABLE 4.9

ESTIMATED COSTS ASSOCIATED WITH CURRENT MONITORING PROGRAM[a/]

REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

472 Samples Collected per Year						
Cost type	**Quantity**	**Units**		**Unit Cost**		**Cost**
Direct Labor						
Sample collection						
(1 person, 50 minutes per sample at $65/hr)	393	hours	$	65.00	$	25,566.67
Data validation and management						
(1 person, 1 hour per sample at $80/hr)	472	hours	$	65.00	$	30,680.00
Reporting						
(2 hours per sample at $80/hr)	944	hours	$	80.00	$	75,520.00
		Subtotal Direct Labor Costs:			**$**	**131,766.67**
Laboratory Analyses/Methods[b/]						
1613	2	analyses	$	1,700.00	$	3,400.00
A5210B	7	analyses	$	45.00	$	315.00
E160.1	7	analyses	$	20.00	$	140.00
E300	7	analyses	$	25.00	$	175.00
E300.0	7	analyses	$	25.00	$	175.00
E310.1	7	analyses	$	20.00	$	140.00
E376.2	8	analyses	$	45.00	$	360.00
E507	6	analyses	$	142.00	$	852.00
E601	8	analyses	$	90.00	$	720.00
E602	8	analyses	$	70.00	$	560.00
M8015	34	analyses	$	75.00	$	2,550.00
SW6010B	86	analyses	$	25.00	$	2,150.00
SW7041	62	analyses	$	30.00	$	1,860.00
SW7470A	52	analyses	$	45.00	$	2,340.00
SW7740	62	analyses	$	30.00	$	1,860.00
SW7841	62	analyses	$	30.00	$	1,860.00
SW8015D	123	analyses	$	85.00	$	10,455.00
SW8015G	157	analyses	$	75.00	$	11,775.00
SW8021	1	analyses	$	155.00	$	155.00
SW8021A	123	analyses	$	155.00	$	19,065.00
SW8081A	232	analyses	$	130.00	$	30,160.00
SW8141	11	analyses	$	152.00	$	1,672.00
SW8151A	25	analyses	$	225.00	$	5,625.00
SW8260B	379	analyses	$	160.00	$	60,640.00
SW8270C	35	analyses	$	260.00	$	9,100.00
SW8321	208	analyses	$	195.00	$	40,560.00
SW9060	7	analyses	$	47.50	$	332.50
SW9221	7	analyses	$	45.00	$	315.00
		Subtotal Analytical Costs:			**$**	**209,311.50**
Annualized cost of re-usable items (see Table 4.10)						
Bladder pump	1/30	30-yr total	$	235,500.00	$	7,850.00
Control box/regulator	1/30	30-yr total	$	18,000.00	$	600.00
Air compressor	1/30	30-yr total	$	12,000.00	$	400.00
		Subtotal Re-usable Items Costs:			**$**	**8,850.00**
Other Direct Costs						
Equipment rental[c/] (1 per team per event, 2 teams)	40	days	$	400.00	$	16,000.00
Vehicle Rental (1 per team per event, 2 teams)	40	days	$	55.00	$	2,200.00
Miscellaneous Field Supplies (1 per event)	4	lump sum	$	100.00	$	400.00
		Subtotal Other Direct Costs:			**$**	**18,600.00**
		TOTAL ESTIMATED ANNUAL COST			**$**	**368,528.17**

[a/] Estimated by Parsons ES based on fiscal year 2000 sampling program (Radian, 2000c).
Costs for analyses using methods SM3500E and SW3810 were unavailable, and are excluded.

[b/] Analytical costs were provided by CalTest Analytical Laboratory unless otherwise noted.

[c/] e.g. - photoionization detector, pH/Eh meter.

monitoring program optimization performed at DDJC-Sharpe is appropriate for comparative purposes at DDJC-Tracy due to the relative similarity of the hydrogeology, the monitoring programs, the sampling techniques, and the target analytes at the two installations. More specifically, similarities between the two installations include:

- Similar types of facility (DLA supply depot) located within 10 miles of each other;
- Similar hydrogeologic settings;
- Similar primary COCs (chlorinated VOCs);
- The same environmental contractor (URS/Radian – Sacramento) conducts both LTM programs;
- The same contract analytical laboratory (Caltest) performs chemical analyses; and
- The same regulatory agencies (Central Valley RWQCB, California Environmental Protection Agency, and USEPA Region 9) oversee ROD implementation.

Based on results of the recent RPO evaluation, the following recommendations were proposed for the South Balloon area at DDJC-Sharpe (Parsons ES, 2001):

- Eliminate VOC monitoring at 20 (29 percent) of 68 wells currently monitored for these analytes;
- Eliminate metals monitoring at 7 (24 percent) of 29 wells currently monitored for metals;
- Reduce the monitoring frequency for at least one analytical method at 57 (77 percent) of 74 wells; and
- Add one analytical method to analyses for 2 of 74 wells (3 percent).

If implemented, these recommendations were expected to reduce annual groundwater sampling program costs at DDJC-Sharpe by approximately 30 percent (Parsons, 2001). If comparable optimization results are extrapolated for DDJC-Tracy, a relative cost saving at DDJC-Tracy of approximately $110,000 per year could be expected. Assuming a 30-year monitoring program life, a total program savings of $3,300,000 (in constant year-2000 dollars) can be projected. Implementation of the RPO decision tree (Figure 4.16) at DDJC-Tracy would be required to refine these extrapolated cost savings.

4.3.3 Diffusion Sampler Evaluation

A field evaluation of diffusion samplers was performed at DDJC-Tracy to compare the effectiveness of this VOC groundwater sampling method to the standard sampling method (low-flow/minimal-drawdown purging, or micropurging) currently used for VOC sampling in the DDJC-Tracy LTM program (Radian, 2000c). Field sampling was conducted using diffusion samplers developed by the US Geological Survey (Vroblesky and Campbell, 2000), and currently manufactured by EON Products, Inc. of Lithonia, Georgia. Seven existing groundwater monitoring wells that are routinely sampled during

the OU1 monitoring program were sampled for VOCs using diffusion-sampling technology. The RPO work plan (Parsons ES, 2000a) provides a description of this passive sampling technology and the procedures for its use.

4.3.3.1 Diffusion-Sampler Field Test

Two field mobilizations to DDJC-Tracy were required to complete the diffusion-sampler evaluation. The diffusion samplers were installed in the selected wells on October 6, 2000, and the samplers were retrieved on October 24, 2000. Groundwater samples were collected from the following monitoring wells at DDJC-Tracy (Figure 2.2):

- Above Upper horizon wells LM032AU, LM035AU, LM143AU; and
- Upper horizon wells LM080A, LM154A, LM156A, LM157A.

The samples were submitted to Caltest for analysis of VOCs using USEPA Method 8260B. To ensure comparability of analytical results between the two sampling methods, the diffusion samplers were retrieved immediately prior to commencement of well purging and sampling for VOCs by URS during the scheduled 4Q00 groundwater sampling event. The URS samples also were submitted to Caltest for analysis using Method 8260B. Sampling results are presented in Section 4.3.3.3.

4.3.3.2 Deviations from the Work Plan

Placement and retrieval of the diffusion samplers were accomplished in accordance with the RPO project work plan (Parsons ES, 2000a), with the following exceptions.

- Dedicated in-well sampling devices (bladder pumps) were not removed from the wells prior to diffusion sampler placement. Rather, the diffusion samplers were placed in the wells at depths believed to be similar to the depths of the dedicated pump intakes. This deviation from the work plan was necessary to avoid affecting the performance of the existing groundwater monitoring program.
- Of the seven wells sampled during the RPO investigation, two (LM032AU and LM035AU) are constructed of 2-inch polyvinyl chloride (PVC), and the remaining five are constructed of either 4- or 6-inch PVC. The standard design of the test diffusion samplers calls for a 1.5-foot-long section of 2-inch-diameter, 4-mil polyethylene tubing that is sealed on both ends. Although the standard sampler was appropriate for use in the wells with casing diameters larger than 2 inches, it was not appropriate for use in the 2-inch-diameter wells. Accordingly, modified diffusion samplers were constructed, using like materials, with 3.3-foot (40-inch) by 1-inch dimensions. The smaller diameter of these samplers required a longer section of tubing to allow for collection of adequate sample volume for analysis.

The diffusion samplers used in the RPO evaluation were shipped empty to the field and filled onsite with deionized water. Use of commercially available, laboratory-filled diffusion samplers would eliminate this field task.

4.3.3.3 Analytical Results and Data Comparability

Analytical results for samples collected using the diffusion samplers are compared to results from the conventional sampling in Table 4.10. The comparison of results for each well is quantified in the table through the use of relative percent differences (RPDs). RPD is defined by the following equation:

$$RPD = 100*[abs(DS-MP)]/[(DS+MP)/2]$$

where:

abs = absolute value

DS = diffusion sampler result

MP = micropurge (conventional) sample result

For this evaluation, an RPD of less than 25 was considered to demonstrate good correlation between sample results. In five of the seven wells evaluated, the RPDs between diffusion sampler and the micropurge samples are less than 25 (Table 4.10), demonstrating good accuracy and comparability. However, the RPDs for both PCE and TCE in samples from wells LM032AU and LM143AU significantly exceeded 25. In both instances, the reported values from the diffusion samplers were less than the values reported for the micropurge samples.

In the case of LM032AU, the low results obtained from the diffusion sampler was due to placement of the sampler at an elevation within the well that left part of the sampler above the groundwater surface elevation (Table 4.10). At the time of sample retrieval, approximately 3 feet (75 percent) of the diffusion sampler extended above the groundwater surface and was exposed to the atmosphere. This allowed volatilization of VOCs from the sampler, resulting in decreased VOC concentrations when compared to traditional (micropurge) sampling. Interestingly, the diffusion sampler in well LM035AU also was exposed to the atmosphere at the time of sampler retrieval, but results for this well were comparable to those of conventional sampling (Table 4.10).

The reasons for the high RPDs between results for the diffusion and micropurge samples from well LM143AU are less apparent. In this well, both types of samples were collected from approximately the same depth, and the diffusion sampler was completely submerged prior to retrieval, such that volatilization of VOCs was unlikely. Both samples were collected from within the screened interval of the well, though at discrete depths about 2 feet apart (Table 4.10). The observed differences in sample results may be due to lithogoic, hydraulic, and/or chemical heterogeneity within the screened or open intervals of the well, and/or to the relative permeability of the well screen (Vroblesky and Campbell, 2000).

Although the results obtained using each method for LM035AU are comparable, apparent discrepancies in the well construction information and the field conditions were noted. As shown in Table 4.10, the calculated groundwater elevation at this well is lower than the elevation of the dedicated pump intake. Because a groundwater sample was obtained from this well using the micropurge method, and because the elevation of the

TABLE 4.10
COMPARISION OF DIFFUSION SAMPLER AND MICROPURGE SAMPLING RESULTS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

	Preliminary Analytical Results (4Q00)				Comparison		Well Data and Sampling/Groundwater Depths				
	Diffusion Sampler [a/]		Low-flow Purge		PCE	TCE					
Well ID	PCE (µg/L) [c/]	TCE (µg/L)	PCE (µg/L)	TCE (µg/L)	RPD[b/] (percent)	RPD (percent)	Well Diameter (inches)	Screened Interval Elevation (feet amsl)[d/]	Pump Intake Elevation (feet amsl)	Diffusion Sampler Elevation (feet amsl)	Groundwater Elevation (feet amsl)
LM032AU	38	9.1	110 E [e/]	42 E	97	129	2	58.65 - 48.65	52.65 - 52.15	61.95 - 58.62	58.94
LM143AU	0.6	< 0.5	1.1	1.2	59	≥82	4	59.00 - 44.00	51.50 - 51.00	55.02 - 53.52	56.96
LM035AU	5.8	< 0.5	5.1	0.58	13	≥15	2	69.02 - 59.02	64.02 - 63.52	63.18 - 59.85	60.05
LM080A	< 0.5	0.8	< 0.5	0.82	NA[f/]	2	4	44.96 - 34.96	39.96 - 39.46	46.71 - 45.21	53.04
LM154A	< 0.5	6.6	< 0.5	5.3	NA	22	6	35.67 - 25.67	30.67 - 30.17	28.70 - 27.20	48.02
LM156A	< 0.5	8.6	< 0.5	7.9	NA	8	6	37.50 - 12.50	25.00 - 24.50	22.99 - 21.49	46.98
LM157A	< 0.5	6.6	0.41 J	5.8	NA	13	6	36.05 - 11.05	23.55 - 23.05	22.58 - 21.08	46.46

[a/] PCE = tetrachloroethene; TCE = trichloroethene.

[b/] RPD = Relative percent difference.

[c/] µg/L = micrograms per liter.Values reported are in feet above mean sea level.

[d/] amsl = above mean sea level.

[e/] E = laboratory data qualifier indicating that the result was beyond the calibration range of the insturment.

[f/] NA = not applicable; analyte not detected in one or both samples.

dedicated pump is fixed during sample collection, the preliminary 4Q00 groundwater elevation data provided by URS are presumed to be in error.

The calculated elevation of the diffusion sampler at well LM035A also was lower than the elevation of the pump intake (Table 4.10). During diffusion sampler deployment at the 2-inch wells, the samplers were lowered into the well until the stainless steel weight hanging from the bottom of the sampler encountered the top of the dedicated pump assembly. The diffusion sampler was then secured to the top of the well cover so that it was positioned directly above the dedicated pump. Because the diameter of well LM035AU is 2 inches, and the pump diameter is 1.66 inches, it was not possible to have placed the 1-inch-diameter diffusion sampler below the dedicated pump. Finally, the bottom of the diffusion sampler was calculated to be less than 0.2 foot above the deepest portion of the well screen in LM035AU (Table 4.10). If this were true, and the dedicated pump was installed deeper than the diffusion sampler, then the pump intake elevation would be below the well screen and would not be appropriate for groundwater sampling.

Despite the concerns discussed above, this pilot-scale evaluation demonstrates that diffusion sampling results are comparable to those obtained using the traditional micropurge method in at least four (80 percent) of the five wells in which the diffusion samplers were completely submerged.

4.3.3.4 Cost Comparison

Table 4.11 presents a summary of unique costs associated with each of the two sampling methods evaluated; costs that are comparable for both methods (e.g., laboratory analyses, QC samples, reporting, and personal protective equipment) are not included. Because actual DDJC-Tracy LTM sampling costs were unavailable, most of the costs presented are estimated (in year 2000 constant dollars). To estimate total program costs, a monitoring program life of 30 years (i.e., 2 years longer than projected ETI system operation) was assumed. Initial program setup labor costs (e.g., installing dedicated pumps, installing diffusion sampler ropes/weights/etc.) are assumed to be similar for both methods, and were not considered.

As noted in Section 4.3.2.2, a total of 157 wells, including extraction wells, were sampled during FY00. However, the applicability of diffusion samplers for use in extraction wells has not been evaluated. Also, it is assumed that sample collection from extraction wells at DDJC-Tracy occurs directly at the discharge line of the well, omitting the need for conventional purging. For these reasons, extraction wells are excluded from the cost analysis presented in this section.

The total number of monitoring wells proposed for sample collection in FY00 was 124 (Radian, 2000c). As discussed in Section 4.3.3.3, diffusion samplers are capable of monitoring only certain contaminants in groundwater, including VOCs and fuel hydrocarbons (Vroblesky and Campbell, 2000). However, at DDJC-Tracy, groundwater is monitored for additional constituents (e.g., pesticides, metals, and nitrate). As such, use of diffusion samplers in all wells currently monitored at DDJC-Tracy is not appropriate. Of the 124 monitoring wells scheduled for sample collection in FY00, a total of 75 were identified for collection of samples for VOC and/or fuel-hydrocarbon analysis only (Radian, 2000c).

TABLE 4.11
CURRENT SAMPLING PROGRAM COST ANALYSIS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recoverable or Re-Usable Items						
Item	**Use-Rate Assumption**	**Initial No. of Units Required**	**Equipment Replacement Frequency (years)**	**Total Number Required**	**Unit Cost**	**Item Total**
Bladder pump (each)	1 per well	124	8	465	$ 400.00	$ 186,000.00
Control box/regulator (each)	1 per sampling team	2	5	12	$ 1,500.00	$ 18,000.00
Air compressor (each)	1 per sampling team	2	5	12	$ 1,000.00	$ 12,000.00
					Total projected program capital costs:	**$ 216,000.00**
Non-Recoverable or Non-Reusable Items						
Item	**Use-Rate Assumption**	**No. of Units per Year**	**Program Duration (years)**	**Total Number Required**	**Unit Cost**	**Item Total**
Labor (hours)	50 minutes per sample	357	30	10,700	$ 65.00	$ 695,500.00
					Total projected program capital costs:	**$ 695,500.00**
					Total Projected Program Costs:	**$ 911,500.00**

Finally, as described in Section 4.3.3.3, due to various lithologic, chemical, and well construction variables, diffusion sampling may not be appropriate in all wells at DDJC-Tracy. If the sample population evaluated in this evaluation is representative of the entire well population at DDJC-Tracy, an estimated 80 percent of the 75 candidate diffusion-sampler wells in the LTM program may be appropriate for diffusion sampling.

For simplicity, it was assumed that on average, wells are sampled three times per year (some wells sampled quarterly, some wells sampled semi-annually, and some wells sampled annually) with a quality assurance (QA)/QC sample-collection rate of 15 percent (15 QA/QC samples collected per 100 primary samples). In order to compare estimated costs for the current sampling program (conventional sampling only) with a modified sampling program consisting of both conventional sampling and diffusion sampling, the following two scenarios were assumed:

- For the current sampling program, a total of 124 wells and 428 total samples (124 wells, three samples per year, plus 15 percent QA/QC samples) were assumed to be sampled annually using the conventional (micropurge) method; and

- For the optimized sampling program, a total of 60 wells (80 percent of a total 75 suitable wells) and 207 annual samples (60 wells, three samples per year, plus 15 percent QA/QC samples) wells were assumed for the diffusion sampler method, and a total of 64 wells and 221 annual samples (64 wells, three samples per year, plus 15 percent QA/QC samples) were assumed for the micropurge method.

Estimated program costs for each of the two scenarios are presented in Tables 4.11 (current sampling program) and 4.12 (optimized sampling program). The program duration was assumed to be 30 years (i.e., 2 years longer than ETI system operation). As shown in Tables 4.11 and 4.12, the estimated cost of the current sampling program is approximately $910,000 and the estimated cost of the modified sampling program is approximately $760,000. Capital costs comprise the largest relative cost difference between the two sampling methods. The materials required for diffusion sampling are inexpensive and "low-tech", with no moving parts. As such, with the exception of the disposable diffusion samplers themselves, the other materials needed for the sampling (weights, hangers, and rope) have a long useful-life expectancy, and if replacement is necessary, these materials are relatively inexpensive. Conversely, the capital cost for micropurging is significant. Most of the equipment used for micropurging (pumps, regulators, and compressors) is relatively expensive, prone to breakdown, and will require replacement at relatively frequent intervals.

Another benefit of diffusion sampling is the minimal labor required in the field per sampling event. As presented in Table 4.12, approximately 30 minutes labor per sample is estimated for diffusion sampling. This estimate includes time to collect the sample and deploy a replacement sampler for the next sampling round. Conversely, micropurging is estimated to require an estimated additional 20 minutes of labor (e.g., time for groundwater field parameters to stabilize) per sample collected. If the modified sampling program were adopted by DDJC-Tracy, a total program cost savings of approximately $150,000 could be realized.

TABLE 4.12
OPTIMIZED SAMPLING PROGRAM COST ANALYSIS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recoverable or Re-Usable Items						
Item	**Use-Rate Assumption**	**Initial No. of Units Required**	**Equipment Replacement Frequency (years)**	**Total Number Required**	**Unit Cost**	**Item Total**
Diffusion Sampling						
Stainless steel weights (each)	1 per well	60	30	60	$ 13.50	$ 810
Stainless steel hangers (each)	1 per well	60	30	60	$ 7.50	$ 450
Rope (feet)	45 per well	2,700	3	27,000	$ 0.07	$ 1,890
					Total projected re-usable diffusion sampling costs:	**$ 3,150**
Micropurging						
Bladder pump (each)	1 per well	64	8	240	$ 400	$ 96,000
Control box/regulator (each)	1 per sampling team	1	5	6	$ 1,500	$ 9,000
Air compressor (each)	1 per sampling team	1	5	6	$ 1,000	$ 6,000
					Total projected re-usable micropurge costs:	**$ 111,000**

Non-Recoverable or Non-Reusable Items						
Item	**Use-Rate Assumption**	**No. of Units per Year**	**Program Duration (years)**	**Total Number Required**	**Unit Cost**	**Item Total**
Diffusion Sampling						
Sampler w/ mesh covering (each)	1 per sample	207	30	6,210	$ 14	$ 86,940
Labor (hours)	30 minutes per sample	103.5	30	3,105	$ 65	$ 201,825
					Total projected non-recoverable diffusion sampling costs:	**$ 288,765**
Micropurging						
Labor (hours)	50 minutes per sample	184	30	5,525	$ 65	$ 359,125
					Total projected non-recoverable micropurge costs:	**$ 359,125**

Total projected program costs: $ 762,040

4.3.3.5 Summary and Recommendations

Benefits of diffusion sampling include:

- Minimal capital investment;
- Long life expectancy of capital investment;
- Simple technology requiring minimal training for field personnel;
- Reduced monitoring labor costs;
- Virtually no purge waters generated; and
- Minimal decontamination required.

Drawbacks of diffusion sampling include:

- Limited suite of target analytes (i.e., VOCs) can be effectively sampled;
- No opportunity to collect field parameters commonly measured during well purging (e.g., pH, conductivity, and temperature);
- Only appropriate use at DDJC-Tracy is for VOC monitoring, monitoring other COCs requires alternate sampling methodology.

Benefits of micropurging using dedicated bladder pumps include:

- Initial capital costs already invested;
- Ability to collect samples for a large suite of target analytes;
- Opportunity to collect field parameters commonly measured during well purging, and
- Minimal decontamination required.

Drawbacks of micropurging using dedicated bladder pumps include:

- More complicated field procedures requiring moderate level of training for field personnel;
- Generation of relatively large volumes of purge water requiring disposal;
- Higher O&M costs for pumps and other equipment; and
- Limited life expectancy of capital equipment;

Diffusion sampling for VOCs can provide several benefits over conventional (e.g. micropurging) sampling. Although diffusion sampling would not be appropriate for use at all of the monitoring wells currently included in the DDJC-Tracy LTM program,

results of the pilot-scale RPO evaluation of diffusion samplers suggests that as many as 60 of the wells in the FY00 program may be appropriate for diffusion sampling.

Because the micropurge sampling method has already been initiated at DDJC-Tracy, the (considerable) initial capitals costs have been incurred. In order to take full advantage of the costs already invested in this sampling technology, Parsons ES recommends maintaining the existing approach to sampling using micropurging. However, as the existing dedicated sampling equipment begins to fail, rather than investing additional capital in equipment replacement, Parsons ES recommends transitioning to diffusion sampling technology where appropriate. In order to evaluate the use of this technology at DDJC-Tracy, Parsons ES recommends that a well-by-well evaluation be performed as the existing low-flow pumps require replacement.

4.3.4 Analytical Laboratory Assessment

As described in Section 4.3.2.2, laboratory analytical costs are estimated to account for approximately 57 percent of the total annual LTM program costs at DDJC-Tracy. Of the total annual analytical costs, almost one-third is spent on analysis of VOCs using USEPA Method SW8260B (see Table 4.9). The current contract laboratory that provides groundwater analytical services for scheduled LTM sampling is Caltest of Napa, California. The negotiated DDJC-Tracy contract price charged by Caltest for analysis of VOCs using USEPA Method SW8260B is $160 per sample.

Parsons ES conducted market research of prices charged by another local laboratory for the same analyses, and found that the Caltest price is not competitive for VOC Method SW8260B. The price for this analysis quoted by Severn Trent Laboratories (STL), in Sacramento, California was $121 per sample. If the lower price for VOC analysis of groundwater samples is used, an annual cost savings of approximately $15,000, and total (30-year) program savings of $450,000, could be realized. These savings would be substantially greater if laboratory services for VOC analyses for the DDJC-Sharpe groundwater sampling program also were renegotiated to the STL price.

In order to maintain comparability between RPO samples and regular monitoring program samples, soil and groundwater samples collected during the RPO field programs at DDJC-Tracy (Appendix A) and DDJC-Sharpe (Parsons ES, 2001) were submitted to Caltest for analysis of VOCs using Method SW8260B. Parsons ES noted several laboratory deficiencies during these evaluations, including:

- The sample bottles ordered from laboratory were not provided as requested;
    - Pre-preserved (acidified) volatile organic analysis (VOA) bottles were requested for the DDJC-Tracy sampling events; however the laboratory delivered unpreserved bottles, which resulted in a reduced allowable holding time;
    - Requested trip blank sample bottles were provided with air trapped in the headspace, which is unallowable for VOC analyses; and
    - Amber-glass sample bottles were requested for inorganic parameter samples collected during the MNA evaluation at DDJC-Sharpe (Parsons ES, 2001), in

order to reduce the possibility that photosensitive constituents (e.g., nitrate) would undergo photolysis reactions, but clear glass bottles were supplied.

- Receipt of analytical results (deliverables) was delayed beyond the negotiated contractual agreement, with no explanation provided; and

- Problem resolution was hampered by the inaccessibility of the designated laboratory point of contact.

In light of the non-competitive pricing for VOC analysis and the service deficiencies observed during the RPO efforts, careful review of Caltest's pricing and auditing of Caltest practices is warranted. Reallocation of even a subset of analyses to a laboratory that can provide more competitive pricing could result in substantial cost savings. The current laboratory selection/auditing process should be reviewed to ensure the contract laboratory is consistently meeting all analytical method requirements, and that pricing for analytical services is competitive. Because data comparability is a key consideration in any LTM program, efforts to ensure competitive, accurate services from the incumbent laboratory may be preferable to contracting with a different laboratory for analytical services. Nonetheless, data quality objectives typically are easily met by qualified laboratories, and continuity of a contracting relationship should not take precedence over cost and general quality considerations when decisions on laboratory services are revisited.

4.3.5 Groundwater Monitoring Program Optimization Summary

Periodic monitoring of groundwater quality and performance of the groundwater ETI systems is conducted at DDJC-Tracy to evaluate environmental conditions, assess progress toward achieving the RAOs, ensure compliance with WDRs, and track system performance and the progress of remedial activities.

Initial review of this LTM program identified optimization opportunities that could improve the effectiveness of the monitoring program and reduce the estimated costs. These optimization opportunities include:

- Enhancement of the ongoing annual monitoring network optimization effort through the use of qualitative review and spatial statistics to supplement the temporal trend analysis currently performed;

- Incorporation of diffusion sampling technology into the existing sampling program; and

- Stricter oversight of the contract analytical laboratory to ensure competitive pricing for analytical services and better QC of laboratory practices.

In lieu of actual cost data for LTM at DDJC-Tracy, current annual monitoring program costs were conservatively estimated to be approximately $370,000. Based on the cost analyses developed in Sections 4.3.2 through 4.3.4, implementation of these recommendations at DDJC-Tracy could result in cost savings of approximately $225,000 per year, or $6,750,000 (in year-2000 dollars) over a 30-year monitoring period.

SECTION 5

OPTIMIZATION RECOMMENDATIONS

DDJC-Tracy and its environmental contractors have an effective RPO Phase I program in place. This program is characterized by monthly, quarterly, and/or annual reviews of the groundwater monitoring program, treatment plant performance, and assessment of progress toward ACLs for OU1, along with annual recommendations for adjustments in the LTM program and groundwater extraction well pumping rates.

In addition to the Phase I efforts, DDJC-Tracy also has undertaken studies to address site-specific or longer-term remedial optimization at the Depot, such as collecting site-specific bioaccumulation data for SWMU 4 to allow re-evaluation of the ROD remedy (Radian, 2000f; URS, 2001), evaluating alternative disposal methods for treated groundwater (Radian, 2000b and 2000e), and assessing the potential contribution of natural attenuation toward restoring groundwater quality at and downgradient from the Depot (Radian, 1999b). These efforts are commendable, and some have already resulted in significant cost savings (e.g., through revision of the remedy for SWMU 4) without compromising ROD objectives.

The current RPO Phase II effort has reviewed available information, and has identified additional optimization opportunities that could enhance the cost-effectiveness and efficiency of remedial systems and the groundwater monitoring program at DDJC-Tracy. This section reviews these opportunities, suggests additional data collection strategies to collect supporting information for negotiations to be held during the 5-year ROD review, and estimates potential cost savings associated with each opportunity. Implementation suggestions for these opportunities also are provided. Based on discussions at the May 2, 2001 DDJC-Tracy remedial project manager (RPM) meeting in Sacramento, the status of implementation of the RPO recommendations is reviewed.

5.1 REVISE CONCEPTUAL MODEL AND DATA-PRESENTATION STRATEGY

Recommendation 1: Simplify the presentation of the hydrogeologic CSM for DDJC-Tracy as suggested in Section 2.4.

<u>Rationale:</u> *The current CSM (Figure 4.1) over-emphasizes the relative importance of hydrostratigraphic units within the Upper Tulare Aquifer. Though it has been demonstrated that the four currently designated horizons at DDJC-Tracy are hydraulically connected and have similar hydraulic characteristics, the current CSM perpetuates subtle distinctions among the complex horizon lithologies, and may unnecessarily complicate the interpretation of contaminant fate and transport in the subsurface, thereby contributing to piecemeal remediation of COC plumes at and downgradient from the Depot. Simplifying the model presentation to depict*

two complex, hydraulically connected saturated units (a shallow and a deeper unit) could clarify plume interpretations and encourage remediation and monitoring of the COC plumes independent of arbitrary monitoring zones.

Implementation: *The proposed CSM revisions have been reviewed by the DDJC-Tracy environmental contractors and the regulators, and the RPMs have concurred that use of the model will be effective for implementing the OU1 ROD. Incorporation of the revised model into the next OU1 annual groundwater monitoring report is underway. Once OU1 data reporting is simplified for two saturated intervals (rather than the four-horizon scenario currently in use), quarterly and annual reporting efforts for monitoring data should be streamlined, and associated costs should be incrementally reduced.*

Recommendation 2: Complete the characterization of the COC plumes at DSERTS 68 and downgradient from (east of) Banta Road, and of hydrogeologic conditions downgradient from the Tracy Annex, to facilitate optimization of the extraction system and monitoring program.

Rationale: *Effective implementation of a groundwater pump-and-treat system is dependent on adequate characterization of the nature and extent of contamination and the hydrogeologic conditions that may influence contaminant fate and transport. Because the leading edges of the PCE/TCE plume emanating from DSERTS 68 (Area 3) and the TCE contamination observed in the shallow saturated zone approximately 0.25 mile east of Banta Road (Figures 2.17 and 2.18) have not been delineated, the effectiveness of boundary extraction wells for plume containment cannot be assessed, and the LTM program cannot be optimized to track the effects of extraction and attenuation on mass removal/plume containment.*

Moreover, the apparently discontinuous nature of dissolved TCE on the Annex and downgradient from the Annex, both laterally and vertically, merits further investigation. The reappearance of contamination in the shallow saturated zone is suspicious, as prevailing groundwater hydraulics downgradient from on-Depot contaminant source areas indicate that contamination migrates downward through the aquifer with increasing distance from the sources in the shallow saturated zone.

Implementation: *Characterization of the TCE plume downgradient from Banta Road is being implemented by URS using previously allocated funding. It is recommended that particular attention be paid to 1) evaluating potential secondary off-Annex sources for TCE, possibly associated with past septic-system cleaning practices on private land in this area; and 2) to assessing the vertical distribution of dissolved TCE to determine contaminant migration pathways in the shallow saturated zone (i.e., the Upper and Middle horizons). Emphasizing these objectives should not affect the cost for implementing the field effort. Depending on the results of the pending investigation, it may be useful to install several additional permanent monitoring wells between Banta Road and the half-section road 0.5 mile east of Banta Road to better evaluate potential migration of COCs from the Annex. Threee wells are planned along the BCID road; it is assumed that the cost for installing additional wells is included in the negotiated price for the plume investigation (Table 5.1).*

TABLE 5.1
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/d/]
Optimization of Conceptual Model and Data-Presentation Strategy				
Recommendation 1: Simplify the presentation of the hydrogeologic CSM for DDJC-Tracy.	TBD[c/]	TBD	Low –Regulatory concurrence has been obtained; implementation planned for 2001 Annual Monitoring Report..	$1 K
Recommendation 2: Complete characterization of: • COC plumes at DSERTS 68 and east of Banta Road, and • Hydrogeologic conditions downgradient from the Tracy Annex.	TBD	TBD	Low – Supplemental characterization efforts are underway.	TBD
Recommendation 3: Revise the data-presentation strategy for tracking COC concentrations and distributions in OU1 groundwater in the annual monitoring reports.	TBD	TBD	Low – Regulatory concurrence has been obtained; implementation planned for 2001 Annual Monitoring Report.	$1 K
Optimization of SVE System				
Recommendation 4: Based on operational performance data, focus SVE in PCE/TCE hot spots at the three SVE sites.	≤ $43 K	$128 K	Low - Implementation mechanisms in place.	$5 K
Recommendation 5: Based on operational performance data, eliminate offgas treatment of SVE vapor effluent based on system monitoring data.	≤ $40 K	$120 K	Low – Requires regulatory concurrence; implementation mechanisms in place..	$1 K
Recommendation 6: Based on operational performance data, implement passive extraction of SVE systems during inactive periods of system cycling.	$2.4 K	$7.2 K	Low –Regulatory concurrence has been obtained; design evaluation underway.	$1 K
Recommendation 7: When COC concentrations reach asymptotic levels, implement STOP and, if necessary, select and implement site-specific soil cleanup goals.	TBD	TBD	Moderate – Requires regulatory approval.	$1 K

TABLE 5.1 (Continued)
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/cd/]
Optimization of the OU1 Groundwater ETI System				
Recommendation 8: Based on data review, temporarily suspend pumping at 13 extraction wells (Table 5.2), monitor COC concentrations for rebounding, and if possible, shut down wells. Remove carbon treatment units from wells EW005AUA and EW021A.	$80.7 K	$2.26 M	Moderate – Requires regulatory approval; preparation of work plan has been authorized.	$10 K
Recommendation 9: Install at least one extraction well near the source area at DSERTS 68 (Area 3) to remove and limit migration of dissolved PCE/TCE mass from this hot spot.	TBD	TBD	Low – Regulatory concurrence has been obtained.	$15 K
Recommendation 10: Replace the air stripper at TP-1 with liquid-phase GAC for treatment of VOCs and pesticides, and route flow from all extraction wells in dieldrin plume to TP-1. Remove all wellhead GAC units.	$10.5 K	$295 K	Low –Regulatory approval has been granted to proceed with design evaluation.	$125 K
Recommendation 11: Replace or supplement the TP-2 recarbonation system with addition of AQUA MAG™ product to better control the scaling problems.	TBD	TBD	Low – Implementation has been initiated.	$5 K
Recommendation 12: Revise the ROD and WDR order to incorporate alternative effluent discharge options.	TBD	TBD	Moderate – Regulatory approval required; ROD amendment in preparation.	$1 K
Optimization of Groundwater Monitoring Program				
Recommendation 13: Perform a monitoring network optimization evaluation once the ETI system is fully operational.	$110 K	$1.1 M	Low –Regulatory concurrence desirable.	$20 K
Recommendation 14: As existing dedicated low-flow pumps require replacement, incorporate diffusion sampling for VOCs into groundwater monitoring program.	$5 K	$150 K	Moderate – Requires regulatory approval.	$22.5 K

TABLE 5.1 (Concluded)
REMEDIAL OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Recommendation	Estimated Annual Cost Savings[a/]	Cost Savings Over Life Cycle[a/b/]	Difficulty of Implementation & Implementation Status [c/]	Estimated Cost to Implement[a/d/]
Optimization of Groundwater Monitoring Program (continued)				
Recommendation 15: Continue the current laboratory selection and auditing process to ensure the contract laboratory is consistently meeting all analytical method requirements, and that pricing for analytical services is competitive.	$15 K	$450 K	Low – Implementation underway.	$0 K
TOTAL	$307 K	$4.51 M		$209 K

[a/] Estimated costs given in constant 2000 dollars. K – thousands of dollars. M – million of dollars.
[b/] Life cycle for SVE system is estimated to be a maximum of 3 years.
Life cycle for conceptual model, data presentation strategy, and ETI system is estimated to be 28 years.
Life cycle for groundwater monitoring program is estimated to be 30 years.
[c/] Implementation status as of May 2, 2001 Remedial Project Manager's meeting in Sacramento.
[d/] Estimated implementation costs exclude labor costs associated with regulatory negotiations, as this is inferred to be a DLA role rather than a contractor function.
[e/] TBD – To be determined.

Better delineation of the COC plume emanating from the DSERTS 68/Area 3 source could be accomplished via direct-push methods. If possible, installation of additional of permanent monitoring points in the east-central part of the Annex would be useful in monitoring plume continuity and contaminant migration toward Banta Road. Because the scope of field investigations on the Annex is constrained by the terms of the agricultural lease, costs for this effort are not provided (Table 5.1). Regulators have concurred with additional characterization at DSERTS 68.

Recommendation 3: Per Section 2.5, revise the data-presentation strategy for tracking COC concentrations and distributions in OU1 groundwater in the annual monitoring reports to associate concentrations with sampling locations, and to better assess plume evolution through time.

<u>Rationale</u>: *Historically, plume evolution has been tracked in the annual groundwater monitoring reports for the fiscal year for which data are reported, and compared only to the previous year's interpretation. Plumes are loosely interpreted by hydrostratigraphic horizon, and variability in monitoring points sampled from year to year can strongly influence interpretations of apparent annual changes in plumes that may not be borne out by the data. Because plume evolution has not been tracked for the entire period of remediation, it has been difficult to assess remedial progress. Plotting concentration data by sampling location in a thematic format for sequential monitoring periods since groundwater ETI system startup dramatically improves a reviewer's ability to understand changes that can be attributed to changes in chemical concentrations and distribution versus distortions attributable to changing sampling designs through time. The thematic data-presentation method suggested in Section 2.5 also can support optimization of the LTM monitoring program, thereby ensuring that temporal data are collected consistently at key monitoring locations in order to assess plume stability through time and to evaluate the effects of the ETI system on plume magnitude and extent.*

<u>Implementation</u>: *The proposed data-presentation strategy has been approved by the DDJC-Tracy RPMs for use in the 2001 annual monitoring report. Implementatiopn of this recommendation should not materially affect the cost of reporting that is routinely conducted for DDJC-Tracy (Table 5.1).*

5.2 OPTIMIZATION OF SVE SYSTEMS

Recommendation 4: Focus SVE in PCE/TCE hot spots in the vadose zone at the three SVE sites.

<u>Rationale</u>: *Continually re-focusing SVE on the most contaminated soil volumes at each site will optimize the use of resources and expedite cleanup. Capital cost savings of about $76,000 are possible for a smaller SVE system at SWMU 1/Area 2; and capital cost savings of about $52,000 could be realized for a smaller system at DSERTS 66/Area 1. The extent of PCE and TCE in the subsurface at DSERTS 68/Area 3 currently is uncertain, and the design characteristics of an SVE system that would be adequate to achieve RAOs for CAHs in soil vapor at this site are unknown.*

Implementation: Because the recently installed SVE systems are now operating, it will be most cost-effective to optimize these systems based on observed concentrations of COCs in the extracted vapors. VEWs extracting soil-vapor with relatively low concentrations of VOCs could be taken off line, or their flow rates could be reduced, and venting in hot spots could continue at maximum design flow rates. The cost to implement this recommendation would be negligible, as the data required to optimize the SVE systems will be collected as part of routine system monitoring (Table 5.1). The mechanisms for implementing this recommendation are in place, and have been approved by the regulatory RPMs.

Recommendation 5: Based on results of SVE system monitoring, eliminate offgas treatment of SVE vapor effluent.

Rationale: The results of influent vapor-stream loading calculations completed by Radian (2000a) indicate that following system prove-out and some initial period of operation, direct discharge of untreated vapor-phase effluent from SVE operations at sites 1 and 66 probably would not introduce volatile COC mass to the atmosphere at levels in excess of current regulatory limits. Influent VOCs concentrations at DSERTS 68 likely would also quickly fall below the emissions threshold after system startup. Therefore, GAC treatment of extracted soil vapor may not be necessary.

Implementation: This possible elimination of offgas treatment could be evaluated during operation of the SVE systems based on results for vapor samples collected from the influent lines to the treatment system at each site. Elimination of GAC treatment of the SVE vapor effluent stream at all three sites could generate potential total cost savings of more than $120,000 (Table 5.1).

Recommendation 6: Implement passive extraction of SVE systems during inactive periods of system cycling.

Rationale: The mass removal rate of a continuously operating passive SVE system is estimated to be approximately one-tenth the mass removal rate of a continuously operating active SVE system. Implementation of passive SVE in conjunction with continued active SVE operations could reduce the length of time required to achieve RAOs in soil at the three DDJC-Tracy sites by as much as 10 percent, resulting in a 10-percent cost savings for OM&M of the SVE systems (Table 5.1).

Implementation: The SVE systems at DDJC-Tracy are being operated in cycles, with active SVE occurring at only a single site at any given time. This method of operation presents an opportunity to implement passive SVE treatment technology at the two inactive SVE sites, concurrently with active SVE treatment proceeding at the other site. Only minor modifications would be required to adapt the SVE systems for periodic use as passive venting systems (e.g., installation of one-way air-flow valves), though the below-grade manifolding will require modifications to avoid venting of vapors into subgrade vaults. During periods of inactivity at an SVE site, a valve or vent in the manifold, or at individual wellheads, could be left open to the atmosphere, thereby allowing free exchange of air and vapor between the atmosphere and the SVE well system. A modification of this type could be implemented at little or no additional cost (Table 5.1). Regulatory RPMs have

concurred in principle with the use of passive venting to supplement active SVE at DDJC-Tracy.

Recommendation 7: When COC concentrations reach asymptotic levels in soil gas, implement STOP (Castle AFB, 1999), and if necessary, develop site-specific soil cleanup goals for SWMU 1 and DSERTS 66 and 68.

Rationale: The ROD-specific soil-vapor cleanup levels of 780 ppbv for PCE and 350 ppbv for TCE apparently were derived on the basis of Henry's Law, which describes the concentration of a substance dissolved in the aqueous phase at equilibrium with its vapor phase (Appendix C). The assumptions required for this derivation are unrealistic, and lead to cleanup standards for PCE and TCE in soil vapor that are overly conservative. In addition, several attenuation mechanisms, including volatilization, sorption to soil, dilution, dispersion, and chemical or biological degradation, are capable of decreasing the mobility or concentrations of CAHs in the subsurface.

The results of an evaluation of site-specific conditions in the vadose zones at sites 1, 66, and 68 indicate that PCE and TCE in soil, in equilibrium with vapor-phase concentrations of PCE in the range of 870 to 940 ppbv and TCE in the range of 590 to 640 ppbv, could remain in the vadose zone at each of the three sites without causing further migration of PCE and TCE to the water table at concentrations that would exceed the ROD ACLs. These site-specific RAOs for CAHs in soil are from 10 percent to about 80 percent higher than the current RAOs (Table 3.4), while being protective of groundwater quality. Adoption of site-specific RAOs could result in the SVE systems achieving soil cleanup objectives in less time than currently projected, at lower cost.

Implementation: Modification of the soil cleanup goals specified in the Comprehensive ROD (Radian, 1998a) will require concurrence by the regulatory agencies. The RPMs have agreed that once asymptotic COC concentrations are reached, the STOP process can be implemented, and if appropriate, site-specific cleanup goals may be developed and applied in place of the ROD goals. Planned monitoring of the SVE systems should provide the data necessary to optimize the systems. When the results of soil-vapor monitoring indicate that the concentrations of COCs in soil vapor at a specific VMP no longer exceed vapor-phase soil cleanup criteria, the SVE system in that area could be shut down, because the mass of COCs remaining in that soil volume would be unlikely to represent a continued potential threat to groundwater. Soil-vapor monitoring should be continued for some period of time following system shut-down to evaluate whether the concentrations of COCs in soil vapor increase, as volatile constituents sorbed to soil or within the soil matrix diffuse into the soil pore spaces (the "rebound" effect). In some cases, the concentrations of COCs may continue to rebound above screening-level soil vapor criteria during equilibrium (shut-down) testing. In such cases, the STOP protocol (Castle AFB, 1999) will be pursued to evaluate the relative costs/benefits of continued operation of SVE systems having marginal extraction rates and high unit costs for VOC mass removal.

5.3 OPTIMIZATION OF THE OU1 GROUNDWATER ETI SYSTEM

Recommendation 8: Carefully evaluate contaminant trends and capture zones for 13 wells that are extracting groundwater that contains COCs at concentrations below ROD-specified ACLs. If appropriate, temporarily suspend pumping at these wells, and monitor COC concentrations for rebounding. If rebound testing results confirm that these wells are not significantly contributing to remedial progress, they could be shut down. Also, remove the GAC pesticide-treatment units installed at wells EW005AUA and EW021A. Well-specific recommendations are summarized in Table 5.2.

Rationale: Extraction-system-wide, 13 wells are pumping groundwater that contains COCs at concentrations below ACLs (Table 5.2). Shutdown and rebound monitoring would provide confirmation that removal of these wells from the extraction system will not adversely affect remedial progress. Well EW008A already has been recommended for shut down (Radian, 2000c). Unless it is demonstrated through rebound testing that some of the remaining 12 wells are critical for mass removal and/or plume containment, they also should be considered as candidates for shutdown. Once superfluous wells are shut down, annual OM&M cost savings of about $80,650 could be realized (Table 5.1), or these funds could be more effectively allocated. The GAC units installed for treatment of pesticides at wells EW005AUA and EW021A appear to be unnecessary, as available groundwater monitoring results indicate that dieldrin (the pesticide COC identified in the ESD for the OU1 ROD) has not been detected above the ACL at these wells for at least 1 year (Table D.3, Appendix D). The basis for well-specific recommendations is summarized in Table 5.2.

Implementation: Optimization of the extraction system will require regulatory concurrence. During the May 2001 RPM meeting, regulatory RPMs were receptive to the concept of rebound testing as outlined in this recommendation, and have requested a work plan for the specific rebound testing procedure and a final list of candidate wells. If rebound monitoring is approved, the subject extractions wells should be taken off line, and COC concentrations should be monitored at an agreed-upon frequency to assess the effects of removing the wells from service on progress toward achieving the ROD objectives. The monitoring schedule should be developed with consideration of solute travel times from upgradient area where dissolved COC concentrations remain above the ACLs, with quarterly monitoring as a minimum. Rebound monitoring would provide confirmation that removal of these wells from the extraction system will not adversely affect remedial progress. Radian (2000c) has recommended shut down of extraction well EW008A, and rebound testing at this well may not be necessary. The cost to implement rebound monitoring for 12 wells, assuming an average quarterly sampling frequency for VOCs and pesticides at each well, is provided in Table 5.1. The costs savings associated with removing the GAC treatment unit from wells EW005AUA and EW0021A (Table 5.2) are not reflected in Table 5.1 due to a lack of design and O&M data for the wellhead GAC units. Reinstallation of these GAC units at wells where pesticide concentrations are higher (e.g., EW002AU and EW003) would represent a more effective use of these resources, and a better return on the capital investment.

TABLE 5.2
EXTRACTION SYSTEM OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

TP [b/]	Extraction Well	3Q00 Status [c/]	FY99 Flow (gpm) [d/]	Well Features	Well Function [e/]	COCs > ACLs During Past Year [a/]		Optimization Recommendation
						VOC [f/]	Dieldrin	
1	EW001AU	OOS	0		MR	NA [g/]	NA	Abandon
1	EW002AU	A	31	GAC	C/MR	X	X	Continue pumping/monitoring
1	EW003A	A	23		C/MR	X	X	Continue pumping/monitoring (candidate for GAC unit)
1	EW004AU	A	7		C/MR		X	Continue pumping/monitoring
1	EW005AUA	A	0	GAC; Dual Screens	C/MR	X		Remove GAC unit and continue pumping/monitoring
1	EW006AU	A	28		C/MR	X		Continue pumping/monitoring
1	EW007A	A	3		C/MR			Conduct rebound testing
1	EW008A	A	5		C/MR			Shut down
1	EW009B	OOS	0		C/MR	X		Activate for VOC mass removal
1	EW010AU	A	8		C			Conduct rebound testing
1	EW011AU	A	3		MR	X		Continue pumping/monitoring
1	EW012AU	A	54		MR	X		Continue pumping/monitoring
1	EW033AU	OOS	0		C	X		Activate for VOC mass removal
1	EW035AU	OOS	0		C?			Abandon
1	EW037AU	OOS	0		C?			Abandon
2	EW013C	A	46		C			Conduct rebound testing
2	EW014A	A	13		C			Conduct rebound testing
2	EW015A	A	26	Dual Screens	C			Conduct rebound testing
2	EW016A	A	53	Dual Screens	C			Conduct rebound testing
2	EW017A	A	64	Dual Screens	C			Conduct rebound testing

TABLE 5.2 (Continued)
EXTRACTION SYSTEM OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

TP [b/]	Extraction Well	3Q00 Status [c/]	FY99 Flow (gpm) [d/]	Well Features	Well Function [e/]	COCs > ACLs During Past Year [a/]		Optimization Recommendation
						VOC [f/]	Dieldrin	
2	EW018A	A	17	Dual Screens	C			Conduct rebound testing
2	EW019A	A	52	Dual Screens	C	X		Continue pumping/monitoring
2	EW020A	A	33	Dual Screens	C/MR	X		Continue pumping/monitoring
2	EW021A	A	11	GAC; Dual Screens	C/MR	X		Remove GAC unit and continue pumping/monitoring
2	EW022A	A	2	GAC; Dual Screens	MR			Conduct rebound testing
2	EW024B	A	4	Dual Screens	C/MR			Conduct rebound testing
2	EW025B	A	2		C/MR	X		Continue pumping/monitoring
2	EW026B	A	37		C/MR	X		Continue pumping/monitoring
2	EW027B	A	41		MR	X	X	Continue pumping/monitoring
2	EW028B	A	57		C/MR	X	X	Continue pumping/monitoring
2	EW029B	A	21	Dual Screens	C/MR	X		Continue pumping/monitoring
2	EW030C	A	22	Dual Screens	C			Conduct rebound testing

TABLE 5.2 (Continued)
EXTRACTION SYSTEM OPTIMIZATION RECOMMENDATIONS SUMMARY
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

TP [b/]	Extraction Well	3Q00 Status [c/]	FY99 Flow (gpm) [d/]	Well Features	Well Function [e/]	COCs > ACLs During Past Year [a/]		Optimization Recommendation
						VOC [f/]	Dieldrin	
2	EW031C	A	6	Dual Screens	C/MR	X		Continue pumping/monitoring
2	EW032AU	A	7		C/MR			Conduct rebound testing.
2	EW034AU	A	14		MR	X		Continue pumping/monitoring

a/ COCs = chemicals of concern; ACLs = aquifer cleanup levels established in the Record of Decision (Radian, 1998a). Based on analytical results from monitoring events conducted since third quarter 1999 (see Appendix D, Tables D.1 through D.3).

b/ TP = treatment plant.

c/ 3Q00 = third quarter 2000; A = active; OOS = out of service.

d/ gpm = gallons per minute; see Table 4.5.

e/ C = dissolved COC plume containment; MR = mass removal of COCs.

f/ VOC = tetrachloroethene and/or trichloroethene (the volatile organic compounds considered COCs).

g/ NA = data not available.

Recommendation 9: Install a new extraction well near the source area at DSERTS 68 (Area 3) to remove dissolved PCE/TCE mass from this hot spot.

Rationale: *Vadose-zone soils have been demonstrated to be a continuing source of CAH contamination to groundwater at DSERTS 68, and soils at this site are undergoing remediation via SVE. Groundwater concentrations of PCE and TCE measured at monitoring well LM032AU, located downgradient from the DSERTS 68 source area, have historically been among the highest detected at DDJC-Tracy. During the characterization sampling conducted during this RPO evaluation, groundwater concentrations beneath the source area at this site were as high as 470 µg/L for PCE and 150 µg/L for TCE.*

Despite historical evidence of elevated concentrations of groundwater COCs at the nearby monitoring well, the integrated ETI system is not targeting this site for mass removal of COCs. Extraction well EW034AU is located downgradient from the site along the flowpath of the plume emanating from the source area. However, the leading edge of the plume, which has not been clearly delineated, extends beyond the apparent capture zone of that well. Inoperable well EW035AU (recommended for abandonment, Table 5.1) is located crossgradient from the source area to the east (Figure 1.4). Based on the elevated COC concentrations at DSERTS 68, it would be prudent to target this area for groundwater extraction by installing a new extraction well, screened in the shallow portion of the saturated zone, to remove COC mass and to control downgradient migration. Pumping of extraction well EW034AU also should continue.

Implementation: *At the RPM meeting on May 2, 2001, regulatory RPMs concurred with this recommendation. Installation of an additional groundwater extraction well at the DSERTS 68 source area should be facilitated by the proximity of the well effluent line that connects inoperable well EW035AU to TP-1 (Figure 1.4). Once EW035AU is abandoned, a new well, screened in the shallow saturated zone, could be installed south of the UP ROW (on the Depot) at the source area delineated during the Radian (2000c) soil-vapor survey, the RPO field investigation (Section 2.3), and the plume delineation under Recommendation 2, above. Well design details (and installation costs) should be comparable to those of existing shallow extraction wells (Table 5.1). Care should be taken during well installation to avoid damaging the SVE system.*

Recommendation 10: Replace the air stripper at TP-1 with liquid-phase GAC for treatment of VOCs and pesticides.

Rationale: *The air strippers at TP-1 and TP-2 have experienced maintenance problems associated with scale buildup, and wellhead pre-treatment for pesticides using GAC is required in the dieldrin plumes. Treatment plant influent PCE and TCE concentrations are low (less than 10 µg/L), and the influent throughput at TP-1 was about 162 gpm in FY99 and 84 gpm in FY00 (Table 4.5). If extraction system optimization (Recommendation 8) is implemented, throughput at this plant could be lower, especially if effluent from a new DSERTS 68 extraction well is routed to TP-2. At low influent COC concentrations and flow rates, treatment with liquid-phase GAC becomes cost competitive with air stripping for VOC removal. GAC treatment*

has the added benefits over air stripping of minimizing groundwater contact with air, which would reduce scaling and precipitate problems; emitting no offgas; and being effective for removal of pesticides. Routing of effluent from all shallow extraction wells within the pesticide plume to TP-1 should not exceed plant capacity.

Conversion of TP-1 to treatment using GAC could save an estimated $295,000 over the projected remaining 28 years of ETI system operation required to achieve ROD objectives (Table 5.1). This estimate excludes cost savings associated with elimination of maintenance of the dedicated GAC units at extraction wells in the pesticide plume, and therefore is considered conservative. As extraction volumes continue to be optimized at TP-2, replacement of this air stripper also may become cost effective. A long-term optimization goal would be to reduce pumping volumes to a level that would allow consolidation of flows from all extraction wells for GAC treatment at TP-2, and taking TP-1 off line.

Implementation: Regulatory approval for conversion of the TP-1 air stripper to VOC treatment using aqueous-phase GAC was provided in principle at the May 2001 RPM meeting. This system modification will be incorporated into the 60-percent design document for the pesticide remedy being prepared by URS. The effects of the extraction system optimization (Recommendation 8) on potential air stripper conversion to aqueous-phase carbon at TP-1 should be considered in the 60-percent design evaluation. The cost for installing a GAC unit at TP-1 is estimated at $125,000 (Table 5.1).

Recommendation 11: Replace or supplement the TP-2 recarbonation system with addition of AQUA MAG™ (or a similar product) to better control the scaling problems.

Rationale: Per discussions with the DDJC-Tracy O&M contractor, the re-introduction of carbon dioxide downstream from the air strippers to control calcium deposits has not been effective. The AQUA MAG™ product manufactured by Carus Chemical Corporation was proven effective for use with the OU1 TP-1 air stripper at DDJC-Tracy during a 1996 pilot test conducted by Radian. This product could be cost-competitive with the current re-carbonation system, and should improve post-stripper-treatment effectiveness. This would result in reduced downtime for TP-2 and lower O&M costs associated with scale removal and repairs to downstream pipe fittings and infiltration gallery media.

Implementation: URS's recent update of a 1996 scaling study reached the same conclusion as this RPO evaluation, and implementation of this recommendation has been initiated. Estimated costs for implementing the use of AQUA MAG™ are presented in Table 5.1.

Recommendation 12: Revise the WDR order and the ROD to incorporate alternative effluent discharge options.

Rationale: The WDR order (California RWQCB, 1998a) currently allows discharge of excess influent from the treatment plants to the stormwater retention pond (SWMU 4) at DDJC-Tracy. However, such discharge is discouraged by the RWQCB because the hydraulic effects adversely impact groundwater COC plume migration.

Based on the poor performance of the IGs, supplemental effluent discharge capacity may be required. Changes in discharge options should be reflected in updates to the ROD and the WDRs.

Implementation: Revision of the WDR order and ROD should be negotiated to expand discharge options to include overland flow and/or offsite discharge to surface water. The latter option would also require a site-specific NPDES permit. Once discharge options are agreed upon, the cost of implementing this recommendation should be minimal (Table 5.1). A ROD amendment addressing alternative effluent discharge options is currently being prepared by URS. The ROD amendment is subject to public review and must be approved by all regulatory RPMs.

5.4 OPTIMIZATION OF GROUNDWATER MONITORING PROGRAM

Recommendation 13: Perform a monitoring network optimization evaluation per the decision logic presented on Figure 4.16 and as described in Section 4.3.

Rationale: The primary objectives of monitoring are to: 1) evaluate long-term temporal trends in contaminant concentrations at points within or outside of the remediation zone as a means of monitoring the performance of the ETI system (temporal evaluation); and 2) evaluate the extent to which contaminant migration is occurring, particularly if a potential exposure point for a susceptible receptor exists (spatial evaluation). As discussed in Section 4.3, a reduced monitoring network may be adequate to meet the two primary objectives of monitoring, at reduced cost and with relatively little loss of information.

The current estimated annual cost of the groundwater monitoring program is $370,000. If the results of the monitoring network optimization evaluation at DDJC-Tracy are similar to those at DDJC-Sharpe, an annual cost savings of approximately $110,000 (30 percent) could be realized.

Implementation: Once steady-state ETI operating conditions are achieved, review the monitoring network optimization approach with RPMs to attain regulatory approval prior to implementation. Perform a qualitative evaluation (see Figure 4.16) identifying those wells that must remain in the monitoring program. Perform a temporal analysis on the remaining wells identifying contaminant trends over time. Based on the results of the temporal analysis, identify those wells that are not providing useful temporal information. Perform the spatial analysis on all wells currently included in the monitoring program to identify spatially redundant wells. If a monitoring well is identified as providing insignificant temporal and spatial information, and if there is no qualitative reason to continue sampling the well, consider removing the well from the monitoring program or changing the analytical requirements or sampling frequency for that well.

Recommendation 14: As dedicated equipment for low-flow purge sampling (e.g., in-well pumps) requires replacement, replace micropurge sampling with diffusion samplers at up to 60 wells at which LTM is conducted for VOCs and/or fuel hydrocarbons only. Consider diffusion sampling at new wells installed in the downgradient portion of the TCE plume.

Rationale: *The pilot-scale evaluation of diffusion sampling performed as part of the RPO investigation demonstrates that this technology is a viable option for VOC monitoring at DDJC-Tracy. This technology can provide analytical results comparable to current sampling methods, is relatively simple to implement and maintain, would reduce generation of investigation-derived waste, and would reduce overall LTM program costs. As presented in Section 4.3.3.5, an estimated $150,000 could be saved over the lifetime (30 years) of the monitoring program if the use of diffusion samplers were to be implemented in 80 percent of the suitable wells at DDJC-Tracy. Capital and OM&M costs could be reduce for new monitoring wells that may be installed in the TCE plume if diffusion sampling for VOCs is used in lieu of micropurge sampling.*

Implementation: *It is assumed that vertical profiles of COC contamination within each monitoring well were developed before dedicated low-flow pumps were installed, and that therefore the optimal sampling depths (i.e., the intervals of highest contaminant concentration within the well) have been identified. Accordingly, the only expense in evaluating whether or not diffusion sampling is appropriate for a given well is to collect paired samples for VOC analysis using the two methods for comparison of the results of the two sampling methods. As described in Section 4.3.3.3, if the results are similar, or if the diffusion sampler result is higher than the conventional method result, diffusion sampler use may be appropriate for that particular well. The results of a 45-well diffusion sampler demonstration planned for DDJC-Sharpe during the summer of 2001 should be applicable to DDJC-Tracy as well.*

To maximize the benefit of DDJC-Tracy's investment in the low-flow-purge sampling program, replacement of micropurging should be considered as dedicated sampling pumps near the end of their useful lives. As new monitoring wells are installed, diffusion sampling should be evaluated before in-well sampling pumps are installed. The costs to implement phased replacement of in-well equipment with diffusion samplers are summarized in table 5.1.

Recommendation 15: Continue the current laboratory selection/auditing process to ensure the contract laboratory is consistently meeting all current analytical method requirements, and that pricing for analytical services is competitive.

Rationale: *Deficiencies in pricing and customer service of the incumbent analytical laboratory were identified during the RPO investigation. A comparison of laboratory analytical costs indicated that current Caltest analytical costs could be reduced by as much as $15,000 per year if a competing laboratory were used for VOC analyses (Method SW8260B) alone. This price difference could save DDJC-Tracy a total of approximately $450,000 during the lifetime (30 years) of the LTM program. Furthermore, QC and customer service issues identified during the RPO investigation (Section 4.3) suggest that laboratory auditing/selection process should be revisited.*

Implementation: *The annual laboratory review process is already in place, and therefore the cost to implement tighter controls is negligible. Market research on competitive analytical costs was recently completed by URS.*

As part of this DLA RPO initiative, implementation of the recommendations made in this section should be considered and carried out, as appropriate, by the Depot and its contractors. Conceptually, implementation of several recommendations was approved by DTSC, the Central Valley RWQCB, and USEPA Region 9 at the May 2, 2001 RPM meeting in Sacramento. The RPO program at DDJC-Tracy should continue the established performance-evaluation framework currently in place, and should be extended as necessary to assess the effectiveness of the optimization efforts implemented as a result of the recommendations presented herein. These events could be implemented in accordance with the following general schedule:

Item	Timeframe	Schedule
Review of Draft RPO Report and DLA/DDC/AFCEE concurrence	To be completed 3 weeks after posting on the DLA web site	12 March 2001
RPO briefing of DDJC-Tracy, the environmental contractor (URS), and the regulatory agencies	Immediately following review	13-14 March 2001
Regulatory review of Draft RPO Report	Review and comment to be completed within 5 weeks of RPO briefing	24 April 2001
Remedial Project Manager (RPM) meeting	Immediately following regulatory review period	2 May 2001
Implementation of recommendations	Beginning within 3 months of May 2001 RPM meeting	15 August 2001
Optimized systems operation [a/]	14 months following implementation	August 2001 – November 2002
Data collection and analysis	Quarterly through implementation period	October 2001, January 2002, April 2002, July 2002, October 2002
Data interpretation	1 month after quarterly data collection/analysis	November 2001, February 2002, May 2002, August 2002, November 2002
Follow-up meetings with regulatory agency	Quarterly or as required during implementation and trial operating period	November 2002
5-Year ROD Review	5 years after Comprehensive ROD was implemented (1998)	2003

SECTION 6

REFERENCES

Advanced Engineering & Planning Corp., Inc. (AEPCO), 1991. *Alternatives Evaluation/Implementation Report, Industrial Process System Assessment and Process Alternatives Evaluation at Defense Depot Region West (DDRW), Tracy.* January.

AFCEE and Air Force Base Conversion Agency (AFBCA). 1999. *Remedial Process Optimization Handbook*. Interim Draft. Brooks Air Force Base, Texas. June.

American Society of Civil Engineers (ASCE). 1990a. *Review of Geostatistics in Geohydrology -- I. Basic Concepts*. Journal of Hydraulic Engineering 116(5):612-632. Task Committee on Geostatistical Techniques in Hydrology

ASCE. 1990b. *Review of Geostatistics in Geohydrology -- II*. Applications. Journal of Hydraulic Engineering 116(5):633-658. Task Committee on Geostatistical Techniques in Hydrology

Brown, R.A., Henry, E., Herman, C., and W. Leonard. 1991. The Use of Aeration in Environmental Cleanups. Proceedings of the 1991 NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water. Houston, Texas. November 20-21, 1991. p. 265-279.

Clark, I. 1987. *Practical Geostatistics*: Elsevier Applied Science, Inc. London.

California Regional Water Quality Control Board (RWQCB). 1998a. *Waste Discharge Requirements for Defense Logistics Agency, Defense Depot San Joaquin, Tracy, Operable Unit 1 Ground Water Treatment System, San Joaquin County*. Order No. 98-053. Central Valley Region. February 27.

California RWQCB. 1998b. *The Water Quality Control Plan (Basin Plan) for the Central Valley Region*. Fourth Edition. September.

Castle Air Force Base (AFB). 1999. *SVE Termination or Optimization Process (STOP) Protocol Document.* Internal document. September.

Cohen, R. M., and Mercer, J. W., 1993. *DNAPL Site Evaluation – Project Summary*. United States Environmental Protection Agency. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma. EPA/600/SR-93/022. April.

ENSOTECH, 1991. *Geologic Well Logs for Interim Groundwater Remediation at Tracy Defense Depot*. Draft. February.

Gibbons, R.D. 1994. *Statistical Methods for Groundwater Monitoring*. John Wiley & Sons, Inc., New York.

Gordon, E.K. 2000. Parsons Engineering Science, Inc. Memorandum to P. Welker (URS Corporation task manager). RE: Peer review comments on the August 2000 Draft Baseline Ecological Risk Assessment Report for Solid Waste Management Unit 4, DDJC-Tracy. August 29.

Gross, W.W., Hall, L.A., and M.M. Mooradiian. 1992. Soil-Vapor Extraction Well Design and Testing. Proceedings of the 35th Annual Meeting of the Association of Engineering Geologists. Long Beach, California. October 2-9, 1992. p. 342-348.

Johnson, P.C., Kemblowski, M.W., and J.D. Colhart. 1990a. Quantitative analysis for the cleanup of hydrocarbon-contaminated soils by *in-situ* soil venting. *Journal of Ground Water* 28(3):413-429.

Johnson, P.C., Stanley, C.C., Kemblowski, M.W., Byers, D.L., and J.D. Colhart. 1990b. A practical approach to the design, operation, and monitoring of *in-situ* soil-venting systems. *Ground Water Monitoring Review*. Spring 1990. p. 159-178.

Jury, W.A., W.F. Spencer, and W.J. Farmer. 1983a. Behavior assessment model for trace organics in soil – I: model description. *Journal of Environmental Quality* 12(4): 558-564.

Jury, W.A., W.J. Farmer, and W.F. Spencer. 1983b. Behavior assessment model for trace organics in soil – II: chemical classification and parameter sensitivity. *Journal of Environmental Quality* 13(4): 567-579.

Kvaerner Davy. 1997a through 1997h. *Groundwater Treatment Plant Performance Monitoring Reports*. Defense Distribution San Joaquin (DDJC) Tracy, California. May through December 1997.

Kvaerner Davy. 1997a through 1997h. *Groundwater Treatment Plant* [1] *Performance Monitoring Reports*. Defense Distribution San Joaquin (DDJC) Tracy, California. May through December 1997.

Kvaerner Environmental. 1998a through 1998j. *OU-1 Groundwater Treatment System Performance Monitoring Reports – Treatment Plant 1*. Defense Distribution San Joaquin (DDJC) Tracy, California. January through October 1998.

Kvaerner Environmental. 1999a through 1999l. *OU-1 Integrated Groundwater Treatment System Performance Monitoring Reports – Treatment Plants 1 and 2*. Defense Distribution San Joaquin (DDJC) Tracy, California. November 1998 through October 1999.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt 1990. *Handbook of Chemical Property Estimation Methods*. American Chemical Society. Washington, DC.

Montgomery Watson. 1995. *Preliminary Design Data Report for Operable Unit 1*. Volume I, Draft. Prepared for US Army Corps of Engineers, Huntsville Division. February.

Montgomery Watson. 1996a. *Final Defense Distribution Region West-Tracy, California Operable Unit 1 Explanation of Significant Difference for the Change from Groundwater Extraction and Reinjection of Treated Groundwater to Groundwater Extraction, Reinjection of Treated Groundwater and Dispersion*. Prepared for U.S. Army Corps of Engineers, Huntsville Division. January.

Montgomery Watson. 1996b. *DDRW-Tracy Comprehensive Remedial Investigation/Feasibility Study*. Final. November.

Montgomery Watson. 1997. *Comprehensive Site-wide Baseline Risk Assessment*. Appendix R to the Final DDRW-Tracy Comprehensive RI/FS.

Montgomery, J.H., and L.M. Welkom. 1990. *Groundwater Chemicals Desk Reference*. Lewis Publishers, Inc. Chelsea, Michigan.

Parsons ES. 2000a. *Remedial Process Optimization Phase II Work Plan for the Tracy Defense Distribution Depot, San Joaquin, California*. September.

Parsons ES. 2000b. *Draft Remedial Process Optimization Report for Operable Unit D, McClellan Air Force Base, California*. Prepared for AFCEE-Technology Transfer Division. Brooks AFB, TX. October.

Parsons ES. 2000c. *Final Remedial Process Optimization Report for George Air Force Base, California*. Prepared for AFCEE-Technology Transfer Division. Brooks AFB, TX. November.

Parsons ES. 2000d. *Draft Remedial Process Optimization Report for Defense Depot Hills, Utah*. Prepared for AFCEE-Technology Transfer Division. Brooks AFB, TX. November.

Parsons ES. 2001. *Draft Remedial Process Optimization Report for Defense Depot San Joaquin California (DDJC) Sharpe, California*. Prepared for AFCEE-Technology Transfer Division. Brooks AFB, TX. February.

Peters, B.B., Kacoroski, A.S., Rohay, V.J., and D.P. Schwaegler. 1994. Enhancement of passive air flow through boreholes using an impermeable surface cover (abstract). *Eos*, Journal of the American Geophysical Union. 75(44):263.

Radian International LLC (Radian). 1996. *DDRW-Tracy Well Monitoring Program, 1995 Annual Well Monitoring Report*. Final. October.

Radian. 1997. *DDRW-Tracy Well Monitoring Program, 1996 Annual Well Monitoring Report*. Final.

Radian. 1998a. *Site-Wide Comprehensive Record of Decision, Defense Distribution Depot San Joaquin, Tracy Site, Tracy, California* . Final. April.

Radian. 1998b. *DDRW-Tracy Well Monitoring Program, 1997 Annual Well Monitoring Report*. Final. May.

Radian. 1999a. *Final Update – Defense Distribution Depot San Joaquin (DDJC)-Tracy Site Environmental Program Status Briefing Report*. Prepared for U.S. Army Corps of Engineers and DDJC-Tracy. March.

Radian. 1999b. *Technical Memorandum - Assessment of Natural Attenuation at DDJC-Sharpe and Tracy*. From S. Louie to M. Cloud, J., Guzman (DDJC-BE), and D. Sheets (CEHNC). 31 March.

Radian. 1999c. *Draft Technical Memorandum Recommending No Further Action at SWMU 20, DDJC-Tracy Site.* From T. Cudzilo to H. Muniz (California

Department of Toxic Substances Control), K. Bessette (Central Valley Regional Water Quality Control Board), and M. Work (US Environmental Protecting Agency, Region 9). 29 September.

Radian. 1999d. *DDRW-Tracy Well Monitoring Program, 1998 Annual Well Monitoring Report*. Final.

Radian. 2000a. *DDJC-Tracy Bioventing/Soil Vapor Extraction Sites Remedial Design – 100 Percent Design*. January.

Radian. 2000b. *Defense Distribution Depot San Joaquin, Tracy Site, Tracy, California, Overland Flow Pilot Study Report*. Prepared for US Army Corps of Engineers, Huntsville Division. Revised Final. March.

Radian. 2000c. *Final DDJC-Tracy Well Monitoring Program 1999 Annual Monitoring Report*. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville. May.

Radian. 2000d. *Defense Distribution Depot San Joaquin (DDJC), Tracy Site, Tracy, California, Bioventing/Soil Vapor Extraction Sites Remedial Action Work Plan and Construction Quality Control Plan.* Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville.

Radian. 2000d. *Waste Management Plan for DDJC-Tracy*. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville.

Radian. 2000e. *DDJC-Tracy Overland Flow Scale-Up Work Plan*. Revised Draft. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville. July.

Radian. 2000f. *Baseline Ecological Risk Assessment, Solid Waste Management Unit 4.* Final. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville. September.

Radian. 2000g through 2000p. Groundwater Treatment Plant Monthly Performance Monitoring Reports. Defense Distribution Depot San Joaquin, Tracy Site, Tracy, California. November 1999 through September 2000.

Rock, N.M.S. 1988. *Numerical Geology*. Springer-Verlag. New York.

Rossabi, J., Riha, B., Looney, B.B., Rohay, V.J., Peters, B.B., and R.J. Cameron. 1993. Barometric pumping for VOC remediation. *Eos*, Journal of the American Geophysical Union 74(43):277.

Sharpe, G. 2001. Personal communication with URS program manager for DDJC-Tracy environmental services. RE: 1996 scaling study for effluent treatment; OU1 infiltration gallery performance in 2000/2001; status of ROD amendment and ESD. March 13.

State Water Resources Control Board. 1997. National Pollutant Discharge Elimination System General Permit No. CAS000001, Water Quality Order No. 97-03-DWQ, issued to Defense Distribution Region Tracy. May 6.

Sterrett, R.J. 1993. Vapor Extraction Systems – An Overview. Proceedings of 35th Annual Meeting of the Association of Engineering Geologists. Long Beach, California. October 2-9, 1992.

Sulborski, A.H., Anthony, J.W., Hughes, T.H., and G. Shepherd. In press. Passive *ex-situ* volatilization – A viable low-cost remediation alternative for soil.

URS Corporation (URS). 2001. *Baseline Ecological Risk Assessment, Solid Waste Management Unit 4.* Revised Final. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville. March.

US Environmental Protection Agency (USEPA). 1994a. *Methods for Monitoring Pump-and-Treat Performance*. Office of Research and Development. EPA/600/R-94/123.

USEPA. 1994b. *Field Investigation of Effectiveness of Soil Vapor Extraction Technology.* Risk Reduction Engineering Laboratory. EPA/600/SR-94/142. September.

USEPA. 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*. Office of Research and Development. EPA/600/R-98/128. September.

Vogel, T.M. 1994. Natural bioremediation of chlorinated solvents. In *Handbook of Bioremediation.* Eds: R.D. Norris, R.E. Hinchee, R. Brown, P.L. McCarty, L. Semprini, J.T. Wilson, D.H. Kampbell, M. Reinhard, E.J. Bouwer, R.C. Borden, T.M. Vogel, J.M. Thomas, and C.H. Ward. Lewis Publishers, Boca Raton, Florida.

Vroblesky, D.A., and T.R. Campbell. 2000. *Draft Guidance Document For Use Of Polyethylene-Based Passive Diffusion Bag Samplers To Obtain Volatile Organic Compound Concentrations In Wells*. USGS Water Resources Division, Columbia, S.C.

Weeks, E.P. 1994. Thermal and wind pumping as mechanisms for passive vapor extraction in hilly terrain (abstract). *Eos*, Journal of the American Geophysical Union 75(44):263.

Wiedemeier, T.H., and P.E. Haas. 1999. *Designing Monitoring Programs to Effectively Evaluate the Performance of Natural Attenuation*. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas. Draft Revision 0. August.

Woodward Clyde Consultants (WCC). 1992a. *Final Operable Unit No. 1 Remedial Investigation/Risk Assessment Report, Defense Distribution Region West, Tracy, California*. November

WCC. 1992b. *Operable Unit No. 1 Feasibility Study Report, Defense Distribution Region West, Tracy, California.* December.

WCC. 1993. *Final Operable Unit No. 1, Record of Decision, DDRW-Tracy, California*. Prepared for U.S. Army Engineering and Support Center, Huntsville. Salt Lake City, Utah. August 13.

APPENDIX A

GEOPROBE® SAMPLING PROCEDURES, BORING LOGS, AND SAMPLING RECORDS FOR OCTOBER 2000 RPO INVESTIGATION

APPENDIX A

GEOPROBE® SAMPLING PROCEDURES

As part of the remedial process optimization (RPO) Phase II evaluation of the Tracy Defense Distribution Depot, San Joaquin, California (DDJC-Tracy) site, Parsons Engineering Science, Inc. (Parsons ES) conducted a limited soil and groundwater sampling program in October 2000 to fill characterization data gaps identified during the RPO scoping visit. In general, this program was conducted in accordance with the sampling and analysis plan presented in the RPO work plan (Parsons ES, 2000). The field methods used to collect soil and groundwater samples are reviewed in this appendix. Geoprobe® boring logs and sampling records are provided following the field method discussion.

A1.0 RPO SOIL CHARACTERIZATION

Three sites are slated for remediation of volatile organic compounds (VOCs) in the vadose zone using soil vapor extraction (SVE) (see Section 4.1 of this RPO report). One of these sites is Defense Site Environmental Recording and Tracking System (DSERTS) 68, the former Area 3 Drum Storage Area. As noted in Section 2.1.3, DSERTS 68 was a target of the RPO field effort conducted in October 2000 to fill characterization data gaps. Soil and groundwater sampling procedures are reviewed in the project work plan (Parsons, 2000).

Elevated VOC concentrations in soil vapor in the portion of DSERTS 68 immediately upgradient from monitoring well LM032AU have been documented (WCC, 1992; Montgomery Watson, 1996; Radian, 2000a). Dissolved PCE and TCE concentrations at well LM032AU have historically been among the highest at the Depot, though this dissolved solvent plume is poorly delineated (see Section 2.3 of the RPO report). Despite thorough characterization of vapor-phase contamination in the vadose zone at DSERTS 68 (Radian, 2000a), soil data for this area were limited to results for samples collected from 1991 through 1994, largely in the previously defined Area 3 that lies southeast of the highest reported soil vapor VOC concentrations (Montgomery Watson, 1996). PCE and TCE were detected at maximum concentrations of 227 micrograms per kilogram (µg/kg) and 440 µg/kg, respectively, in these soil samples. Concentrations of both chemicals persisted at concentrations greater than 100 µg/kg to depths of at least 12 feet bgs (Montgomery Watson, 1996).

To better characterize current residual solvent contamination in vadose zone soils at this site, Parsons ES used a truck-mounted Geoprobe® direct-push rig to drill eight boreholes (designated SB1 through SB8) to the water table (approximately 15 to 20 feet below ground surface [bgs]) at DSERTS 68 in October 2000. Approximate locations of the soil sampling locations at DSERTS 68 are shown on Figure 2.9. All Geoprobe® boreholes were continuously cored and logged; geologic boring logs are provided at the end of this appendix.

The core samples were evaluated through the polybutyrate Geoprobe® liner for the presence of dense nonaqueous-phase liquid (DNAPL) using an ultraviolet (UV) light (Cohen and Mercer, 1993). No DNAPL was detected in any of the boreholes samples. However, because the UV-light detection method was not calibrated against a known DNAPL-contaminated soil sample within a polybutyrate liner, results from the soil DNAPL evaluation are considered inconclusive.

Following DNAPL scanning, headspace analyses were performed on all of the soil core liners at approximate 1- to 2-foot intervals. Headspace analyses were performed after capping both ends of the soil core liners and allowing any VOCs in the soil to volatilize by placing the capped liners in the sun for approximately 15 minutes. Headspace measurements were made by inserting the probe of a photoionization detector (PID) into a hole drilled through one side of the liner. PID results were noted for the appropriate depth on the geologic boring log. For each of the eight soil boreholes, the section of core that produced the highest headspace VOC reading was submitted to Caltest Analytical Laboratory (Caltest) for analysis of VOCs using US Environmental Protection Agency (USEPA) Method SW8260B. Analytical results for the Geoprobe® soil samples are provided in Appendix B, summarized on Figure 2.9, and discussed in Section 2.3 of the report.

Upon completion of soil sampling, boreholes were either converted for use as temporary groundwater monitoring wells (Section A.2), or were abandoned by filling the open intervals with bentonite chips. Investigation-derived waste (IDW) was managed in accordance with the DDJC-Tracy waste minimization plan (Radian, 2000b).

A2.0 RPO GROUNDWATER SAMPLING

Parsons ES conducted limited groundwater sampling from temporary wells installed with the Geoprobe® rig in October 2000. Sampling was conducted to fill data gaps related to better characterizing the dissolved CAH plume associated with DSERTS 68, and to assess CAH plume continuity in the east-central portion of the Tracy Annex, where permanent monitoring points are widely spaced. Groundwater sampling at Geoprobe® locations is described in this subsection.

A2.1 Groundwater Sampling at DSERTS 68

Following soil sampling at DSERTS 68 (see Section A.1), groundwater samples were collected from temporary wells constructed in the two boreholes that exhibited the highest soil headspace results (SB3 and SB8). Each temporary well consisted of a 5-foot section of screen, a bottom cap for the screen, and blank riser piping to the ground surface. Well screens were installed across the water table in the Above Upper hydrostratigraphic unit. No filter pack was installed around the temporary well screens.

Groundwater was purged from the temporary wells using a low-flow method. Direct-reading meters were used in conjunction with a flow-through cell to measure groundwater field parameters at regular intervals during purging. Field parameters measured included: pH, conductivity, oxidation/reduction potential (ORP), dissolved oxygen (DO), turbidity, and temperature. Field parameters recorded throughout well purging are presented on groundwater sampling forms which are included in Appendix A. Once all field

parameters had stabilized, groundwater samples were collected. Groundwater samples were submitted to Caltest for analysis of VOCs using USEPA Method SW8260B. Analytical results for DSERTS 68 groundwater samples are provided in Appendix B and discussed in Section 2.3 of the RPO report. Well sampling records are provided following the Geoprobe® borehole logs in this appendix.

Upon completion of all soil and groundwater sampling at DSERTS 68, the temporary wells were removed from the borehole and disposed of in accordance with the DDJC-Tracy waste management plan (Radian, 2000b). The boreholes were then abandoned by filling the open interval with bentonite chips.

A2.2 Annex Plume-Continuity Delineation

Groundwater samples also were collected from 13 temporary wells installed using the Geoprobe® rig in two areas on the Tracy Annex. For both areas, groundwater samples were collected in a manner similar to that described in Section A.2.1 for the temporary wells installed at DSERTS 68. No soil samples were collected at the Annex groundwater sampling locations.

The area downgradient from the soil investigation area at DSERTS 68 (Area 3) was investigated to better delineate the PCE/TCE plume migrating onto the Annex property from the DSERTS 68 source area. Groundwater samples were collected from six temporary wells (designated TW1 through TW6) screened in the Above Upper aquifer in the area downgradient from DSERTS 68 (Figure 2.10).

The Geoprobe® also was used to install an additional seven temporary wells (designated Annex 1 through Annex 7) in the central and eastern portions of the Annex (Figure 2.2). These wells were constructed and sampled to fill data gaps between existing monitoring wells at the Annex. Five of the seven temporary wells were screened in the Above Upper horizon, and two wells (Annex 1 and Annex 5) were screened in both the Above Upper and the Upper (A) horizons. The wells were purged and sampled as described for the DSERTS 68 temporary wells. Following sampling, the wells were abandoned by removing the well construction materials and filling the open boreholes with bentonite chips.

All groundwater samples collected from the Annex temporary wells were submitted to Caltest for analysis of VOCs using USEPA Method 8260B. Analytical results for these samples are provided in Appendix B and discussed in Section 2.3 of the report. Well sampling records are provided following the Geoprobe® borehole logs in this appendix.

A3.0 APPENDIX A REFERENCES

Cohen, R. M., and Mercer, J. W. 1993. *DNAPL Site Evaluation – Project Summary*. United States Environmental Protection Agency. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma. EPA/600/SR-93/022. April.

Montgomery Watson. 1996. *DDRW-Tracy Comprehensive Remedial Investigation/Feasibility Study*. Final. November.

Parsons ES. 2000. *Remedial Process Optimization Phase II Work Plan for the Tracy Defense Distribution Depot, San Joaquin, California*. September.

Radian. 2000a. *Defense Distribution Depot San Joaquin (DDJC), Tracy Site, Tracy, California, Bioventing/Soil Vapor Extraction Sites Remedial Action Work Plan and Construction Quality Control Plan.* Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville.

Radian. 2000b. *Waste Management Plan for DDJC-Tracy*. Prepared for US Army Corps of Engineers, Engineering and Support Center, Huntsville.

Woodward Clyde Consultants (WCC). 1992. *Final Operable Unit No. 1 Remedial Investigation/Risk Assessment Report, Defense Distribution Region West, Tracy, California*. November

OCTOBER 2000 GEOPROBE® BORING LOGS

GEOLOGIC BORING LOG

BORING NO.: SB1 CONTRACTOR: Parsons ES DATE SPUD:
CLIENT: AFCEE - DDJC-Tracy RIG TYPE: Geoprobe DATE CMPL.:
JOB NO.: 737734.04000.70000 DRLG METHOD: ELEVATION:
LOCATION: near Area 3 BORING DIA.: 2" TEMP:
GEOLOGIST: JPT / TED DRLG FLUID: none WEATHER:
COMENTS: background = 2.5

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID (ppm) above background	TLV (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
	1			4" - Silty clay, damp, brown, slightly plastic					3.5			
									20.0			
	5			8" - Silt, brown, slightly damp with some clay and little very fine sand					17.6			
									13.6			
	10								12.1			
				12' - silty clay brown, damp, plastic					16.1			
									14.1			
	15			16' - brown clay with some silt, plastic, damp			grab @16'		23.1			
				17'10" - Water level					14.1			
	20			20' - sand - medium to coarse with little silt, wet, multi-colored sand								
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC - Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB-2
CLIENT: AFCEE - DDJC-Tracy
JOB NO.: 737734.04000.70000
LOCATION:
GEOLOGIST: JPT / TEO
COMENTS:

CONTRACTOR: Parsons ES
RIG TYPE: Geoprobe
DRLG METHOD:
BORING DIA.: 2"
DRLG FLUID: none

DATE SPUD: 10/7/00
DATE CMPL.: 10/7/00
ELEVATION:
TEMP:
WEATHER:

background: 2.5

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-1' asphalt & rd. base								
				1-4' brown damp clayey silt slightly plastic					4.0			
									12.6			
	5											
									5.5	bg: 5.0		
				4-8' SAA					7.0	bg: 4.0		
	10								7.5	bg: 5.0		
				8-12' SAA except grading to more clay & higher plasticity					16.1	bg: 3.5		
									10.5	bg: 3.5		
	15								16.6	bg: 3.5		
				12-16' ~~SA~~ silty clay, brown, damp, plastic					18.6	bg: 3.5		
							17' core sample SB2-17 @1455		21.1	bg: 4.0		
				18'2" water leve					7.5	bg: 3.5		
	20			16-20' - SAA.								
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB-3
CLIENT: AFCEE - DDJC-Tracy
JOB NO.: 737734.04000.70006
LOCATION:
GEOLOGIST: JPT / TED
COMENTS:

CONTRACTOR: Parsons ES
RIG TYPE: Geoprobe
DRLG METHOD:
BORING DIA.: 2"
DRLG FLUID: none

DATE SPUD: 10/8
DATE CMPL.: 10/8
ELEVATION:
TEMP:
WEATHER:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-2' Asphalt & fill								
				2-4' clayey silt. Brown dry-damp. slightly plastic				4'	10.7	bg:2.5		
								6'	13.4	bg:3.7		
	5			4-8' silt with some clay and some very fine sand. dry-damp. brown. Slightly plastic				8'	19.8	bg:4.3		
								10'	19.7	bg:5.3		
				8-12' - brown silty clay. damp. plastic				12'	27.3	bg:5.9		
	10						~~grab~~ Core	13'	41.6	bg:5.9		
							@13' SB3-13	14'	30.5	bg:5.9		
				12-16' - SAA			940	16'	21.4	bg:5.9		
	15							18'	11.2	bg:4.8		
				16-20' - SAA with saturated zone from 17'10" to 18'0" and from 18'6" to 20'. "Perched" water zone has higher content (20-40%) medium to coarse sand.								
	20											
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52.

GEOLOGIC BORING LOG

BORING NO.: SB-4
CLIENT: AFCEE - DDJC-Tracy
JOB NO.: 737734.04000.70000
LOCATION:
GEOLOGIST: JPT / TEO
COMENTS:

CONTRACTOR: Parsons ES
RIG TYPE: Geoprobe
DRLG METHOD:
BORING DIA.: 2"
DRLG FLUID: none

DATE SPUD: 10/7/00
DATE CMPL.:
ELEVATION:
TEMP:
WEATHER:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-4' - only ~6" of recovery. Fill material.								
	5			4-8' - only ~ 2" recovery, brown silty clay w/ little medium sand. Damp, slightly plastic.					11.6	bg: 2.5		
									19.1	bg: 5.0		
	10			8-12' - SAA but grading to less sand.					13.1	bg: 6.0		
							core @ 11'6" 1630		21.6	bg: 4.5		
				12-16' - SAA but becoming more plastic wet 2" thick section from 15' 8" to 15' 10".					7.5	bg: 4.5		
	15								5.5	bg: 3.5		
				16-20' - SAA. Wet at 18' 2" bgs. to 20'. Moist zone from 18' 8" to 18' 11"					6.5	bg 4.0		
	20			20-24' - SAA. Moist (not wet) zone from 23' 6" - 23' 9"								
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB5 CONTRACTOR: Parsons ES DATE SPUD: 10/4/00
CLIENT: AFCEE - DOJC-Tracy RIG TYPE: Geoprobe DATE CMPL.:
JOB NO.: 737734.04000.70000 DRLG METHOD: ELEVATION:
LOCATION: BORING DIA.: TEMP:
GEOLOGIST: JPT / TED DRLG FLUID: none WEATHER:
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	B.G. ~~TLV~~(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-2' Asphalt & fill / road base								
				2-4' silty clay, brown, damp with little very fine sand					9.1	3.2		
				4-8' - Silty fine to medium damp sand. Brown. with some/little clay. 3" at top of core (4'-4'3") is a grey silty clay					36.4	5.5		
	5								16.4	6.4		
				8-12' - Clay. with some silt and little very fine sand. Brown. Damp. slightly plastic.					23.5	5.9		
	10								28.3	6.4		
				12-16' - SAA with ~~to~~ less sand					33.7	6.4		
									28.3	4.8		
							core from 14'		32.6	5.9		
	15								16.0	6.4		
				16-20' - Wet from 17'7" to 20' SAA.			SB5-14		31.0	5.9		
									8.0	5.9		
	20											
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DOJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB6
CONTRACTOR: Parsons ES
DATE SPUD: 10/8/00
CLIENT: AFCEE - DDJC-Tracy
RIG TYPE: Geoprobe
DATE CMPL.:
JOB NO.: 737734.04000.70000
DRLG METHOD:
ELEVATION:
LOCATION:
BORING DIA.:
TEMP:
GEOLOGIST: JPT / TED
DRLG FLUID: none
WEATHER:
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	b.g. ~~TLV(ppm)~~	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-2 Asphalt & fill					~~7.5~~	~~3.2~~		
				2-4' - Brown clayey silt. Dry to damp with vacuoles & root casts (1-2mm diameter)					7.5	3.2		
									17.1	3.2		
	5			4-8' - Brown sandy-clayey silt. Dry to damp. Few pebble to gravel sized well rounded particles.					12.3	4.9		
									16.0	4.3		
				8-12' - Brown silty clay. damp to moist. Slightly plastic.					9.6	5.9		
	10								20.3	3.8		
				12-16' - SAA.					24.1	4.8		
							core at 12' SB6-12		24.1	80		
									17.3	4.3		
	15			16-20' - Wet at 18' 1" to 20' Clayey-silty medium to fine sand with few pebbles. Brown					23.5	7.5		
									8.0	3.9		
	20											
	25											
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB-7 CONTRACTOR: Parsons ES DATE SPUD: 10/8/00
CLIENT: AFCEE - DOJC-Tracy RIG TYPE: Geoprobe DATE CMPL.:
JOB NO.: 737734.04000.70000 DRLG METHOD: ELEVATION:
LOCATION: BORING DIA.: TEMP:
GEOLOGIST: JPT / TED DRLG FLUID: none WEATHER:
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	B.g. TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-2 Asphalt/Fill								
				2-4 Silty clay. Brown. damp. slightly plastic					28.3	3.2		
				4-8 ~~sandy clayey~~ sandy-clayey silt. Brown. Little pebbles. Damp.					8.6	5.3		
	5								16.6	3.7		
				8-12 clayey silt with little fine sand. Brown. Damp					25.7	4.3		
	10						core SB7-10 @10' bgs 1625		26.2	3.7		
				12-16' - clayey silt. Brown. Damp. Slightly plastic.					25.1	4.3		
									20.9	4.8		
	15			16-20' Firm brown clay. Damp. Plastic					15.0	4.8		
									14.4	4.3		
	20			20-24' SAA					9.6	4.3		
									6.4	3.2		
				24-28' - Water coming up through push rod while drilling					7.0	4.8		
	25			24-25'6" SAA					8.8	3.2		
				25'6"-27'10" - saturated Coarse sand/medium sand.					1.6	1.6		
				27'10"-28' - Thick brown clay								
	30											
	35											
	40											

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DOJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

GEOLOGIC BORING LOG

BORING NO.: SB-8
CONTRACTOR: Parsons ES
DATE SPUD: 10/8/00
CLIENT: AFCEE - DDJC-Tracy
RIG TYPE: Geoprobe
DATE CMPL.:
JOB NO.: 737734.04000.70000
DRLG METHOD:
ELEVATION:
LOCATION:
BORING DIA.:
TEMP:
GEOLOGIST: JPT / TED
DRLG FLUID: none
WEATHER:
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	~~TLV(ppm)~~ 6.9.	TOTAL BTEX(ppm)	TPH (ppm)
	1			0-2 Asphalt/fill								
				2-4' - silty brown clay. Damp to dry. Slightly plastic					4.8	2.7		
									23.0	4.7		
	5			4-8' - SAA with some medium to fine sand. One gravel piece. well rounded.					13.9	4.3		
									21.9	4.3		
				8-12' - Same as above with no gravel								
	10								16.6	4.8		
				12-16' - Brown silty-clay. Damp. Slightly plastic.					35.8	4.3		
									34.2	5.9		
	15								24.1	3.2		
				16-20' - Very stiff brown damp clay. No evidence of saturation			core SB8-16 @ 16' bgs		44.9	5.9		
									13.4	5.9		
	20			20-23' SAA					9.6	5.9		
									24.6	4.8		
				23-23'6" - SAA					8.6	5.3		
									~~8.6~~	~~5.3~~		
	25			23'6" - 24'10" - Coarse black sand								
				24'10" - 27' - Medium brown sand w/ some clay & silt. Saturated at 24'10" to 27'					11.8	4.3	- Pressurized	
									10.6	4.8	at 24'	
	30											
	35											
	40											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG
DDJC- Tracy
RPO Phase II Site Investigation

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

S:\ES\cad\AFCEE\731299\EAKER\99dn0526.dwg, 06/11/99 at 11:52

OCTOBER 2000 GEOPROBE® SAMPLING RECORDS

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: SB-3

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: near area 3, close to LM032AU

DATE AND TIME OF SAMPLING: 10/9/00, 1040 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: partly cloudy ~80°

1. [X] WATER LEVEL: NM

[ ] Water Depth Measured At _____ Feet Below Datum _____

With _____

[ ] Other. Explain: _____

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe: _____

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1105	1112	1120	1130	1135	1140		Measured With
Temp (°C)	22.57	22.50	22.47	22.74	22.83	22.83		Horiba U-22
pH	6.91	6.92	6.93	6.95	6.92	6.94		↓
Cond (µS/cm)	1,960	1,950	1,930	1,940	1,960	1,940		↓
Do (mg/L)	1.97	2.14	2.21	2.46	2.32	2.25		↓
Turbidity	87.4	131.0	206.0	113.0	89.6	92.1		↓
Redox (mv)	134	131	132	136	132	130		↓
gallons purged	2.5	3	4	4.5	5.0	5.25		

Additional Comments: Allowed approx. 2 gallons to purge prior to hooking up flow-thru cell to minimize turbidity in flow-thru cell. Drained & refilled flow-cell at 1125

4. [ ] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1145 ✓ ID = SB3GW **DATE SAMPLE COLLECTED:** 10/9/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: _____ DUPLICATE SAMPLE TIME: _____

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [ ] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: _____

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: SB-8

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: Near area 3

DATE AND TIME OF SAMPLING: 10/9/00, 935 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Partly cloudy, 70'ish

1. [X] WATER LEVEL: NM

[ ] Water Depth Measured At _____ Feet Below Datum _____

With _____

[ ] Other. Explain: _____

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe: _____

3. [ ] DIRECT INSTRUMENT READINGS:

Time	935	940	945	950	955	1000		Measured With
Temp (°C)	22.27	22.14	22.14	22.27	22.37	22.44		Horiba U-22
pH	6.97	7.05	7.08	7.10	7.11	7.13		↓
Cond (µS/cm)	1,710	1,710	1,710	1,700	1,700	1,700		↓
Do (mg/L)	2.72	2.73	2.86	2.95	2.88	2.96		↓
Turbidity (NTU)	54.5	39.2	32.2	24.8	~~18~~ 17.9	16.6		↓
Redox (mv)	78	78	79	78	79	79		↓
approx. gallons purged	0.5	~0.75	~1.0	~1.25	~1.7	~2		

Additional Comments: _____

4. [ ] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1005 / SB8GW **DATE SAMPLE COLLECTED:** 10/9/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: SB8DGW DUPLICATE SAMPLE TIME: 1010

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter Y/N
3	40 mL	glass VOA	SW8260B	None	No
3	40 mL	"	"	"	"

5. [ ] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Lab to ship preserved bottles for tomorrow arrival. Talked w/ lab about lack of preservative. They said hold time would change to 1 week so we must send samples ASAP.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW1

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: Orchard dg. of area 3

DATE AND TIME OF SAMPLING: 10/9/00, 1330 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Cloudy 70's

1. [X] WATER LEVEL:

[X] Water Depth Measured At ~~15.8~~ 15.8' Feet Below Datum ground

With solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1345	1350	1355	1400	1405			Measured With
Temp (°C)	20.70	20.46	20.41	20.31	20.14			Horiba
pH	7.24	7.17	7.15	7.13	7.13			↓
Cond (µS/cm)	1,820	1,810	1,810	1,810	1,810			↓
Do (mg/L)	2.41	2.12	2.19	2.29	2.30			↓
Turbidity	745.0	308.0	145.0	67.0	56.5			↓
Redox (mv)	113	95	97	100	101			↓
gallons purged	2.0	2.25	2.5	2.75	3			

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1405 ID = TW1 **DATE SAMPLE COLLECTED:** 10/9/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Well screened from approx. 14'-19' bgs

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW2

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: Orchard d.g. of Area 3 and dg. of TW1

DATE AND TIME OF SAMPLING: 10/9/00, 1425 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Cloudy 60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.8 Feet Below Datum ground surf.

With _____

[ ] Other. Explain: _____

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe: _____

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1440	1450	1455	1500	~~1505~~ 1510	1515		Measured With
Temp (°C)	20.08	20.08	19.98	19.97	19.96	19.95		Horiba U-22
pH	7.22	7.15	7.15	7.13	7.13	7.13		↓
Cond (µS/cm)	1,680	1,710	1,700	1,710	1,710	1,710		↓
Do (mg/L)	3.69	1.13	1.02	0.68	0.57	0.54		↓
Turbidity	>999	>999	480	128	37.5	45.5		↓
Redox (mv)	123	116	103	97	90	89		↓
gallons purged	2.5	3.0	3.5	3.75	4.75	5.0		

Additional Comments: refresh flo-thru cell @1443 - suspect slough off from borehole walls.

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1520 (Sample ID = TW2) **DATE SAMPLE COLLECTED:** 10/9/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: _____ DUPLICATE SAMPLE TIME: _____

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [ ] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: well screened from 14.5' to 19.5' bgs

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW 3

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: Orchard gtg. of EW

DATE AND TIME OF SAMPLING: 10/10/00, 1125 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Cloudy, rainy, cool 60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 15.15 Feet Below Datum ground surface

With Solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1130	1137	1140	1145	1150	1155		Measured With
Temp (°C)	19.26	19.52	19.58	19.66	19.77	19.86		
pH	6.96	7.03	7.04	7.05	7.05	7.06		
Cond (µS/cm)	1,830	1,890	~~1,890~~ 1,900	1,900	1,900	1,910		
Do (mg/L)	2.21	0.94	0.83	0.76	0.73	0.72		
Turbidity	410	75.0	32.8	11.9	0.4	0.0		
Redox (mv)	49	38	41	45	49	52		
gallons purged	0.5	1.0	1.25	1.5	1.75	2.0		

Additional Comments: Screen interval = 15' – 20' bgs. Pulled sample from 18' bgs

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1200 **DATE SAMPLE COLLECTED:** 10/10/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: _____ DUPLICATE SAMPLE TIME: _____

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	None	No

5. [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled

[ ] Container Lids Taped

[ ] Containers Placed in Ice Chest

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW4

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: Orchard dg of TW3

DATE AND TIME OF SAMPLING: 10/10/00, 1445 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: cloudy 60°

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.88' Feet Below Datum grand

With Solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1505	1510	1515	1530	1535	1540		Measured With
Temp (°C)	19.08	19.11	19.06	18.96	18.92	18.67		Horiba
pH	6.93	6.92	6.92	6.93	6.93	6.93		
Cond (µS/cm)	2,800	2,810	2,820	2,830	2,820	2,840		
Do (mg/L)	1.84	1.61	1.48	1.43	1.44	1.41		
Turbidity	86.1	44.0	29.5	23.2	22.7	27.2		
Redox (mv)	164	154	145	137	136	136		
gallons purged	1.25	1.5	1.75	2.5	~3.0	3.5		

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1540 (ID = TW4) **DATE SAMPLE COLLECTED:** 10/10/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B		No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Well screened from ~14.8 - 19.8' bgs. Sample pulled from approx. 17.3' bgs.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW5

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)
SAMPLING LOCATION DESCRIPTION: Orchard d.g. of area 3
DATE AND TIME OF SAMPLING: 10/9/00, 1750 a.m./p.m.
SAMPLE COLLECTED BY: : JPT/TED of Parsons ES
WEATHER: partly cloudy 70°

1. [X] WATER LEVEL:

[X] Water Depth Measured At 16.67' - 1.07' stickup Feet Below Datum 15.60' bgs
With Solinst
[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump
[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1835	1840	1845	1850				Measured With
Temp (°C)	19.98	20.01	20.01	20.00				Horiba
pH	7.37	7.35	7.35	7.34				↓
Cond (µS/cm)	1,050	1,040	1,040	1,040				
Do (mg/L)	1.50	1.44	1.41	1.32				
Turbidity	755.0	>999	>999.0	>999.0				
Redox (mv)	194	183	179	174				
gallons purged	3.5	3.75	4.0	4.25				

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1855 / ID=TW5 **DATE SAMPLE COLLECTED:** 10/9/00
DUPLICATE COLLECTED: YES/NO
DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled
[X] Container Lids Taped
[X] Containers Placed in Ice Chest

OTHER COMMENTS: screened from 14.9' to 19.9' bgs
originally screened from ~ 19' - 24' bgs. Since water level was ~ 15.5', I pulled up casing 5' to modify screen to bracket water level.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: TW~~5~~6

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: ~~A~~ orchard dg of Area 3 and dg of TW~~5~~5

DATE AND TIME OF SAMPLING: 10/9/00, 1545 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Cloudy. 60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 15.85' Feet Below Datum ground surface

With solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1600	1605	1610	1615	1620			Measured With
Temp (°C)	19.16	19.17	19.17	19.18	19.18			
pH	7.04	7.03	7.03	7.02	7.02			
Cond (µS/cm)	2,110	2,110	2,110	2,110	2,110			
Do (mg/L)	0.28	0.03	0.00	0.00	0.00			
Turbidity	159.0	85.2	69.7	64.2	62.9			
Redox (mv)	142	125	119	115	112			
approx. gallons purged	0.5	0.75	1.25	2.25	2.5			

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1620 (ID=TW6 **DATE SAMPLE COLLECTED:** 10/9/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS:

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 1

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: see map. Orchard ~ 500' N. of "Orchard rd" intersection

DATE AND TIME OF SAMPLING: 10/11/00, 945 (a.m.)/p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: overcast. Low 60's/upper 50's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.10' Feet Below Datum bgs

With solinst

[ ] Other. Explain:

2. [ ] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1020	1025	1030	1035	1040	1045		Measured With
Temp (°C)	18.13	18.36	18.56	18.67	18.71	18.74		Horiba U-22
pH	6.92	7.00	7.02	7.02	7.02	7.02		
Cond (µS/cm)	2,660	2,690	2,700	2,680	2,680	2,680		
Do (mg/L)	0.61	0.28	0.47	0.22	0.06	0.21		
Turbidity	85.0	31.9	14.3	18.3	12.8	8.5		
Redox (mv)	181	175	167	162	157	155		
gallons purged ~	1	1.5	2.0	2.5	2.75	3.0		

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1045 / ID = Annex 1 AU **DATE SAMPLE COLLECTED:** 10/11/00

Blank ~~DUPLICATE~~ COLLECTED: YES/NO (for Sunny Select Distilled H_2O)

DUPLICATE ID: SS1 DUPLICATE SAMPLE TIME: ~~E~~ 1200

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N	
3	40 mL	glass VOA	SW8260B	none	No	Annex 1 AU
3	"	"	"	"	"	SS1

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: This sample taken from AU aquifer. Well screened from ~15-20' bgs.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 1

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: approx 500' N of HP046

DATE AND TIME OF SAMPLING: 10/12/00, 1720 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: sunny, 70's/60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.3' Feet Below Datum bgs

With Solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1800	1820	1825	1830	1835	1840		Measured With
Temp (°C)	20.18	20.00	19.92	19.79	19.74	19.66		Horiba U-22
pH	7.29	7.23	7.22	7.21	7.21	7.21		↓
Cond (µS/cm)	1,690	1,670	1,670	1,660	1,660	1,660		↓
Do (mg/L)	1.34	2.26	2.48	2.55	2.65	2.68		↓
Turbidity	300.0	259.0	281.0	300.0	349.0	350.0		↓
Redox (mv)	-56	-19	-15	-14	-14	-13		↓
gallons purged	1.0	2.0	2.5	2.75	3.0	3.25		

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1840 (ID= Annex 1U **DATE SAMPLE COLLECTED:** 10/12/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: screened from 47.5'-52.5' bgs. Pump intake at approx. 52' bgs

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 2

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: ~500' N of orchard Rd & 500' W of Banta Rd.

DATE AND TIME OF SAMPLING: 10/12/00, 1145 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Partly Cloudy 70's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.1 Feet Below Datum bgs

With Solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1245	1250	1255	1300	1305	1310	1315	Measured With
Temp (°C)	18.95	18.92	18.92	18.97	19.02	19.05	18.98	Horiba U-22
pH	7.11	7.09	7.08	7.08	7.08	7.08	7.07	↓
Cond (µS/cm)	2,720	2,710	2,700	2,700	2,690	2,690	2,690	↓
Do (mg/L)	1.05	0.68	0.47	0.40	0.28	0.21	0.18	↓
Turbidity	344.0	270.0	465.0	792.0	944.0	>999.0	569.0	↓
Redox (mv)	193	187	182	178	176	174	172	↓
gallons purged	0.5	0.75	1.0	1.25	1.75	2.25	2.5	

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1315 / ID: Annex2AU **DATE SAMPLE COLLECTED:** 10/12/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Screened from approx 14.8'-19.8'. Sample taken from approx. 17.8' bgs.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 3

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: 700' S of Annex 5 or row crop rd

DATE AND TIME OF SAMPLING: 10/12/00, 1900 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: clear, dark, 50's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 14.1' Feet Below Datum bgs

With Solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1905	1907						Measured With
Temp (°C)	19.00	18.87						
pH	7.06	7.05						
Cond (µS/cm)	3,380	3,320						
Do (mg/L)	1.97	2.02						
Turbidity	>999	>999						
Redox (mv)	102	99						
gallons purged~	0.5	0.6						

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 945 / Annex3AU **DATE SAMPLE COLLECTED:** 10/13/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Well screened from 14.7'-19.7' bgs. Pumped dry very quickly ~~and~~ (<10 min) and took a long time to charge. Will collect sample on 10/13/00 without purging further.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 4

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: 350' S. of Annex5 & row crop rd.

DATE AND TIME OF SAMPLING: 10/12/00, 1500 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: partly sunny high 70's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 12.86 Feet Below Datum bgs

With _____

[ ] Other. Explain: _____

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe: _____

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1515	1520	1525	1530	1535	1540		Measured With
Temp (°C)	19.20	19.15	19.13	19.09	19.10	19.10		Horiba U22
pH	6.99	6.99	6.99	6.99	6.99	6.99		↓
Cond (µS/cm)	3,200	3,210	3,220	3,220	3,220	3,220		↓
Do (mg/L)	0.72	0.63	0.59	0.57	0.56	0.57		↓
Turbidity	515.0	413.0	379.0	329.0	243.0	258.0		↓
Redox (mv)	42	41	41	43	45	47		↓
gallons purged	1.0	1.25	1.5	1.75	2.25	2.50		

Additional Comments: _____

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1545 / ~~Annex 5A~~ Annex 4AU **DATE SAMPLE COLLECTED:** 10/12/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: _____ DUPLICATE SAMPLE TIME: _____

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: well screened from ~15-20' bgs. Sample taken from approx. 17' bgs.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 5

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: middle of row crop rd.

DATE AND TIME OF SAMPLING: 10/11/00, 1215 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: Rainy, 50's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 11.65' Feet Below Datum bgs

With _____

[ ] Other. Explain: _____

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe: _____

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1230	1235	1240	1245	1250			Measured With
Temp (°C)	18.29	18.24	18.19	18.22	18.24			Horiba U-22
pH	7.01	6.99	6.99	6.98	6.98			↓
Cond (µS/cm)	3,600	3,600	3,590	3,590	3,580			
Do (mg/L)	0.63	0.29	0.20	0.20	0.24			
Turbidity	279.0	173.0	31.3	12.9	8.9			
Redox (mv)	90	86	88	91	92			
gallons purged	0.75	1.0	1.25	1.5	1.75			

Additional Comments: _____

4. [X] SAMPLE CONTAINERS: ID= Annex5AV1

TIME SAMPLE COLLECTED: 1250 **DATE SAMPLE COLLECTED:** 10/11/00

DUPLICATE COLLECTED: YES/(NO)

DUPLICATE ID: _____ DUPLICATE SAMPLE TIME: _____

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Screened from 15-20' bgs. Sampled from ~17' bgs

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 5 U

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: along row crop rd.

DATE AND TIME OF SAMPLING: 10/11/00, 1700 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: raining, 50's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 12.7' Feet Below Datum bgs

With solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [ ] DIRECT INSTRUMENT READINGS:

Time	1740	1745	1750	1800	1805			Measured With
Temp (°C)	17.43	17.51	17.52	17.60	17.55			Horiba U22
pH	7.23	7.22	7.22	7.22	7.22			
Cond (µS/cm)	1,920	1,910	1,910	1,910	1,910			
Do (mg/L)	3.04	2.81	2.80	2.78	2.80			
Turbidity	541.0	660.0	706.0	706.0	725.0			
Redox (mv)	74	77	79	79	79			
gallons purged	3	3.25	3.5	4.0	4.25			

Additional Comments:

4. [X] SAMPLE CONTAINERS: ID=Annex5U

TIME SAMPLE COLLECTED: 1805 **DATE SAMPLE COLLECTED:** 10/11/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS:

Screen set from 50-55'. Pump intake set at approx. 47' bgs. Lots of sediment collected inside screen. Tubing became clogged twice.

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 6

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: intersection of Banta rd & row crop rd.

DATE AND TIME OF SAMPLING: 10/11/00, 1110 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: overcast, mid-60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 13.2 Feet Below Datum bgs

With solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1135	1140	1145	1150	1155			Measured With
Temp (°C)	18.90	18.91	18.81	18.83	18.80			Horiba U-22
pH	7.08	7.07	7.07	7.07	7.07			
Cond (µS/cm)	2,930	2,920	2,920	2,920	2,920			
Do (mg/L)	0.54	0.36	0.30	0.28	0.27			
Turbidity	105.0	266.0	143.0	61.2	69.3			
Redox (mv)	105	83	74	71	69			
gallons purged	1.25	1.50	2.0	2.25	2.5			

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1200 / ID = Annex6AU **DATE SAMPLE COLLECTED:** 10/11/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	none	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS: Sampled from approx. 17' bgs

GROUNDWATER SAMPLING RECORD

MONITORING POINT ID: Annex 7

SITE LOCATION/CLIENT: DDJC-Tracy (Job#: 737734.04000.45.01.70000)

SAMPLING LOCATION DESCRIPTION: halfway down rd to LM147A

DATE AND TIME OF SAMPLING: 10/12/00, 950 a.m./p.m.

SAMPLE COLLECTED BY: : JPT/TED of Parsons ES

WEATHER: overcast, upper 60's

1. [X] WATER LEVEL:

[X] Water Depth Measured At 15.3' Feet Below Datum bgs

With solinst

[ ] Other. Explain:

2. [X] MONITORING WELL EVACUATION:

[X] Method: micropurge with HDPE tubing and peristaltic pump

[ ] Other, Describe:

3. [X] DIRECT INSTRUMENT READINGS:

Time	1015	1022	1035	1055	1100	1105	1110	Measured With
Temp (°C)	20.14	20.12	20.04	20.39	20.20	20.21	20.37	Horiba U22
pH	6.92	7.11	7.13	7.14	7.15	7.14	7.15	↓
Cond (µS/cm)	1,940	1,920	1,890	1,890	1,890	1,870	1,870	↓
Do (mg/L)	3.16	2.34	2.40	2.37	2.37	2.40	2.40	↓
Turbidity	>999.0	689.0	>999.0	877.0	162.0	118.0	76.1	↓
Redox (mv)	155	105	115	124	123	124	121	↓
gallons purged ~	1.25	2	2.5	3.5	4.0	4.25	4.5	

Additional Comments:

4. [X] SAMPLE CONTAINERS:

TIME SAMPLE COLLECTED: 1110 / ID: Annex 7AU **DATE SAMPLE COLLECTED:** 10/12/00

DUPLICATE COLLECTED: YES/NO

DUPLICATE ID: DUPLICATE SAMPLE TIME:

Quantity	Container Size	Container Type	Analysis	Preservative Type	Preservative Field/Lab	Filter. Y/N
3	40 mL	glass VOA	SW8260B	HCl	pre	No

5. [X] CONTAINER HANDLING:

[X] Container Sides Labeled

[X] Container Lids Taped

[X] Containers Placed in Ice Chest

OTHER COMMENTS:

Screened from ~ 14.8' - 19.8' bgs. Pump intake placed at approx. 17' bgs.

APPENDIX B

SUMMARY ANALYTICAL DATA FOR OCTOBER 2000 RPO SOIL AND GROUNDWATER SAMPLING

TABLE B.1
SUMMARY ANALTYICAL RESULTS FOR RPO SOIL SAMPLES FROM SWMU 68
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Study ID	Sample ID	Sample Date	Matrix	Sampling Interval (ft bgs)	PCE (ug/Kg)	TCE (ug/Kg)	CIS-1,2-DCE (ug/Kg)	1,1-DCE (ug/Kg)
SWMU 68	SB1-16	10/7/2000	Soil	15.75-16.25	10	1.5 U	0.5 U	1.5 U
SWMU 68	SB2-17	10/7/2000	Soil	16.75-17.25	1.5 U	1.5 U	0.5 U	1.5 U
SWMU 68	SB3-13	10/8/2000	Soil	12.75-13.25	75	10	0.5 U	1.5 U
SWMU 68	SB4-12	10/7/2000	Soil	11.75-12.25	30	1.5 U	0.5 U	1.5 U
SWMU 68	SB5-14	10/8/2000	Soil	13.75-14.25	16	10	0.5 U	1.5 U
SWMU 68	SB6-12	10/8/2000	Soil	11.75-12.25	15	7	0.5 U	1.5 U
SWMU 68	SB7-10	10/8/2000	Soil	9.75-10.25	13	18	0.5 U	1.5 U
SWMU 68	SB8-16	10/8/2000	Soil	15.75-16.25	34	10	0.5 U	1.5 U

TABLE B.2
SUMMARY ANALYTICAL RESULTS FOR RPO GROUNDWATER SAMPLES FROM SWMU 68 AND ANNEX
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Study ID	Sample ID	Sample Date	Matrix	Sampling Interval (ft bgs)	PCE (ug/L)	TCE (ug/L)	CIS-1,2-DCE (ug/L)	1,1-DCE (ug/L)
SWMU 68	SB3GW	10/9/2000	Groundwater	15-20	470	150	1.6	7
SWMU 68	SB8GW	10/9/2000	Groundwater	15-20	20	110	0.1 U	0.3 U
SWMU 68	SB8GW-DUP	10/9/2000	Groundwater	15-20	17	94	0.1 U	0.3 U
Plume Continuity	ANNEX 1AU	10/11/2000	Groundwater	15-20	1.2	0.9	0.1 U	0.3 U
Plume Continuity	ANNEX 1U	10/12/2000	Groundwater	47.5-52.5	0.3 U	0.8	NR	NR
Plume Continuity	ANNEX 2AU	10/12/2000	Groundwater	14.8-19.8	1	7.2	NR	NR
Plume Continuity	ANNEX 3AU	10/13/2000	Groundwater	14.7-19.7	0.7	5.8	NR	NR
Plume Continuity	ANNEX 4AU	10/12/2000	Groundwater	15-20	1.2	14	NR	NR
Plume Continuity	ANNEX 5AU	10/11/2000	Groundwater	15-20	0.7	1.3	0.1 U	0.3 U
Plume Continuity	ANNEX 5U	10/11/2000	Groundwater	50-55	0.3 U	2	NR	NR
Plume Continuity	ANNEX 6AU	10/11/2000	Groundwater	13-18	0.3 U	0.6	0.1 U	0.3 U
Plume Continuity	ANNEX 7AU	10/12/2000	Groundwater	14.8-19.8	0.7	4.1	NR	NR
Plume Continuity	TW1	10/9/2000	Groundwater	14-19	0.3 U	4.2	0.1 U	0.3 U
Plume Continuity	TW2	10/9/2000	Groundwater	14.5-19.5	0.3 U	1.6	0.1 U	0.3 U
Plume Continuity	TW3	10/10/2000	Groundwater	15-20	15	6.5	0.1 U	0.3 U
Plume Continuity	TW4	10/10/2000	Groundwater	14.8-19.8	18	20	0.1 U	0.3 U
Plume Continuity	TW5	10/9/2000	Groundwater	15.5-19.9	0.3 U	0.3 U	0.1 U	0.3 U
Plume Continuity	TW6	10/9/2000	Groundwater	15.8-18.8	0.3 U	0.3 U	0.1 U	0.3 U

APPENDIX C

EVALUATION OF CHEMICAL MIGRATION IN THE UNSATURATED ZONE

APPENDIX C

EVALUATION OF CHEMICAL MIGRATION IN THE UNSATURATED ZONE

C1.0 INTRODUCTION

Solid waste management unit (SWMU) 1 and DSERTS 66 and 68 at the Tracy Defense Distribution Depot, San Joaquin, California (DDJC-Tracy) are the locations of former operational areas where chlorinated solvents were stored, used, and/or disposed of. Releases of chemicals at these sites have introduced volatile organic compounds (VOCs) to soils and groundwater in the vicinity, at concentrations that exceed cleanup goals established for these media in the DDJC-Tracy Records of Decision (RODs) (Woodward Clyde Consultants [WCC], 1993; Montgomery Watson, 1996a; Radian International LLC [Radian], 1998). The primary chemicals of concern (COCs) in soils at these sites are tetrachloroethene (PCE) and trichloroethene (TCE). The selected remedies for sites 1, 66, and 68 involve installation, operation, and monitoring of soil vapor extraction (SVE) systems to treat soils contaminated with VOCs.

C1.1 Current Cleanup Criteria for Volatile Organic Compounds

Groundwater contamination is being remediated as Operable Unit 1 (OU1) using a combination of extraction, treatment, and injection (ETI) and monitored natural attenuation (MNA), in accordance with the requirements of the OU1 ROD (WCC, 1993; Montgomery Watson, 1996a). The ROD establishes the PCE and TCE federal maximum contaminant levels of 5 micrograms per liter (µg/L) as aquifer cleanup levels (ACLs) for each of these COCs in groundwater. Radian (1999 and 2000) has designed SVE systems for the three SVE sites to remediate unsaturated soils to meet the soil vapor cleanup criteria. As specified in the Comprehensive Site-Wide ROD (Radian, 1998), the objective of the SVE systems to be installed at SWMU 1/Area 2 (former sewage lagoon and drum storage area), DSERTS 66 (asphalt-equipment cleaning area), and DSERTS 68 (former Area 3 drum storage area) is to prevent further degradation of groundwater quality resulting from continued migration of PCE and TCE from vadose-zone soils to groundwater at dissolved concentrations exceeding the ROD-specified groundwater cleanup goals for these chemicals. The DDJC-Tracy Comprehensive ROD specifies 350 parts per billion by volume (ppbv) of TCE and 780 ppbv of PCE as those concentrations in soil vapor that will prevent introduction of these COCs to groundwater in the saturated zone (i.e., at and beneath the water table) at concentrations exceeding the ACLs (Radian, 1998).

The ROD-specified cleanup standard of 350 ppbv of TCE in soil vapor is the same as that established for the nearby DDJC-Sharpe, which also is on the National Priorities List (NPL). The cleanup standard for DDJC-Sharpe was derived on the basis of Henry's Law, which establishes the concentration of a substance dissolved in the aqueous phase at equilibrium with its vapor phase (ESE, 1994, Appendix L; Radian, 2000):

$$C_{vapor} = H_{dimensionless} \times C_{aqueous} \qquad \text{(C-1)}$$

where

C_{vapor}	=	concentration of substance in the vapor phase [M/L^3];
$C_{aqueous}$	=	concentration of substance dissolved in water, at equilibrium with vapor-phase concentration [M/L^3]; and
$H_{dimensionless}$	=	dimensionless Henry's Law constant.

The Henry's Law constant is a measure of the relative tendency of a chemical to move between the dissolved and vapor phases, and is a function of the vapor pressure and solubility of the chemical. A chemical with a high Henry's Law constant will have a high ratio of chemical concentration in the vapor phase compared with that chemical's concentration in the aqueous phase, and also is likely to volatilize to the surrounding atmosphere.

Values of the Henry's Law constant for various chemicals that are tabulated in the scientific literature (e.g., Yaws, 1999) are usually expressed in dimensional terms (atmosphere-cubic meters per mole [atm-m^3/mol]), which can be converted to the dimensionless form of the constant, using (Lyman *et al.*, 1990):

$$H_{dimensionless} = \frac{H_{dimensional}}{R \times T} \qquad \text{(C-2)}$$

where

$H_{dimensional}$	=	dimensional Henry's Law constant [atm-m^3/mol];
R	=	ideal gas constant [8.21 x 10^{-5} atm-m^3/mol-°K]; and
T	=	absolute ambient temperature [°K].

At an absolute ambient temperature of 25 degrees Celsius (°C) (298°Kelvin [K]), the dimensional Henry's Law constant for TCE is 0.00910 atm-m^3/mol (Table C.1). Using equation C-2, the dimensionless Henry's Law constant for TCE at an ambient temperature of 298°K is calculated to be:

$$H_{dimensionless} = \frac{0.00910 \text{ atm} - \text{m}^3 / \text{mol}}{8.21 \times 10^{-5} \text{ atm} - \text{m}^3 / \text{mol} - °\text{K} \times 298°\text{K}} \qquad \text{(C-3)}$$

$$H_{dimensionless} = 0.372$$

TABLE C.1
PROPERTIES OF CHEMICALS OF CONCERN
REMEDIAL PROCESS OPTIMIZATION PHASE II REPORT
DDJC-TRACY, CALIFORNIA

Chemical of Concern[b/]	Molecular Weight (g/mol)[c/]	Henry's Law Constant ($atm\text{-}m^3/mol$)[d/]	Vapor Pressure (mm Hg @ 20°C)[e/]	Density (g/cm^3)[f/]	Solubility (mg/L)[g/]	Vapor-Air Diffusion Coefficient (cm^2/day)[h/]	Water-Liquid Diffusion Coefficient (cm^2/day)	K_{oc}[a/] (mL/g)[i/]	log K_{oc}	First-Order Decay Constant in Water (1/days)[j/]
PCE	165.83 [k/]	2.69E-02 [l/]	1.40E+01 [m/]	1.623 [k/]	150 [m/]	6,912 [n/]	0.65 [n/]	2.63E+02 [o/]	2.42	0.0001 - 0.001 [p/, q/]
TCE	131.39 [k/]	9.10E-03 [l/]	6.00E+01 [m/]	1.464 [k/]	1,100 [m/]	7,603 [n/]	0.72 [n/]	1.07E+02 [o/]	2.03	0.0001 - 0.001 [p/, q/]

[a/] K_{oc} = Organic carbon partition coefficient.
[b/] PCE = tetrachloroethene, TCE = trichloroethene.
[c/] grams per mole.
[d/] atmospheres-cubic meters per mole.
[e/] millimeters of mercury at 20 degrees Centigrade.
[f/] grams per cubic centimeter.
[g/] milligrams per liter.
[h/] square centimeters per day.
[i/] milliliters per gram.
[j/] per day.
[k/] Weast *et al* ., 1989.
[l/] Yaws, 1999.
[m/] Verschueren, 1983.
[n/] Tetra Tech, Inc., 1988.
[o/] Montgomery and Welkom, 1990.
[p/] Howard *et al* ., 1991.
[q/] Wiedemeier *et al.* , 1999.

Using the dimensionless Henry's Law constant for TCE, the concentration of TCE in the vapor phase, at equilibrium with a concentration of 5 µg/L of TCE dissolved in water (the ACL for TCE in groundwater) can be estimated, using Equation C-1:

$$C_{vapor} = 0.372 \times 5\,\mu g / L\ of\ water$$

$$C_{vapor} = 1.86\,\mu g / L\ of\ air$$

Chemical concentrations in the vapor phase are generally expressed on a volume-per-volume basis (e.g., ppbv of TCE in air). Therefore, it is necessary to convert the mass-based estimate (1.86 µg of TCE per liter of air) to a volume-per-volume estimate of the vapor-phase concentration of TCE in air, that would be in equilibrium with 5 µg/L of TCE in water. If air is assumed to be an ideal gas, the ideal gas law can be used to estimate the molar volume of air:

$$\frac{n}{v} = \frac{P}{R \times T} \qquad \text{(C-4)}$$

where

n/v = moles of air (n) per unit volume of air (v) [n/M^3] at pressure P [atm].

At an ambient pressure of 1 atm (equivalent to sea-level pressure), the molar volume of air is:

$$\frac{n}{v} = \frac{1.0\ atm}{8.21 \times 10^{-5}\ atm - m^3 / mol - °K \times 298°K} \times \frac{1\ m^3}{1{,}000\ L}$$

$$\frac{n}{v} = 4.087 \times 10^{-2} \quad mol\ of\ air / L\ of\ air$$

The volume-per-volume concentration of TCE in air may be expressed as the ratio of the moles of TCE and the moles of air, in a unit volume of air:

$$\frac{n_{TCE}}{n_{air}} \equiv \frac{vapor - phase\ moles\ of\ TCE}{moles\ of\ air}$$

$$\frac{n_{TCE}}{n_{air}} \equiv \frac{1.86\,\mu g\ of\ TCE}{L\ of\ air} \times \frac{1\,L\ of\ air}{4.087 \times 10^{-2}\ mol\ of\ air} \times \frac{1\,mol\ of\ TCE}{131.39\,g\ per\ mol\ of\ TCE} \times \frac{1\,g}{10^6\ \mu g} \times \frac{10^9}{1\,billion}$$

$$\frac{n_{TCE}}{n_{air}} = 346\ ppbv$$

Thus, a volume-per-volume concentration of about 350 ppbv of TCE in soil vapor is in equilibrium with TCE at a concentration of 5 μg/L dissolved in water that is in contact with the vapor phase. A similar calculation may be used to derive the concentration of PCE in soil vapor (780 ppbv) in equilibrium with PCE at a concentration of 5 μg/L, dissolved in water in contact with the vapor phase.

Several assumptions are necessary if vapor-phase concentrations of PCE and TCE, in equilibrium with concentrations of 5 μg/L of each constituent dissolved in water, are to be established as cleanup standards for these constituents in soil vapor:

1. Soil vapor containing TCE at a concentration of 350 ppbv, or PCE at a concentration of 780 ppbv, must be in direct contact with the underlying water table, and must remain in contact until equilibrium concentrations are established.

2. Soil vapor containing TCE at a concentration of 350 ppbv, or PCE at a concentration of 780 ppbv, is in direct contact with the water table across the entire affected area, and movement of groundwater into or out of the affected area does not occur. This assumption disallows the possibility that dilution of groundwater contaminated with TCE or PCE could reduce the concentrations of those constituents to levels below the ACLs.

3. Vertical (upward) migration of vapor-phase TCE or PCE toward the atmosphere (and away from the water table) does not occur. This is equivalent to stating that the soil vapor concentrations of TCE or PCE are uniform through some thickness of the vadose zone, and remain constant through time.

4. If TCE or PCE in soil vapor is not in direct contact with groundwater in the saturated zone, but is in contact only with soil water in the unsaturated zone at some distance above the water table, equilibrium conditions will be established between TCE or PCE in the vapor phase and TCE or PCE dissolved in soil water. Constituents dissolved in soil water will then migrate to the water table (at whatever depth in the soil column below the contaminated soil vapor) with no attenuation occurring.

During several soil-vapor investigations, TCE nor PCE have been detected in fewer than half of soil-vapor samples collected near the water table at concentrations that exceed the soil-vapor cleanup standards for these VOCs (Radian, 2000). Upward migration of these constituents in soil vapor is known to occur (TCE and TPE are "volatile" organic chemicals); and several different attenuation mechanisms, including volatilization, sorption to soil, dilution, dispersion, and chemical or biological degradation, are capable of acting to reduce the mobility or concentrations of chemicals in the subsurface environment (USEPA, 1998). In light of these observations, the assumptions used to establish the ROD cleanup standards for TCE and PCE in soil vapor appear to be unnecessarily conservative. Accordingly, the current cleanup standards were reviewed, in light of current understanding of site-specific conditions in the subsurface at DDJC-Tracy, to evaluate whether more realistic cleanup standards for TCE and PCE in soil vapor, that would still be protective of underlying groundwater, could be developed.

C1.2 RPO Objectives

As part of the remedial process optimization (RPO) Phase II evaluation for DDJC-Tracy, Parsons Engineering Science, Inc. (Parsons ES) reviewed conditions at sites 1, 66, and 68 and the SVE system designs developed by Radian (1999 and 2000) for these three sites; collected soil and groundwater samples at DSERTS 68 to address data gaps in the characterization of the occurrence of PCE and TCE at this site; and performed analytical modeling of unsaturated-zone contaminant transport using site-specific data as input parameters. The results of the soil and groundwater sampling at DSERTS 68 are reviewed in Section 2 of the RPO Phase II report, site-specific soil cleanup goals are summarized in Section 3, and review of the SVE designs is provided in Section 4.

This appendix describes the site-specific vadose-zone transport calculations that were completed for SWMU 1, DSERTS 66, and DSERTS 68. The purpose of the calculations was two-fold:

- Develop screening-level cleanup goals for vadose zones soils using site-specific data for comparison to Depot-wide ROD cleanup goals that apparently were developed using equilibrium-partitioning (Henry's Law) calculations; and

- Provide low-cost, site-specific analytical model results for eventual comparison with results obtained from more rigorous numerical modeling being conducted by URS (in preparation).

If site-specific cleanup goals for soils at the three sites higher than those specified in the Comprehensive ROD (Radian, 1998) can be developed, supported by recognized analytical procedures, and successfully defended to regulatory authorities, the time (and therefore the costs) required to achieve site cleanup and closure could be reduced. If analytical modeling results compare favorably with numerical modeling results, site-specific screening-level soil cleanup goals could be developed for other VOC-contaminated DLA sites at a reasonable cost, provided the sites are appropriate for application of the simplifying assumptions used in analytical models .

C1.3 Site Descriptions

This subsection provides brief descriptions of the operational histories, environmental settings, nature and extent of contaminants in the subsurface, and SVE system designs for sites 1, 66, and 68 at DDJC-Tracy, which have been identified as candidate sites for remediation of chlorinated COCs in vadose-zone soils using SVE technology (Radian, 1998 and 2000). The locations of these sites are shown on Figure 1.3 of the RPO report. Unless otherwise noted, site information was summarized from the Radian (2000) SVE 100-percent design report. Soil characteristics and VOC concentrations in soil gas used in the SVE system designs were evaluated at the sites in October and November 1998, using cone penetrometer testing (CPT) techniques (Radian, 1999). SVE pilot tests also were conducted in 1999 at SWMU 1/Area 2 and DSERTS 66 to evaluate soil/air permeability and radius of influence of SVE wells (Radian, 2000). As a consequence of the proximity of SWMU1/Area 2 and DSERTS 68/Area 3 (see Figure 1.3 of the RPO report) and similarities between soil properties at the two sites, the results of pilot testing at SWMU 1/Area 2 also were used to design the DSERTS 68 (Area 3) SVE system.

C1.3.1 SWMU 1/Area 2

SWMU 1 is the site of the former Depot sewage lagoon, which received sanitary sewer effluent until 1945. The lagoon was backfilled in 1945, when the new sewage lagoon was constructed (Figure 1.3 of the RPO report). An operational area (Area 2), formerly used as a drum storage area, was built at and southeast of the former sewage lagoon site circa 1957, and was used until 1984. The drum storage area extended from the SWMU 1 location southeast to just east of Building 258, and abuts the northwestern edge of the Area 3 drum storage area (Section C1.3.3). Drums of chemicals, including solvents, were stored in the open on gravel or asphalt pads. Releases from these drums are the suspected source of PCE and TCE (and other minor contaminants) that have been detected in site soils and underlying OU1 groundwater. Land surface at Area 2 is generally level, is paved with asphalt, and currently is used for non-hazardous materials storage.

Vadose-zone soils at Area 2 consist of silts and clays, and groundwater is encountered at a depth of approximately 16 feet below ground surface (bgs). During sampling conducted for the Comprehensive Remedial Investigation (RI) in 1994, PCE was detected in soil samples collected in the depth interval from 4 feet bgs to the water table. The maximum PCE concentration detected in a soil sample was 310 micrograms per kilogram (µg/kg) (Montgomery Watson, 1996b). TCE was not detected in any soil sample, but has been detected in soil-vapor and groundwater samples collected at Area 2.

During Radian's (2000) 1998 CPT investigation, two sub-areas at the SWMU 1/Area 2 site were identified, within which COC concentrations in soil-vapor samples exceeded the ROD-specified cleanup criteria for soil vapor. The maximum concentrations of PCE and TCE detected in soil-vapor samples were 3,400 ppbv and 7,000 ppbv, respectively, with detected concentrations in soil vapor extending from depths of about 6.5 feet bgs to just above the water table. These COCs also have been detected in groundwater at, and just downgradient from the site at concentrations exceeding the ROD-specified ACLs (5 µg/L for both PCE and TCE). The maximum detected concentrations of COCs in groundwater samples from shallow depths in the water-bearing unit (Above Upper horizon) in 1999 were 49.8 µg/L of PCE and 4.12 µg/L of TCE in a sample from downgradient well LM030AUA (see Figure 2.2 of the RPO report). TCE has not been detected above its ACL of 5 µg/L in shallow groundwater since the third quarter of 1998 (3Q98), when it was detected at a concentration of 5.02 µg/L in the sample from well LM030AUA.

Based on the 1998 soil-vapor data, Radian (2000) has estimated that approximately 1.0 pound of PCE and 1.6 pounds of TCE mass remain in the vadose zone at SWMU 1/Area 2. The remedial design for this site calls for installation of 14 vapor monitoring points (VMPs) and 7 SVE wells on 2 extraction circuits, with a design extraction-well flow rate of 15.5 standard cubic feet per minute (scfm).

C1.3.2 DSERTS 66

The site currently referred to as DSERTS 66 (Parsons ES, 2000), also known as Area 1, is located in the vicinity of Building 237 at DDJC-Tracy (Figure 1.3 of the RPO report). The area north of the building historically was used for cleaning asphalt equipment. The solvents used in the cleaning operations apparently were released to soil,

and subsequently have migrated to groundwater. Land surface at the site is level, and is covered with asphalt and gravel.

Vadose-zone soils at DSERTS 66 consist of silts and clays; and groundwater is encountered at a depth of approximately 15 feet bgs. During sampling conducted for the Phase I RI in 1993, PCE was detected in soil samples collected in the depth interval from 3 feet bgs to the water table. The maximum PCE concentration detected in a soil sample was 1,120 µg/kg (Montgomery Watson, 1996b). TCE was not detected in any soil sample, but has been detected in soil-vapor and groundwater samples collected at DSERTS 66.

During Radian's (2000) 1998 CPT investigation, the area within which the concentrations of COCs in soil-vapor samples exceeded the ROD-specified cleanup criteria for soil vapor encompassed the entire vicinity of Building 237. The maximum concentrations of PCE and TCE detected in soil-vapor samples were 10,000 ppbv and 15,000 ppbv, respectively, with detected concentrations extending from depths of about 5 feet bgs to just above the water table. These COCs also have been detected in groundwater samples from locations downgradient from DSERTS 66, at concentrations exceeding the ROD-specified ACLs. The maximum concentrations of PCE and TCE detected during 1999 in groundwater samples from downgradient well LM61AU (Figure 2.2 of the RPO report) were 8.6 µg/L and 7.55 µg/L, respectively.

Based on the 1998 soil-vapor data, Radian (2000) has estimated that approximately 3.4 pounds of PCE and 1.8 pounds of TCE mass remain in the vadose zone at DSERTS 66/Area 1. The remedial design for this site calls for installation of 12 VMPs and 8 SVE wells on 2 extraction circuits, with a design extraction-well flow rate of 19.2 scfm.

C1.3.3 DSERTS 68

The site currently referred to as DSERTS 68 (Parsons ES, 2000) incorporates and extends northwestward from the Area 3 former drum storage area to the Area 2 storage area (Section C1.3.1) at DDJC-Tracy (Figure 1.3 of the RPO report). The storage area formerly was thought to be confined to the Area 3 boundaries indicated on Figure 2.1 of the RPO report (Montgomery Watson, 1996b), but soil contamination extending from that area northwestward to the southeastern edge of the Area 2 drum storage area has since been documented (Section C1.3.1). The site was used for open storage of drums of chemicals, including solvents. Releases from drums at this location are the suspected source of PCE and TCE (and other contaminants) that have been detected in site soils and underlying OU1 groundwater. Land surface at DSERTS 68 is generally level, and is paved with asphalt. Installation of the SVE system in October/November 2000 has resulted in removal of the asphalt cover in some site areas.

Vadose-zone soils at DSERTS 68 consist of silts and clays, and groundwater is encountered at a depth of approximately 16 feet bgs. During sampling conducted at Area 3 (as originally defined) for the Phase I RI in 1993, PCE and TCE were detected in soil samples collected in the depth interval from 2 feet bgs to the water table. The maximum concentrations of PCE and TCE detected in soil samples were 227 µg/kg and 440 µg/kg, respectively (Montgomery Watson, 1996b). Because the only available soil-quality data for the northwestern extension of DSERTS 68 were collected in 1991/1992 (WCC,

1992), Parsons collected eight soil samples from this area in October 2000, using Geoprobe® direct-push technology (Figure 2.9 of this RPO Phase II evaluation report). The concentrations of PCE detected in soil samples collected during that sampling effort ranged from not detected (< 5 µg/kg) to 75 µg/kg (Section 2.3 of the report); and the concentrations of TCE detected in soil samples ranged from not detected (< 5 µg/kg) to 18 µg/kg. VOCs were detected in soil samples collected from the depth interval of 10 to 17 feet bgs.

During Radian's (2000) 1998 CPT investigation, the area within which the concentrations of COCs in soil-vapor samples exceeded the ROD-specified cleanup criteria for soil vapor encompassed an area 750 feet long by about 325 feet wide. The maximum concentrations of PCE and TCE detected in soil-vapor samples were 10,000 ppbv and 15,000 ppbv, respectively, with detected concentrations in soil vapor extending from depths of about 5 feet bgs to just above the water table. These COCs also have been detected in groundwater samples from locations downgradient from DSERTS 68 at concentrations exceeding the ROD-specified ACLs. The maximum concentrations of PCE and TCE, detected in groundwater samples collected from downgradient well LM032AU (Figure 2.2 of the RPO report) during the 2Q99 monitoring event, were 222 µg/L and 96.1 µg/L, respectively. Preliminary results for the November 2000 groundwater monitoring event indicate that the concentrations of PCE and TCE in groundwater samples from well LM032AU were 110 µg/L and 42 µg/L, respectively. Preliminary results for groundwater samples collected from the source area during the October 2000 Geoprobe® investigation corroborated these results at well LM032AU (see Figure 2.13 of this RPO Phase II evaluation report).

Based on the 1998 soil-vapor data, Radian (2000) has estimated that approximately 39.4 pounds of PCE and 24.7 pounds of TCE mass remain in the vadose zone at DSERTS 68/Area 3. The remedial design for this site calls for installation of 28 VMPs and 18 SVE wells on 3 extraction circuits, with a design extraction-well flow rate of 15.5 scfm.

C2.0 OVERVIEW OF UNSATURATED VOC MASS TRANSPORT AND ONE-DIMENSIONAL MODELS

The purpose of site-specific, unsaturated-zone contaminant transport modeling was to evaluate, within the constraints of realistic boundary conditions, site-specific soil properties, and chemical properties appropriate to each COC, the possible downward migration of PCE and TCE through the vadose zone to the water table at SWMU 1, DSERTS 66, and DSERTS 68, and to predict the maximum concentrations of these COCs that could remain in the vadose zone without allowing their continued migration to the water table at concentrations that would exceed the ACLs of 5 µg/L in groundwater. The results of this evaluation can then be used to calculate the concentrations of COCs in the vapor phase, in equilibrium with the maximum sorbed and dissolved soil concentrations, that could remain in the soil column within the vadose zone.

These calculated vapor-phase concentrations of PCE and TCE represent screening-level indicators of site-specific cleanup criteria for COCs in soil at the three sites. If vapor-phase PCE or TCE concentrations at a given site exceed the screening-level soil-vapor cleanup criteria, then it is likely that the concentrations of these COCs in the sorbed, dissolved, and/or vapor phases in the vadose zone are sufficiently elevated that

PCE/TCE will continue to migrate to the groundwater table at concentrations that would exceed the ACLs. Conversely, if COC vapor-phase concentrations are below the screening-level soil-vapor cleanup criteria, then migration of PCE and TCE to the groundwater table at concentrations that would exceed the ACLs is unlikely to occur.

C2.1 Chemical Migration and Fate Processes in the Environment

Under particular conditions, chemicals can exist in the environment in any of four different phases: as pure compound or in a chemical mixture; dissolved in water; sorbed to soil particles; or as a vapor. When initially released to the subsurface environment, organic solvents are usually in the non-aqueous liquid phase (NAPL [pure chemical, chemical mixture, or "free" phase]). Once a chemical has been introduced into the environment, it interacts with the surrounding materials (soils, soil vapor, and water). Chlorinated solvents in the subsurface can migrate as volatile gases in soil vapor, dissolved in soil water, and as a mobile, separate phase.

Solutes in transit through soils in the vadose zone are affected by physical, hydraulic and chemical processes, including dissolution from the NAPL phase, advection, dispersion, diffusion, sorption to soil, chemical binding, ion exchange, dilution, chemical reaction, retardation, and chemical and biological decay. Because many of these processes may contribute to attenuation of chemical concentrations, it is unreasonable to assume that the concentration of a particular chemical dissolved in soil water in the vadose zone at some distance above the groundwater table is representative of the concentration of that chemical that might eventually migrate to the groundwater table. A rigorous analysis of chemical transport in the subsurface should examine the effects of all the processes that affect chemical migration and attenuation, so that the potential for chemical migration to groundwater can be assessed realistically. While this analysis can be accomplished using existing numerical codes, an analytical solution also can be effectively applied under certain circumstances (Javandel *et al*., 1984).

C2.2 Mathematical Simulation of Chemical Migration Processes

In a mathematical model of dissolved contaminant migration within the unsaturated zone, leachate flow and contaminant transport are coupled through an advective transport term in the equation describing conservation of mass. The transport term may be complicated by seasonal and climatic effects, leading to time-variant leachate flow. However, use of an average annual effective infiltration rate in the mass transport equation can provide a reasonable approximation of actual transient flow and resulting contaminant transport (Destouni, 1991; Maidment, 1993). Therefore, use of an analytical solution describing aqueous solute transport under conditions of steady-state flow is appropriate for screening-level calculations.

Water percolation through the soil column is computed using the Hydrologic Evaluation of Landfill Performance (HELP) code (Schroeder *et al*., 1994). Site-specific soil and climatic data are incorporated into the model in which vertical, Richards-type unsaturated movement of liquid water is assumed to occur primarily due to gravitational forces. The percolation out of the bottom layer of the soil column simulated in the HELP model represents the amount of liquid water flux (recharge) to the groundwater system.

Because the vadose zone comprises variably saturated pore spaces (i.e., pore spaces are not completely filled with water), an analytical solution to the one-dimensional (1-D), unsaturated, contaminant-mass transport equation (Jury *et al*., 1983a) was used to evaluate the potential migration of PCE and TCE in the subsurface at sites 1, 66, and 68 at DDJC-Tracy. Using the "Jury" model, chemical migration in the aqueous phase can be examined, and because the porous medium contains some proportion of air in the pore spaces, vapor-phase transport also is accounted for. The solution to the equations describing 1-D, unsaturated transport (Jury *et al*., 1983a and 1983b) is in the form of a partitioning model that distributes a chemical species in equilibrium among its possible phases (dissolved in water, sorbed to soil, and in soil vapor) in accordance with its chemical properties and local conditions in the subsurface.

Use of a 1-D analytical solution of this type is appropriate for the following reasons:

- The analytical solution considers the effects of the principal physical and chemical mechanisms that contribute to chemical migration and environmental attenuation: advection, diffusion, dispersion, volatilization, sorption, decay, and source-mass depletion.

- Use of two-dimensional (2-D) or three-dimensional (3-D) variably saturated flow and transport codes (e.g., SESOIL) requires that the subsurface be characterized in considerable detail, in order to provide the quality and quantity of input data required for accurate numerical modeling. The required level of detail (centimeter-scale) generally is not available.

- Because a conservative, site-specific average infiltration rate can be estimated, and because accurate modeling of transient infiltration is problematic, it may be appropriate to disregard numerical simulations of flow, and instead use a calculation method that requires only steady-state seepage velocity as a primary input.

- Analytical solutions are simpler (and less expensive) to implement, have fewer sources of error, and are easier to verify than comparable numerical solutions. Their use is preferable in cases where available data are insufficient to take advantage of a numerical solution's greater flexibility.

Subsurface transport of chemicals as NAPL or in the aqueous or vapor phase is driven by potential gravitational, hydraulic, and/or chemical gradients. In the unsaturated zone, gravitational and hydraulic potential gradients are primarily vertical, so that the direction of movement of chemicals in the dissolved or NAPL phases is generally downward. The atmosphere represents the ultimate sink for VOCs, so that vapor-phase chemical concentration gradients are usually directed upward, and vapor-phase migration is induced from the subsurface to the atmosphere. As a consequence of the generally vertical orientation of gravitational, hydraulic, and chemical gradients, application of a 1-D solution to the evaluation of conditions in the vadose zone is entirely appropriate, because dissolved-phase chemical migration in a 1-D model occurs in only one direction (downward). In examining precipitation, infiltration, and chemical flux through the vadose zone, water and the various chemical species (sorbed, aqueous, and vapor) are

assumed to originate at some interval below the ground surface, and to travel straight downward through the soil column.

In the 1-D model used for this evaluation , transport can be examined for only a single chemical species at a time, and the interactions among various COCs are disregarded. Although solute concentrations in infiltrating water, resulting from contact with an immiscible mixture containing components that interact in the soluble phase (e.g., VOCs), are known to deviate from ideal behavior, the observed deviations from Raoult's Law in oil/water partitioning coefficients are small (Cline *et al*., 1991). Therefore, relatively little error results from the calculation of chemical transport for a single solute species in a mixture.

In summary, a 1-D analytical model simplifies many of the complexities of a "real" vadose-zone transport system. Nevertheless, if the available data are limited and the transport parameters are suitably restricted, a 1-D model can provide sufficient information for a first-order assessment of chemical migration and possible environmental impacts (Javandel *et al.*, 1984).

C3.0 UNSATURATED-ZONE TRANSPORT CALCULATIONS

C3.1 Governing Equations and Assumptions for Steady-State, Unsaturated Transport

The Jury model (Jury *et al*., 1983a) used to simulate the transport of contaminant mass through the vadose zone to the water table is based on several simplifying assumptions:

- Chemical transport occurs vertically through a uniform soil column, consisting of a homogeneous porous medium that is infinite in vertical extent;
- The chemical adsorption isotherm is linear and reversible;
- The equilibrium liquid/vapor partitioning is linear (Henry's Law applies);
- At the beginning of the simulation, the chemical is initially incorporated into some soil layer (the "incorporation layer;" Figure C.1) at a uniform concentration $\mathbf{C_0}$; and
- The volatilization loss of chemical and the evaporative loss of water to the atmosphere are limited by gaseous diffusion through a stagnant-air boundary layer, above which the chemical has zero concentration, and the atmospheric relative humidity is at some fixed value.

The model consists of a series of partial differential equations that are solved analytically using a Laplace transform technique to yield a solution that involves products of exponential and complementary error functions (Jury *et al*., 1983a and 1984). The solution considers chemical partitioning among three phases (aqueous, sorbed, and vapor), and allows chemical removal through the mechanisms of chemical degradation and vapor diffusion. A further advantage of using the Jury model is that the vapor-phase chemical concentration in equilibrium with the sorbed and dissolved chemical phases can

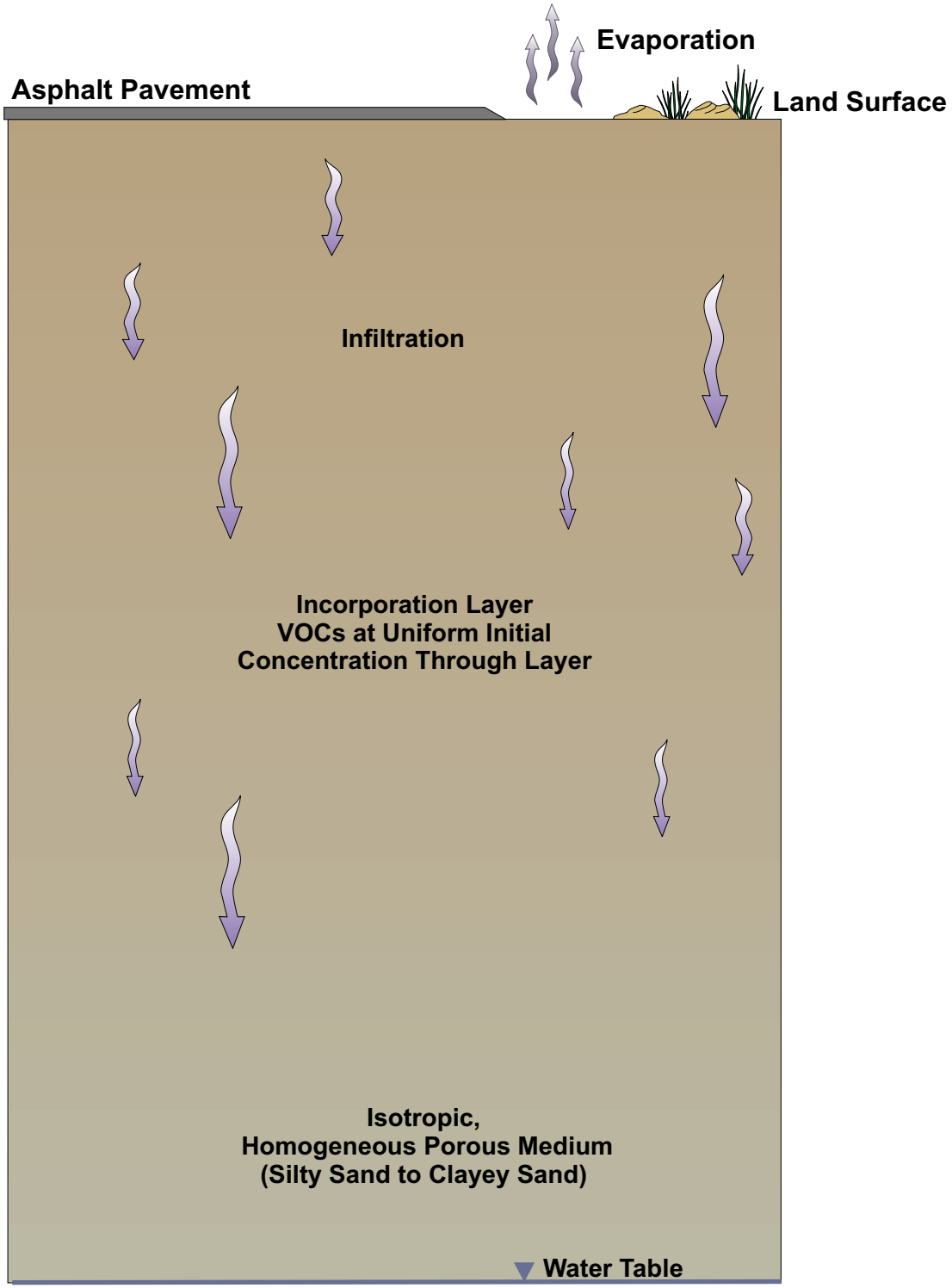


FIGURE C.1

CONCEPTUAL VADOSE ZONE INFILTRATION MODEL

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw/TracyG.cdr nap p4 5/15/01

be calculated, and the vapor-phase flux at the ground surface can be calculated for any point in time.

C3.2 Input Parameters for Unsaturated Transport

Soil properties at sites 1, 66, and 68 were obtained from the results of geotechnical laboratory analyses of soil samples collected at these sites (Radian, 2000c). Soil properties used as input parameters for the Jury calculations are listed in Table C.2. Climatic information for the weather station at the Stockton Metropolitan Airport, California was used to estimate the annual average relative humidity and evaporation rate for DDJC-Tracy (National Oceanic and Atmospheric Administration, 2000). Physicochemical properties for the two COCs (PCE and TCE) were taken from the scientific literature (Table C.1). Soil properties (i.e., bulk density, porosity, degree of saturation, and organic-carbon content), hydrologic characteristics (i.e., rates of infiltration and evaporation), and the chemical properties of PCE and TCE were regarded as fixed.

The rates of percolation of infiltrating water at the subject DDJC-Tracy sites were estimated using the HELP model (Schroeder *et al*., 1994), with default precipitation, temperature, and insulation information for Fresno, California (the recording station nearest DDJC-Tracy for which meteoric data are included in the HELP database), and the known or estimated soil properties for each of the three sites (Table C.2). The simulated soil column used for calculations at SWMU1/Area 2 and DSERTS 68/Area 3 included a thin, low-permeability layer at the top of the column, corresponding to the asphalt pavement that covers most of these two areas. By contrast, land surface across much of DSERTS 66/Area 1 is covered with gravel, and the low-permeability surface layer (asphalt) was not used in the soil column that simulated this site. The infiltration rates of precipitation through the vadose zone to the water table, calculated using the HELP model, are about 0.002 centimeter per day (cm/day) (0.3 inch per year) for SWMU 1/Area 2, 0.002 cm/day (0.6 inch per year) for DSERTS 66 (Area 1/Building 237), and 0.0015 cm/day (0.3 inch per year) for DSERTS 68 (Area 3), and are considered to be relatively uniform through time. The uniformity of infiltration is a result of the fact that over time, if climatic conditions and evapotranspiration rates remain approximately the same, near-steady-state infiltration rates will be established.

C3.3 Model Validation

Prior to applying the Jury model to calculate the residual concentrations of PCE and TCE sorbed to soil and in soil vapor within the vadose zone that would be protective of groundwater quality at the ACLs, the model was used to examine the vertical distribution of contaminants in the vadose zone at a site on DDJC-Tracy. This application was performed to evaluate whether the model structure was valid, and whether the values of input parameters to be used in subsequent simulations were representative of actual conditions.

Soil boring SB107, located near the center of Area 1 in DSERTS 66, was sampled in conjunction with the Phase I soils investigation in 1993 (Montgomery Watson, 1995). Soil samples were collected from the boring at depths of 3, 8, and 15.5 feet bgs, and were

TABLE C.2
SITE-SPECIFIC INPUT PARAMETERS USED TO EVALUATE CONTAMINANT MIGRATION IN THE VADOSE ZONE
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Parameter	Site: SWMU 1 (Area 2)	Site: DSERTS 66 (Area 1)	Site: DSERTS 68 (Area 3)	Comments
Vadose-Zone Soil Properties				
Soil dry bulk density (g/cm^3)[a/]	1.52	1.52	1.49	Results of site-specific geotechnical laboratory analyses (Radian, 2000)
Total porosity	0.473	0.473	0.473	Literature value for fine-grained, silty to clayey sand (Schroeder *et al*., 1994)
Soil volumetric moisture content	0.255	0.226	0.191	Results of site-specific geotechnical laboratory analyses (Radian, 2000)
Average total organic carbon content of soil (fraction)	0.01	0.015	0.017	Results of site-specific geotechnical laboratory analyses (Radian, 2000)
Hydraulic and Climatic Parameters				
Average temperature (°C) [b/]	17.5	17.5	17.5	Annual average for Stockton Metropolitan Airport, California (NOAA, 2000)[c/]
Average relative humidity	0.55	0.55	0.55	Annual average for Stockton Metropolitan Airport, California (NOAA, 2000)
Average evaporation rate (cm/day) [d/]	0.10	0.10	0.10	Annual average for Stockton Metropolitan Airport, California (NOAA, 2000)
Average infiltration recharge (cm/day)	0.002	0.002	0.0015	Output results from HELP[e/] model, using default climatological data for Fresno, CA
Problem Parameters				
Length of simulation time period (days) (PCE)	495	440	360	Period of time required for maximum concentrations of dissolved contaminants to migrate to water table
Length of simulation time period (days) (TCE)	365	315	255	
Depth of incorporation layer (feet bgs) [f/]	15.5	14.5	15.5	Incorporation layer assumed to extend from land surface to a point 0.5 ft above water table
Depth to water table (feet bgs)	16.0	15.0	16.0	Results of site-specific water-level measurements (Radian, 2000)

[a/] g/cm^3 = grams per cubic centimeter.

[b/] °C = degrees Celcius.

[c/] NOAA = National Oceanic and Atmospheric Administration.

[d/] cm/day = centimeters per day.

[e/] HELP = Hydrologic Evaluation of Landfill Performance (Schroeder *et al.*, 1994).

[f/] ft bgs = feet below ground surface.

analyzed for VOCs. PCE was detected at a concentrations of 433 µg/kg in the soil sample collected at a depth of 3 feet bgs, at 867 µg/kg in the sample collected at a depth of 8 ft bgs; and at a concentration of 1,120 µg/kg in the sample collected at a depth of 15.5 ft bgs. Because SB107 was the only boring at which VOCs were detected in samples from more than two depth intervals, it was selected for use in evaluating the model structure.

At the beginning of the calculation, PCE was introduced to the upper part of the simulated soil column. PCE was uniformly distributed at a dissolved-phase concentration of 150 milligrams per liter (mg/L) – the effective aqueous solubility of PCE at saturation (Table C.1) – through a layer (the "incorporation layer") extending from the ground surface to a depth of 1.5 feet bgs, and was initially at equilibrium with PCE sorbed to soil at a concentration of 590 milligrams per kilogram (mg/kg). These initial conditions correspond to the instantaneous introduction of PCE at the surface and into the shallow subsurface as a NAPL, or "product spill". The simulation was continued for a period of 4,750 days (13 years), and at the end of that period the calculated vertical distribution of PCE in the soil column was examined. This procedure is equivalent to examining the effects of a PCE spill that occurred in 1980 by drilling and sampling a soil boring in 1993 (the year that boring SB107 was actually sampled). The object of this series of calculations was to approximate as closely as possible the vertical distribution of PCE that actually had been detected in soil samples.

The initial series of calculations was completed using the assumption that no chemical degradation was occurring as a consequence of biological or other processes. However, it was not possible to match the calculated distribution with the observed vertical distribution of PCE in the soil column under conditions of no chemical degradation. Consequently, the constant describing the rate of chemical degradation ("first-order rate constant") was regarded as a model calibration parameter, and was adjusted until the calculated distribution of PCE was in reasonable agreement with the vertical distribution of PCE in the soil column that was actually observed at soil boring SB107 (Figure C.2). At this point, the model was regarded as valid, and was used in subsequent simulations to estimate the concentrations of PCE and TCE in soil vapor that would be protective of groundwater quality.

C4.0 Simulation Results

C4.1 Calculated Site-Specific Soil Cleanup Criteria

The concentrations of PCE and TCE that would migrate through the unsaturated zone to the water table were calculated for each site. At each site, a single layer, having a uniform chemical concentration, was identified as the incorporation layer (Figure C.3). The incorporation layer at each site extends from land surface to a point 0.5 foot above the local water table. This corresponds to a situation in which a chemical is initially present at a uniform concentration through nearly the entire unsaturated soil column above the water table. Equilibrium concentrations of PCE and TCE in each phase that through time would migrate to the water table (encountered at 16 feet bgs, 15 feet bgs, and 16 feet bgs at sites 1, 66, and 68, respectively; Table C.2) were then calculated. The initial concentrations of PCE and TCE in the sorbed and dissolved phases at equilibrium

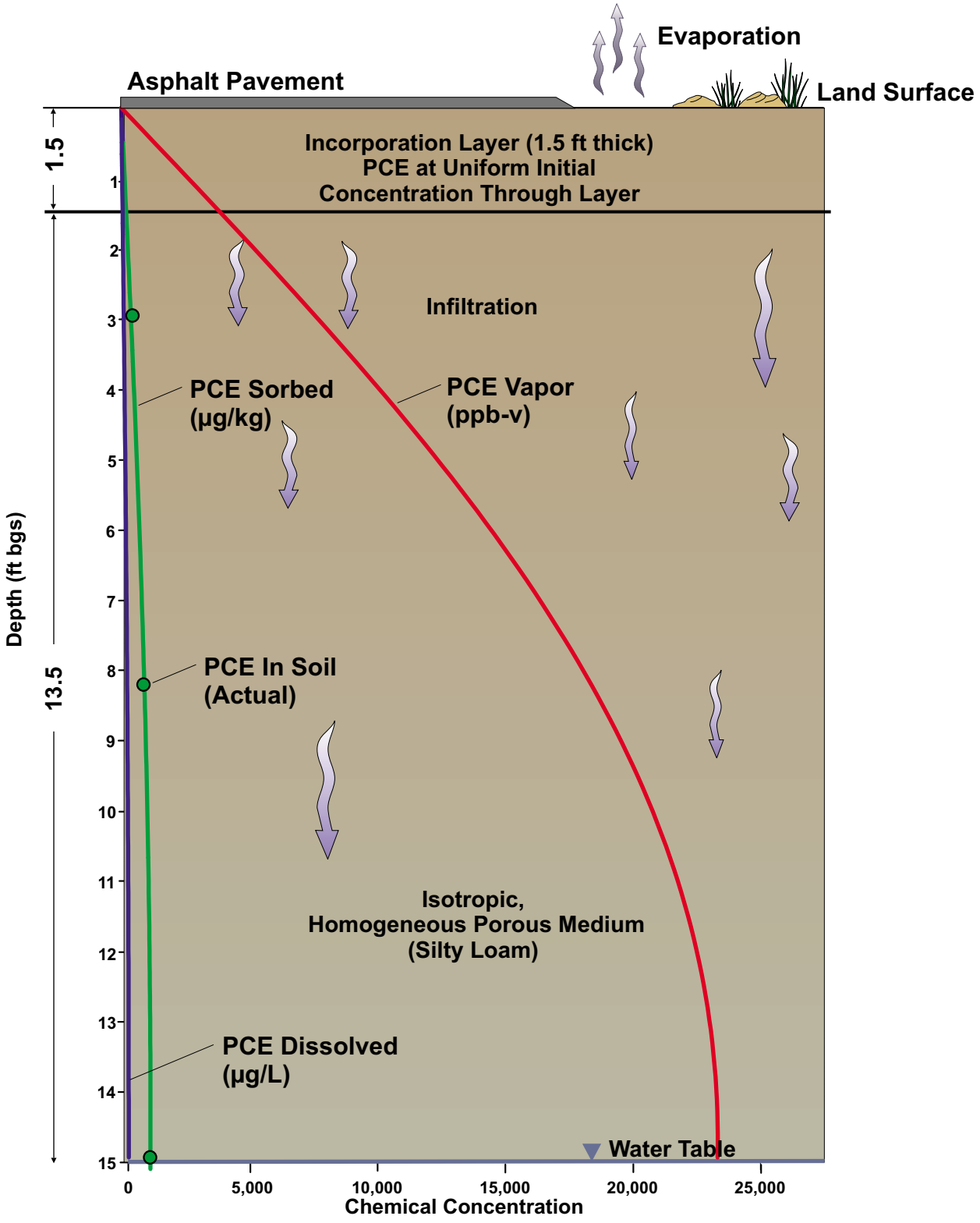


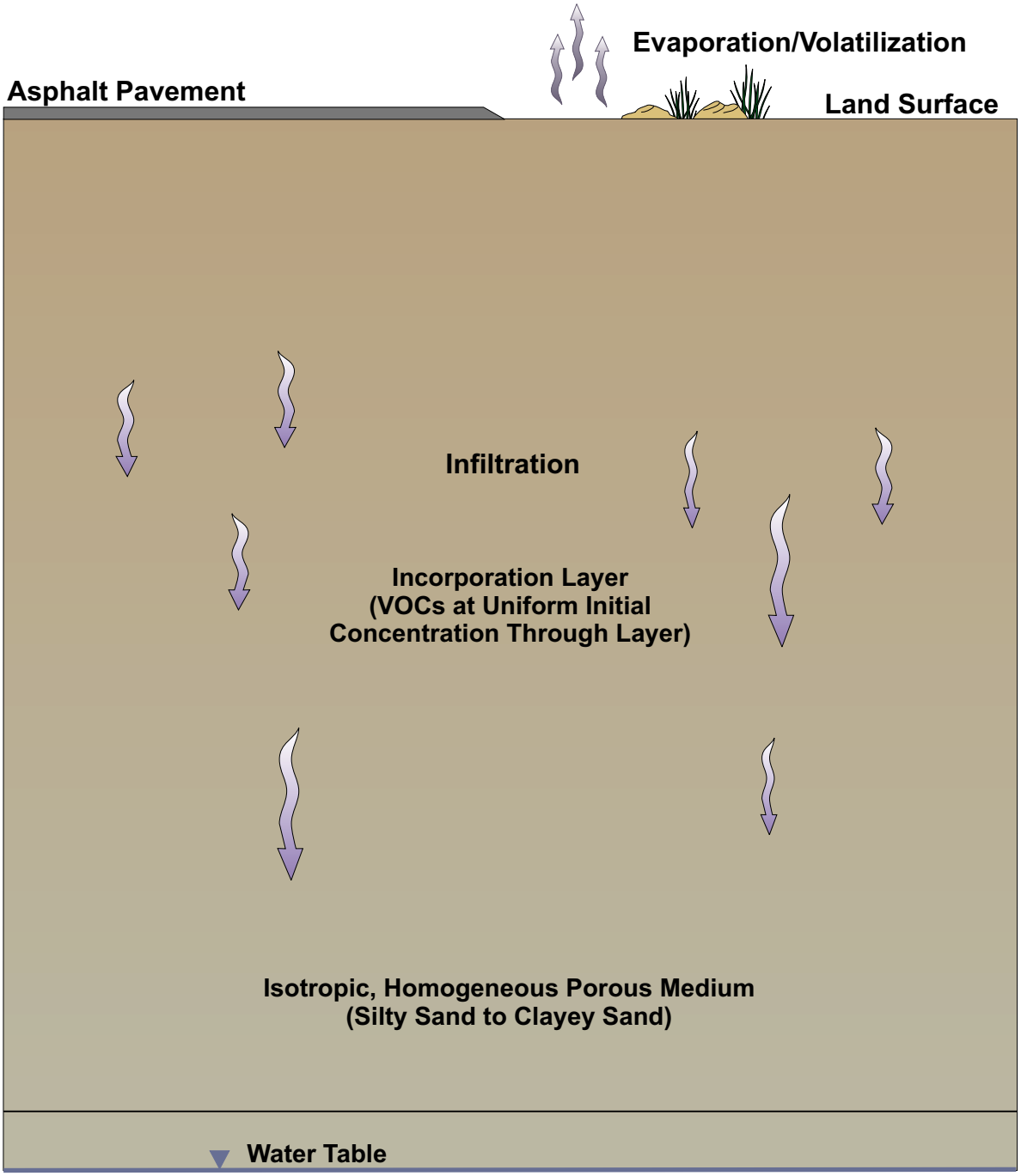
FIGURE C.2

VALIDATED VADOSE-ZONE TRANSPORT MODEL FOR PCE AT DSERTS 66

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw/TracyG.cdr nap p3 5/15/01



Site	Depth to Water Table (ft bgs)	Depth of Incorporation Layer (ft bgs)
SWMU 1	~16	0-15.5
DSERTS 66	~15	0-14.5
DSERTS 68	~16	0-15.5

FIGURE C.3

CONCEPTUAL SOIL COLUMN USED TO EVALUATE CONTAMINANT MIGRATION

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw/TracyG.cdr nap p1 5/15/01

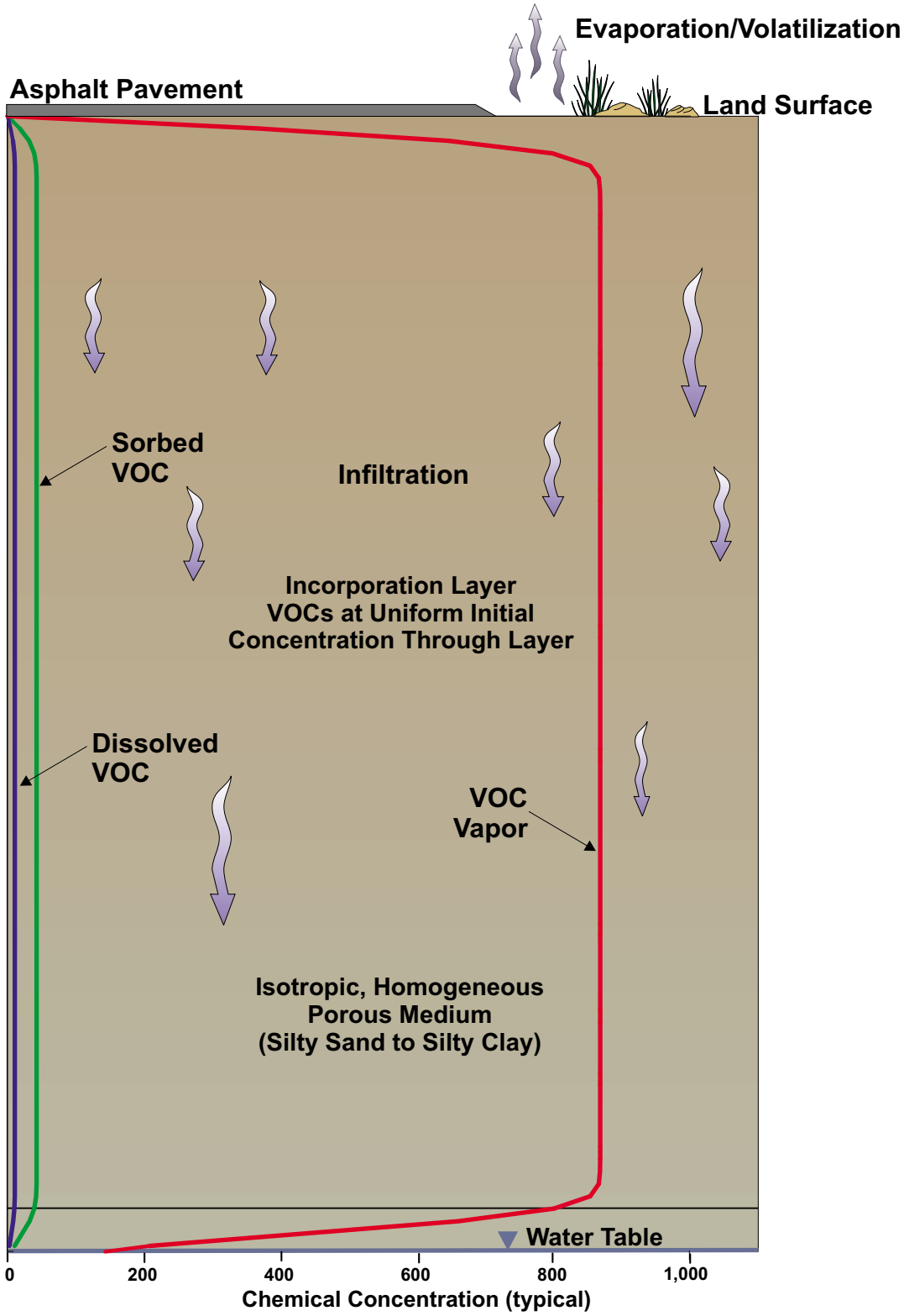
within the full thickness of the incorporation layer were adjusted until the maximum concentration of each dissolved COC arriving at the water table through the entire simulated time period did not exceed the ACL Those concentrations were therefore identified as the maximum concentrations of PCE and TCE that could remain sorbed to soil in the vadose zone without representing a continuing threat to groundwater quality (Table C.3, Column 3). The vapor-phase concentrations of PCE and TCE, in equilibrium with their respective maximum allowable sorbed and dissolved concentrations, were then calculated using the Jury model. These vapor-phase concentrations are equivalent to site-specific soil cleanup criteria (Table C.3, Column 4), in that they can serve to indicate whether VOCs remaining in soil in the vadose zone are present at concentrations that could eventually cause chemical migration to the water table at concentrations that would exceed the ACLs in groundwater (Figure C.4).

TABLE C.3
SITE-SPECIFIC SOIL CLEANUP CRITERIA BASED ON CONTAMINANT CONCENTRATIONS IN SOIL VAPOR
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Site	Chemical of Concern [b/]	Maximum Concentrations Remaining in Vadose-Zone Soils[a/]		Dissolved Concentration in Groundwater at the Water Table (µg/L)[e/]
		Sorbed Concentration (µg/kg) [c/]	Resulting Equilibrium Concentration in Soil Vapor/Soil Cleanup Criterion (ppbv) [d/]	
SWMU 1 (Area 2)	PCE	32	940	5
	TCE	13	640	5
DSERTS 66 (Area 1)	PCE	43	870	5
	TCE	18	590	5
DSERTS 68 (Area 3)	PCE	51	905	5
	TCE	22	640	5

a/ Maximum sorbed chemical concentrations are those concentrations in the vadose zone, under the conditions described, that will produce a concentration of the chemical in groundwater at the water table that does not exceed the aquifer cleanup level for that chemical.
b/ Identified as a groundwater chemical of concern in the Operable Unit 1 Record of Decision (WCC, 1993; Montgomery Watson, 1996a)..
c/ µg/kg = micrograms per kilogram.
d/ ppbv = parts per billion, by volume.
e/ µg/L = micrograms per liter.

As interpreted within the assumptions and limitations of the Jury model, the results of simulations indicate that if the vapor-phase concentrations of PCE and TCE are reduced to the site-specific values listed in Table C.3, these COCs are not likely to continue to migrate from the vadose zone to the water table at concentrations (i.e., the ACLs of 5 µg/L) that pose a threat to groundwater quality. At such time as the results of soil-vapor



Site	PCE			TCE		
	Sorbed (µg/kg)	Dissolved at water table (µg/L)	Vapor (ppb-v)	Sorbed (µg/kg)	Dissolved at water table (µg/L)	Vapor (ppbv)
SWMU 1	32	5	940	13	5	640
DSERTS 66	43	5	870	18	5	590
DSERTS 68	51	5	905	22	5	640

FIGURE C.4

CALCULATED DISTRIBUTION OF PCE AND TCE IN A ONE-DIMENSIONAL SOIL COLUMN

Remedial Process Optimization
DDJC - Tracy, California

PARSONS
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

draw/TracyG.cdr nap p2 5/15/01

monitoring indicate that the concentrations of individual COCs in soil vapor no longer exceed vapor-phase soil cleanup criteria, the SVE systems could be shut down.

C4.2 Uncertainties in Calculation of Soil Cleanup Criteria

In general, conservative assumptions were used to calculate screening-level soil cleanup criteria for vadose-zone soils at sites 1, 66, and 68. These assumptions are "conservative" in that their application tends to produce estimates of the maximum allowable concentrations of the COCs in the sorbed and dissolved phases in the vadose zone that are lower than the concentrations that could actually remain in the vadose zone without adversely affecting groundwater quality. However, several uncertainties in the assumptions and methods must be noted:

- For the purposes of calculations, chemicals are assumed to be introduced to the subsurface in a site-specific "incorporation layer" having a uniform initial chemical concentration throughout (Figure C.1). In reality, the initial concentrations of VOCs in those layers are not uniform.

- Application of the site-specific soil cleanup levels assumes that soil-vapor concentrations are uniform throughout the vadose zone, or conversely that vapor-phase concentrations of COCs can be detected at every point in the vadose zone, and at no point in the vadose zone do vapor-phase COC concentrations exceed the cleanup criteria.

- First-order chemical decay was assumed to occur (albeit at slow rates) in the subsurface at DDJC-Tracy. Chemical decay was incorporated into the calculations in order to achieve better agreement among chemical distributions in the simulated soil column calculated during model validation, and the chemical concentrations that were actually detected in soil samples. Historical results from groundwater sampling suggest that little chemical biodegradation is occurring in the saturated zone at DDJC-Tracy (Section 2.3.3 of the report). While it is possible that biodegradation or other processes may be degrading PCE and TCE in the vadose zone in parts of DDJC-Tracy, it is also possible that the occurrence of chemical degradation is not widespread. Therefore, to examine the sensitivity of the results to the occurrence/absence of chemical decay processes, soil-vapor cleanup criteria were re-calculated in a second set of simulations in which chemical decay was not allowed to occur; and the results were compared with the soil soil-vapor cleanup criteria that had been calculated initially.

  Elimination of chemical decay from simulations of chemical migration in the vadose-zone had no effect on the calculated soil-vapor cleanup criteria. This is a consequence of the extensive incorporation-layer assumption (i.e., chemical is initially present at a uniform concentration throughout the vadose zone) and the short vertical distance required for a chemical to migrate to the water table (0.5 foot). The relatively large amount of chemical mass in the vadose zone overlying the water table, together with the short migration distance, means that the maximum concentrations of chemical reaching the water table occur after a very

short period of time has elapsed, before degradation processes can appreciably reduce the mass of chemical available for migration.

Despite these uncertainties, application of site-specific soil cleanup criteria can provide useful information regarding the progress of soil remediation in the vadose zone. As the vapor-phase soil cleanup criteria are approached, achievement of soil remediation objectives can be verified by other means, including soil sampling and monitoring of groundwater immediately beneath those parts of the vadose zone that have been remediated.

C3.3 APPENDIX C REFERENCES

Cline, P.V., Delfino, J.J., and P.S.C. Rao. 1991. Partitioning of aromatic constituents into water from gasoline and other complex solvent mixtures. *Environmental Science and Technology* 25(5):914-920.

Destouni. 1991. Applicability of the steady state flow assumption for solute advection in field soils. *Water Resources Research* 27(8):2129-2140.

ESE. 1994. *Remedial Investigation/Feasibility Study at Sharpe Site -- Soils Feasibility Study Report.* December.

Howard, P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan, and E.M. Michalenko. 1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers, Inc. Chelsea, Michigan.

Javandel, I., C. Doughty, and C.F. Tsang. 1984. *Groundwater Transport: Handbook of Mathematical Models*. American Geophysical Union Water Resources Monograph No. 10. Washington, D.C.

Jury, W.C., W.F. Spencer, and W.J. Farmer. 1983a. Behavior assessment model for trace organics in soil – I: Model description. *Journal of Environmental Quality.* 12(4):558-564.

Jury, W.C., W.J. Farmer, and W.F. Spencer. 1983b. Behavior assessment model for trace organics in soil – II: Chemical classification and parameter sensitivity. *Journal of Environmental Quality.* 13(4):567-579.

Jury, W.C., Farmer, W.J., and W.F. Spencer. 1984. Behavior assessment model for trace organics in soil -- II. Chemical classification and parameter sensitivity. *Journal of Environmental Quality*. 13(4):567-572.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt 1990. *Handbook of Chemical Property Estimation Methods*. American Chemical Society. Washington, DC.

Maidment, D.R. 1993. *Handbook of Hydrology*. McGraw-Hill Publishers, Inc. New York, New York.

Montgomery Watson. 1995. *Pre-Design Data Report for Operable Unit 1*, Vol. I, Draft. Defense Distribution Region West, Tracy, California.

Montgomery Watson. 1996a. *Final Defense Distribution Region West-Tracy, California Operable Unit 1 Explanation of Significant Difference for the Change from Groundwater Extraction and Reinjection of Treated Groundwater to Groundwater Extraction, Reinjection of Treated Groundwater and Dispersion*. Prepared for U.S. Army Corps of Engineers, Huntsville Division. January.

Montgomery-Watson. 1996b. *Comprehensive Remedial Investigation/Feasibility Study*, Vol. III, Defense Distribution Region West, Tracy, California.

National Oceanic and Atmospheric Administration (NOAA). 2000. Period of Record Climate Summary for Stockton Metropolitan Airport, California. National Climatic Data Center Regional World Wide Web Site accessed at http://www.ncdc.noaa.gov/ol/climate

Pankow, J.F., and J.A. Cherry. 1996. *Dense Chlorinated Solvents and Other DNAPLs in Groundwater - History, Behavior, and Remediation*. Waterloo Press, University of Waterloo. Guelph, Ontario (Canada).

Parsons ES. 2000. *Remedial Process Optimization Phase II Work Plan for the Tracy Defense Distribution Depot*, San Joaquin, California. September.

Radian. 1998. *Site-Wide Comprehensive Record of Decision, Defense Distribution Depot San Joaquin, Tracy Site, Tracy, California* . Final. April.

Radian. 1999. *DDJC-Tracy Bioventing/Soil Vapor Extraction Sites Remedial Design*.

Radian. 2000. *Soil Vapor Extraction Optimization Work Plan, Defense Distribution Depot San Joaquin, Sharpe Site, Lathrop, California.* Draft Final.

Schroeder, P.R., T.S. Dozier, P.C. Zappi, B.M. McEnroe, J.W. Sjostrom and R.L. Peyton. 1994. The *Hydrologic Evaluation of Landfill Performance (HELP) Model*. EPA/600/R-94/168b, U.S. Army Corps of Engineers, Waterways Experiment Station.

TetraTech, Inc. 1988. *Chemical Data for Predicting the Fate of Organic Compounds in Water, Vol. 2 – Database*. Electric Power Research Institute (EPRI). Palo Alto, California. EPRI Report EA-5818.

USEPA. 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*. USEPA. EPA/600/R-98/128. September.

Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals*. Van Nostrand Reinhold Company. New York, New York. 2nd ed.

Weast, R.C., Astle, M.J., and W.H. Beyer, eds. 1989. *CRC Handbook of Chemistry and Physics*. CRC Press, Inc. Boca Raton, Florida. 75th ed.

Wiedemeier, T.H., H.S. Rifai, C.J. Newell, and J.W. Wilson. 1999. *Natural Attenuation of Fuels and Chlorinated Solvents*. John Wiley & Sons. New York.

Woodward Clyde Consultants (WCC). 1992. *Final Operable Unit No. 1 Remedial Investigation/Risk Assessment Report, Defense Distribution Region West, Tracy, California*. November

WCC. 1993. *Final Operable Unit No. 1, Record of Decision, DDRW-Tracy, California*. Prepared for U.S. Army Engineering and Support Center, Huntsville. Salt Lake City, Utah. August 13.

Yaws, C.L. 1999. *Chemical Properties Handbook.* McGraw-Hill Publishers, Inc. New York, New York.

APPENDIX D

SUPPORTING DATA FOR THE EXTRACTION SYSTEM ANALYSIS

TABLE D.1
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW002AU	2.35			1	02M93	AUU	1993
EW002AU	2.28			1	02M93	AUU	1993
EW002AU	9.59			1	05M93	AUU	1993
EW002AU	8.16			1	07M93	AUU	1993
EW002AU	7.09			1	10M93	AUU	1993
EW002AU	7.09			0	10M93	AUU	1993
EW002AU	4.45			0.5	Y1994	AUU	1994
EW002AU	3.55			0.5	Y1994	AUU	1994
EW002AU	3.49			0.5	Y1994	AUU	1994
EW002AU	3.5			0.0487	1Q97	AUU	1997
EW002AU	2.95		J+	0.0487	1Q97	AUU	1997
EW002AU	3.15			0.092	2Q97	AUU	1997
EW002AU	3.9			0.3	3Q97	AUU	1997
EW002AU	3.1			0.3	3Q97	AUU	1997
EW002AU	5.24			0.092	4Q97	AUU	1997
EW002AU	6.18			0.184	1Q98	AUU	1998
EW002AU	8.71			0.184	2Q98	AUU	1998
EW002AU	8.4			0.184	2Q98	AUU	1998
EW002AU	12			0.142	4Q98	AUU	1998
EW002AU	5.8			0.5	1Q99	AUU	1999
EW002AU	4.12			0.114	2Q99	AUU	1999
EW002AU	12.5			0.0568	4Q99	AUU	1999
EW002AU	11			0.14	1Q00	AUU	2000
EW002AU	12			0.14	2Q00	AUU	2000
EW002AU	7.1			0.14	3Q00	AUU	2000
EW002AU	6.4			0.14	3Q00	AUU	2000
EW003	1.08			1	02M93	U	1993
EW003	2.02			1	05M93	U	1993
EW003	1.55			0.5	07M93	U	1993
EW003	2.26			1	10M93	U	1993
EW003	2.26			0	10M93	U	1993
EW003	1.7			0.5	Y1994	U	1994
EW003	1.23			0.5	Y1994	U	1994
EW003	1.16			0.5	Y1994	U	1994
EW003	0	NR		0.0487	1Q97	U	1997
EW003	0	NR		0.092	2Q97	U	1997
EW003	0			0.3	3Q97	U	1997
EW003	0	NR		0.184	4Q97	U	1997
EW003	0	NR		0.184	1Q98	U	1998
EW003	0	NR		0.184	2Q98	U	1998
EW003	2.7			0.142	4Q98	U	1998

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW003	3.9			0.5	1Q99	U	1999
EW003	0.705			0.114	2Q99	U	1999
EW003	5.23			0.0568	4Q99	U	1999
EW003	5.8			0.14	1Q00	U	2000
EW003	5.3			0.14	2Q00	U	2000
EW003	11			0.14	3Q00	U	2000
EW004AU	1.07			1	02M93	AUU	1993
EW004AU	0			1	05M93	AUU	1993
EW004AU	0.679			1	07M93	AUU	1993
EW004AU	0			1	10M93	AUU	1993
EW004AU	0	ND		0.5	10M93	AUU	1993
EW004AU	0.742			0.5	Y1994	AUU	1994
EW004AU	0.69			0.5	Y1994	AUU	1994
EW004AU	0.67			0.5	Y1994	AUU	1994
EW004AU	0.587			0.5	Y1994	AUU	1994
EW004AU	0	NR		0.0487	1Q97	AUU	1997
EW004AU	0	NR		0.0487	2Q97	AUU	1997
EW004AU	0	NR		0.184	1Q98	AUU	1998
EW004AU	0	NR		0.184	2Q98	AUU	1998
EW004AU	0.617			0.142	4Q98	AUU	1998
EW004AU	2.39			0.114	2Q99	AUU	1999
EW004AU	0.757			0.0568	3Q99	AUU	1999
EW004AU	0.729			0.0568	4Q99	AUU	1999
EW004AU	0.66			0.14	1Q00	AUU	2000
EW004AU	0.63			0.14	2Q00	AUU	2000
EW004AU	1			0.14	3Q00	AUU	2000
EW005AU	6.47			1	07M93	AUU	1993
EW005AU	8.82			1	10M93	AUU	1993
EW005AU	8.82			0	10M93	AUU	1993
EW005AU	11			0.5	Y1994	AUU	1994
EW005AU	8.61			0.5	Y1994	AUU	1994
EW005AU	7.43			0.5	Y1994	AUU	1994
EW005AU	5.52			0.0487	1Q97	AUU	1997
EW005AU	5.14			0.092	2Q97	AUU	1997
EW005AU	5.05			0.092	2Q97	AUU	1997
EW005AUA	5.65			0.0515	2Q98	AUU	1998
EW005AUA	10.1			0.114	2Q99	AUU	1999
EW005AUA	3.41			0.0568	4Q99	AUU	1999
EW005AUA	2.2			0.14	1Q00	AUU	2000
EW005AUA	2.3			0.14	2Q00	AUU	2000
EW005AUA	3.6			0.14	3Q00	AUU	2000

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW006AU	15.1			1	02M93	AUU	1993
EW006AU	14.1			1	05M93	AUU	1993
EW006AU	11.7			1	07M93	AUU	1993
EW006AU	8.21			1	10M93	AUU	1993
EW006AU	9.9			0.5	Y1994	AUU	1994
EW006AU	9.7			0.5	Y1994	AUU	1994
EW006AU	9.16			0.5	Y1994	AUU	1994
EW006AU	5.37			0.0487	1Q97	AUU	1997
EW006AU	3.79			0.092	2Q97	AUU	1997
EW006AU	2.7			0.3	3Q97	AUU	1997
EW006AU	2.65			0.092	4Q97	AUU	1997
EW006AU	3.53			0.184	1Q98	AUU	1998
EW006AU	4.41			0.184	2Q98	AUU	1998
EW006AU	2.91			0.142	4Q98	AUU	1998
EW006AU	2.95			0.0568	3Q99	AUU	1999
EW006AU	2.27			0.0568	4Q99	AUU	1999
EW006AU	2.6			0.14	3Q00	AUU	2000
EW007A	7.1			0.5	Y1994	U	1994
EW007A	4.28			0.0487	1Q97	U	1997
EW007A	4.23			0.0487	1Q97	U	1997
EW007A	3.67			0.092	2Q97	U	1997
EW007A	2.8			0.3	3Q97	U	1997
EW007A	2.72			0.184	4Q97	U	1997
EW007A	3.97			0.184	1Q98	U	1998
EW007A	3.71			0.184	2Q98	U	1998
EW007A	3.08			0.142	4Q98	U	1998
EW007A	1.1			0.14	3Q00	U	2000
EW008A	0	NR		0.0487	1Q97	U	1997
EW008A	0	NR		0.092	2Q97	U	1997
EW008A	0			0.3	3Q97	U	1997
EW008A	0	NR		0.092	4Q97	U	1997
EW008A	0	NR		0.092	4Q97	U	1997
EW008A	0	NR		0.184	1Q98	U	1998
EW008A	0	NR		0.184	2Q98	U	1998
EW008A	0	NR		0.142	4Q98	U	1998
EW008A	0	NR		0.114	2Q99	U	1999
EW008A	0.764			0.0568	3Q99	U	1999
EW008A	0	NR		0.0568	4Q99	U	1999
EW008A	1.1			0.14	1Q00	U	2000
EW008A	0.87			0.14	2Q00	U	2000
EW008A	0.37	J		0.14	3Q00	U	2000

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW009B	12			0.5	Y1994	M	1994
EW009B	11			0.5	Y1994	M	1994
EW009B	5.37			0.0487	1Q97	M	1997
EW009B	4.8			0.092	2Q97	M	1997
EW009B	4.2			0.3	3Q97	M	1997
EW009B	14.7			0.142	4Q98	M	1998
EW009B	6.8			0.114	2Q99	M	1999
EW009B	4.74			0.0568	4Q99	M	1999
EW009B	2.9			0.14	2Q00	M	2000
EW009B	5.5			0.14	3Q00	M	2000
EW010AU	0	NR		0.0487	1Q97	AUU	1997
EW010AU	2.72			0.0487	2Q97	AUU	1997
EW010AU	0			0.3	3Q97	AUU	1997
EW010AU	4.8			0.184	1Q98	AUU	1998
EW010AU	2.74			0.0515	2Q98	AUU	1998
EW010AU	1.79			0.142	4Q98	AUU	1998
EW010AU	1.9			0.5	1Q99	AUU	1999
EW010AU	2.27			0.114	2Q99	AUU	1999
EW010AU	1.28			0.0568	3Q99	AUU	1999
EW011AU	0	ND		0.0487	1Q97	AUU	1997
EW011AU	0	NR		0.092	2Q97	AUU	1997
EW011AU	0			0.3	3Q97	AUU	1997
EW011AU	0	< DL		0.184	1Q98	AUU	1998
EW011AU	0	< DL		0.184	1Q98	AUU	1998
EW011AU	0	< DL		0.184	2Q98	AUU	1998
EW011AU	0	< DL		0.142	4Q98	AUU	1998
EW011AU	0	ND		0.114	2Q99	AUU	1999
EW011AU	0	NR		0.0568	3Q99	AUU	1999
EW011AU	0	NR		0.0568	4Q99	AUU	1999
EW011AU	0.25	J		0.14	1Q00	AUU	2000
EW011AU	0		U	0.14	2Q00	AUU	2000
EW012AU	11.4			0.0487	1Q97	AUU	1997
EW012AU	7.28			0.0487	2Q97	AUU	1997
EW012AU	4.9			0.3	3Q97	AUU	1997
EW012AU	6.34			0.092	4Q97	AUU	1997
EW012AU	5.91			0.092	4Q97	AUU	1997
EW012AU	8.01			0.184	1Q98	AUU	1998
EW012AU	8.74			0.184	2Q98	AUU	1998
EW012AU	9.64			0.142	4Q98	AUU	1998
EW012AU	5.7			0.5	1Q99	AUU	1999
EW012AU	5.6			0.5	1Q99	AUU	1999

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW012AU	6.11			0.114	2Q99	AUU	1999
EW012AU	5.25			0.0568	3Q99	AUU	1999
EW012AU	4.79			0.0568	4Q99	AUU	1999
EW012AU	4.1			0.14	1Q00	AUU	2000
EW012AU	3.3			0.14	2Q00	AUU	2000
EW012AU	7			0.14	3Q00	AUU	2000
EW013C	1.4			0.5	1Q99	L	1999
EW013C	1.48			0.114	2Q99	L	1999
EW013C	1.59			0.0568	3Q99	L	1999
EW013C	1.53			0.0568	4Q99	L	1999
EW013C	0.99			0.14	1Q00	L	2000
EW013C	0.96			0.14	2Q00	L	2000
EW013C	1.7			0.14	3Q00	L	2000
EW013C	1.6			0.14	3Q00	L	2000
EW014A	0	ND		0.5	1Q99	U	1999
EW014A	0	ND		0.114	2Q99	U	1999
EW014A	0	ND		0.0568	3Q99	U	1999
EW014A	0	ND		0.0568	4Q99	U	1999
EW014A	0	U		0.14	3Q00	U	2000
EW015A	0	ND		0.5	1Q99	U	1999
EW015A	0	ND		0.114	2Q99	U	1999
EW015A	0	ND		0.0568	3Q99	U	1999
EW015A	0	ND		0.0568	4Q99	U	1999
EW015A	0	U		0.14	1Q00	U	2000
EW015A	0	U		0.14	3Q00	U	2000
EW016A	0	ND		0.5	1Q99	U	1999
EW016A	0	ND		0.114	2Q99	U	1999
EW016A	0	NR		0.0568	3Q99	U	1999
EW016A	0	NR		0.0568	4Q99	U	1999
EW016A	0.23	J		0.14	1Q00	U	2000
EW016A	0		U	0.14	2Q00	U	2000
EW016A	0	U		0.14	3Q00	U	2000
EW017A	0	ND		0.5	1Q99	U	1999
EW017A	0	ND		0.114	2Q99	U	1999
EW017A	0	ND		0.0568	3Q99	U	1999
EW017A	0	ND		0.0568	4Q99	U	1999
EW017A	0	U		0.14	1Q00	U	2000
EW017A	0		U	0.14	2Q00	U	2000
EW017A	0		U	0.14	2Q00	U	2000
EW017A	0	U		0.14	3Q00	U	2000
EW018A	0	ND		0.5	1Q99	U	1999

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW018A	0	NR		0.0568	3Q99	U	1999
EW018A	0	NR		0.0568	4Q99	U	1999
EW018A	0.32	J		0.14	1Q00	U	2000
EW018A	0.29		J	0.14	2Q00	U	2000
EW018A	0.15	J		0.14	3Q00	U	2000
EW019A	0	ND		0.5	1Q99	U	1999
EW019A	0	NR		0.114	2Q99	U	1999
EW019A	0.572			0.0568	3Q99	U	1999
EW019A	0.736			0.0568	4Q99	U	1999
EW019A	0.93			0.14	1Q00	U	2000
EW019A	0.87			0.14	1Q00	U	2000
EW019A	0.97			0.14	2Q00	U	2000
EW019A	0.2	J		0.14	3Q00	U	2000
EW020A	1			0.5	1Q99	U	1999
EW020A	1			0.0568	3Q99	U	1999
EW020A	1.4			0.0568	4Q99	U	1999
EW020A	1.5			0.14	1Q00	U	2000
EW020A	1.2			0.14	2Q00	U	2000
EW020A	1.8			0.14	3Q00	U	2000
EW021A	4.7			0.5	1Q99	U	1999
EW021A	5.81			0.114	2Q99	U	1999
EW021A	5.25			0.0568	3Q99	U	1999
EW021A	5.18			0.0568	3Q99	U	1999
EW021A	5.27			0.0568	4Q99	U	1999
EW021A	0.68			0.14	3Q00	U	2000
EW022A	2.6			0.114	3Q99	U	1999
EW022A	2.34			0.0568	4Q99	U	1999
EW022A	3.1			0.14	1Q00	U	2000
EW022A	2.3			0.14	3Q00	U	2000
EW024B	0	ND		0.0568	3Q99	M	1999
EW024B	0	ND		0.0568	4Q99	M	1999
EW024B	0	U		0.14	1Q00	M	2000
EW024B	0		U	0.14	2Q00	M	2000
EW024B	0	U		0.14	3Q00	M	2000
EW025B	0	NR		0.0568	3Q99	M	1999
EW025B	0	NR		0.0568	4Q99	M	1999
EW025B	0.31	J		0.14	1Q00	M	2000
EW025B	0	U		0.14	3Q00	M	2000
EW026B	6.9			0.5	1Q99	M	1999
EW026B	7.39			0.114	2Q99	M	1999
EW026B	6.65			0.0568	3Q99	M	1999

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW026B	6.4			0.0568	4Q99	M	1999
EW026B	5.7			0.14	2Q00	M	2000
EW026B	14			0.14	3Q00	M	2000
EW027B	7.73			0.114	2Q99	M	1999
EW027B	8.64			0.0568	3Q99	M	1999
EW027B	8.89			0.0568	4Q99	M	1999
EW027B	8.8			0.0568	4Q99	M	1999
EW027B	10			0.14	3Q00	M	2000
EW028B	3.7			0.5	1Q99	M	1999
EW028B	3.75			0.114	2Q99	M	1999
EW028B	4.78			0.0568	3Q99	M	1999
EW028B	3.69			0.0568	4Q99	M	1999
EW028B	5.2			0.14	1Q00	M	2000
EW028B	3.1			0.14	2Q00	M	2000
EW028B	6.4			0.14	3Q00	M	2000
EW028B	5.4			0.14	3Q00	M	2000
EW029B	2.5			0.5	1Q99	M	1999
EW029B	2.6			0.114	2Q99	M	1999
EW029B	2.33			0.0568	3Q99	M	1999
EW029B	2.25			0.0568	3Q99	M	1999
EW029B	1.92			0.0568	4Q99	M	1999
EW029B	2.6			0.14	1Q00	M	2000
EW029B	1.8			0.14	2Q00	M	2000
EW029B	3.4			0.14	3Q00	M	2000
EW030C	0			0.3	3Q97	L	1997
EW030C	0			0.3	3Q97	L	1997
EW030C	0.9			0.5	1Q99	L	1999
EW030C	0.926			0.114	2Q99	L	1999
EW030C	0.951			0.0568	4Q99	L	1999
EW030C	0			0.3	EWB	L	19WB
EW030C	0.87			0.14	3Q00	L	2000
EW031C	2.04			0.0568	3Q99	L	1999
EW031C	1.81			0.0568	4Q99	L	1999
EW031C	4.2			0.14	3Q00	L	2000
EW032AU	3.1			0.5	1Q99	AU	1999
EW032AU	2.8			0.5	1Q99	AU	1999
EW032AU	3.75			0.0568	3Q99	AU	1999
EW032AU	2.91			0.0568	4Q99	AU	1999
EW032AU	2.5			0.14	1Q00	AU	2000
EW032AU	2.1			0.14	2Q00	AU	2000
EW032AU	2.6			0.14	3Q00	AU	2000

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW033AU	8.62			0.114	2Q99	AU	1999
EW033AU	37.1			0.114	3Q99	AU	1999
EW033AU	23.7			0.0568	4Q99	AU	1999
EW033AU	21.1			0.0568	4Q99	AU	1999
EW034AU	14			0.5	1Q99	AU	1999
EW034AU	10.7			0.0568	3Q99	AU	1999
EW034AU	10.9			0.0568	4Q99	AU	1999
EW034AU	15			0.14	1Q00	AU	2000
EW034AU	12			0.14	2Q00	AU	2000
EW034AU	16			0.14	3Q00	AU	2000
EW037AU	0	ND		0.114	2Q99	AU	1999
EW037AU	0	ND		0.114	3Q99	AU	1999
EW037AU	0	NR		0.0568	4Q99	AU	1999
EW040AU	3.48			0.114	2Q99	AU	1999
EW040AU	3.33			0.114	3Q99	AU	1999
EW040AU	2.87			0.114	3Q99	AU	1999
EW040AU	1.57			0.0568	4Q99	AU	1999
EW040AU	3.6			0.3	NWC	AU	19WC
EW040AU	0.65			0.14	1Q00	AU	2000
EW040AU	3.9			0.14	2Q00	AU	2000
EW040AU	4.3			0.14	3Q00	AU	2000
EW041AU	6.92			0.114	2Q99	AU	1999
EW041AU	5.06			0.0568	3Q99	AU	1999
EW041AU	6.13			0.114	4Q99	AU	1999
EW041AU	5			0.3	NWC	AU	19WC
EW041AU	4.6			0.14	1Q00	AU	2000
EW041AU	5.7			0.14	2Q00	AU	2000
EW041AU	6			0.14	3Q00	AU	2000
EW042AU	34.4			0.114	2Q99	AU	1999
EW042AU	22.7			0.0568	3Q99	AU	1999
EW042AU	10.4			0.114	4Q99	AU	1999
EW042AU	26			0.3	NWC	AU	19WC
EW042AU	10			0.14	1Q00	AU	2000
EW042AU	9.4			0.14	1Q00	AU	2000
EW042AU	9.1			0.14	2Q00	AU	2000
EW042AU	6.9			0.14	3Q00	AU	2000
EW043AU	5.75			0.114	2Q99	AU	1999
EW043AU	6.46			0.0568	3Q99	AU	1999
EW043AU	4.85			0.114	4Q99	AU	1999
EW043AU	5			0.3	NWC	AU	19WC
EW043AU	4.8			0.14	1Q00	AU	2000

TABLE D.1 (Continued)
HISTORICAL PCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	PCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW043AU	3.9			0.14	2Q00	AU	2000
EW043AU	5			0.14	3Q00	AU	2000
EW044AU	10.4			0.114	2Q99	AU	1999
EW044AU	7.62			0.0568	3Q99	AU	1999
EW044AU	6.51			0.114	4Q99	AU	1999
EW044AU	8			0.3	NWC	AU	19WC
EW044AU	8			0.3	NWC	AU	19WC
EW044AU	4.9			0.14	1Q00	AU	2000
EW044AU	4.4			0.14	2Q00	AU	2000
EW044AU	4.3			0.14	3Q00	AU	2000

TABLE D.2
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW002AU	3.47			1	02M93	AUU	1993
EW002AU	3.4			1	02M93	AUU	1993
EW002AU	18.2			1	05M93	AUU	1993
EW002AU	12.6			1	07M93	AUU	1993
EW002AU	10.4			1	10M93	AUU	1993
EW002AU	10.4			0	10M93	AUU	1993
EW002AU	6.01			0.5	Y1994	AUU	1994
EW002AU	4.62			0.5	Y1994	AUU	1994
EW002AU	4.59			0.5	Y1994	AUU	1994
EW002AU	3.02			0.0854	1Q97	AUU	1997
EW002AU	2.85		J+	0.0854	1Q97	AUU	1997
EW002AU	3.23			0.108	2Q97	AUU	1997
EW002AU	3.5			0.3	3Q97	AUU	1997
EW002AU	2.9			0.3	3Q97	AUU	1997
EW002AU	6.57			0.108	4Q97	AUU	1997
EW002AU	5.68			0.181	1Q98	AUU	1998
EW002AU	5.71			0.181	2Q98	AUU	1998
EW002AU	5.63			0.181	2Q98	AUU	1998
EW002AU	7.96			0.161	4Q98	AUU	1998
EW002AU	4.2			0.5	1Q99	AUU	1999
EW002AU	3.35			0.0929	2Q99	AUU	1999
EW002AU	8.59			0.0905	4Q99	AUU	1999
EW002AU	7.7			0.15	1Q00	AUU	2000
EW002AU	7.8			0.15	2Q00	AUU	2000
EW002AU	7.3			0.15	3Q00	AUU	2000
EW002AU	6.7			0.15	3Q00	AUU	2000
EW003	1.31			1	02M93	U	1993
EW003	4.69			1	05M93	U	1993
EW003	2.79			0.5	07M93	U	1993
EW003	2.76			1	10M93	U	1993
EW003	2.76			0	10M93	U	1993
EW003	2.4			0.5	Y1994	U	1994
EW003	1.93			0.5	Y1994	U	1994
EW003	1.56			0.5	Y1994	U	1994
EW003	1.27			0.0854	1Q97	U	1997
EW003	0	NR		0.108	2Q97	U	1997
EW003	0			0.3	3Q97	U	1997
EW003	0	NR		0.181	4Q97	U	1997
EW003	0	NR		0.181	1Q98	U	1998
EW003	1.05			0.181	2Q98	U	1998
EW003	2.21			0.161	4Q98	U	1998

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW003	2.8			0.5	1Q99	U	1999
EW003	0.87			0.0929	2Q99	U	1999
EW003	3.54			0.0905	4Q99	U	1999
EW003	3.7			0.15	1Q00	U	2000
EW003	3.3			0.15	2Q00	U	2000
EW003	7.1			0.15	3Q00	U	2000
EW004AU	1.17			1	02M93	AUU	1993
EW004AU	0			1	05M93	AUU	1993
EW004AU	0.99			1	07M93	AUU	1993
EW004AU	0.788			1	10M93	AUU	1993
EW004AU	0.788			0	10M93	AUU	1993
EW004AU	0.91			0.5	Y1994	AUU	1994
EW004AU	0.84			0.5	Y1994	AUU	1994
EW004AU	0.8			0.5	Y1994	AUU	1994
EW004AU	0.698			0.5	Y1994	AUU	1994
EW004AU	0	NR		0.0854	1Q97	AUU	1997
EW004AU	0	NR		0.0854	2Q97	AUU	1997
EW004AU	0	NR		0.181	1Q98	AUU	1998
EW004AU	0	NR		0.181	2Q98	AUU	1998
EW004AU	0.645			0.161	4Q98	AUU	1998
EW004AU	2.01			0.0929	2Q99	AUU	1999
EW004AU	0.874			0.0905	3Q99	AUU	1999
EW004AU	0.828			0.0905	4Q99	AUU	1999
EW004AU	0.64			0.15	1Q00	AUU	2000
EW004AU	0.62			0.15	2Q00	AUU	2000
EW004AU	0.98			0.15	3Q00	AUU	2000
EW005AU	10.2			1	07M93	AUU	1993
EW005AU	14.3			1	10M93	AUU	1993
EW005AU	14.3			0	10M93	AUU	1993
EW005AU	20			0.5	Y1994	AUU	1994
EW005AU	11.9			0.5	Y1994	AUU	1994
EW005AU	10.3			0.5	Y1994	AUU	1994
EW005AU	8.38			0.0854	1Q97	AUU	1997
EW005AU	9.46			0.108	2Q97	AUU	1997
EW005AU	9.45			0.108	2Q97	AUU	1997
EW005AUA	8.83			0.0892	2Q98	AUU	1998
EW005AUA	10.8			0.0929	2Q99	AUU	1999
EW005AUA	7.53			0.0905	4Q99	AUU	1999
EW005AUA	5.3			0.15	1Q00	AUU	2000
EW005AUA	5.3			0.15	2Q00	AUU	2000
EW005AUA	7.6			0.15	3Q00	AUU	2000

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW006AU	21.4			1	02M93	AUU	1993
EW006AU	28.5			1	05M93	AUU	1993
EW006AU	25.1			1	07M93	AUU	1993
EW006AU	27			1	10M93	AUU	1993
EW006AU	27.1			0.5	Y1994	AUU	1994
EW006AU	26.7			0.5	Y1994	AUU	1994
EW006AU	25			0.5	Y1994	AUU	1994
EW006AU	10.8			0.0854	1Q97	AUU	1997
EW006AU	8.13			0.108	2Q97	AUU	1997
EW006AU	4.9			0.3	3Q97	AUU	1997
EW006AU	6.79			0.108	4Q97	AUU	1997
EW006AU	7.68			0.181	1Q98	AUU	1998
EW006AU	8.15			0.181	2Q98	AUU	1998
EW006AU	5.95			0.161	4Q98	AUU	1998
EW006AU	5.16			0.0905	3Q99	AUU	1999
EW006AU	4.69			0.0905	4Q99	AUU	1999
EW006AU	4.9			0.15	3Q00	AUU	2000
EW007A	10			0.5	Y1994	U	1994
EW007A	5.51			0.0854	1Q97	U	1997
EW007A	5.3			0.0854	1Q97	U	1997
EW007A	4.49			0.108	2Q97	U	1997
EW007A	3.5			0.3	3Q97	U	1997
EW007A	3.61			0.181	4Q97	U	1997
EW007A	4.11			0.181	1Q98	U	1998
EW007A	4.11			0.181	2Q98	U	1998
EW007A	3.38			0.161	4Q98	U	1998
EW007A	4.1			0.15	3Q00	U	2000
EW008A	4.14			0.0854	1Q97	U	1997
EW008A	3.54			0.108	2Q97	U	1997
EW008A	1.8			0.3	3Q97	U	1997
EW008A	3.03	Z		0.108	4Q97	U	1997
EW008A	2.85			0.108	4Q97	U	1997
EW008A	3.14			0.181	1Q98	U	1998
EW008A	3.07			0.181	2Q98	U	1998
EW008A	2.55			0.161	4Q98	U	1998
EW008A	2.92			0.0929	2Q99	U	1999
EW008A	2.57			0.0905	3Q99	U	1999
EW008A	2.35			0.0905	4Q99	U	1999
EW008A	2.2			0.15	1Q00	U	2000
EW008A	1.9			0.15	2Q00	U	2000
EW008A	3.4			0.15	3Q00	U	2000

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW009B	29			0.5	Y1994	M	1994
EW009B	25			0.5	Y1994	M	1994
EW009B	14.5			0.0854	1Q97	M	1997
EW009B	13.5			0.108	2Q97	M	1997
EW009B	13			0.3	3Q97	M	1997
EW009B	37.1			0.161	4Q98	M	1998
EW009B	14.5			0.0929	2Q99	M	1999
EW009B	10.7			0.0905	4Q99	M	1999
EW009B	9.3			0.15	2Q00	M	2000
EW009B	13			0.15	3Q00	M	2000
EW010AU	0	ND		0.0854	1Q97	AUU	1997
EW010AU	0	ND		0.0854	2Q97	AUU	1997
EW010AU	0			0.3	3Q97	AUU	1997
EW010AU	0	ND		0.181	1Q98	AUU	1998
EW010AU	0	ND		0.0892	2Q98	AUU	1998
EW010AU	0	ND		0.161	4Q98	AUU	1998
EW010AU	0	ND		0.5	1Q99	AUU	1999
EW010AU	0	ND		0.0929	2Q99	AUU	1999
EW010AU	0	ND		0.0905	3Q99	AUU	1999
EW011AU	6.12			0.0854	1Q97	AUU	1997
EW011AU	6.66			0.108	2Q97	AUU	1997
EW011AU	5.8			0.3	3Q97	AUU	1997
EW011AU	4.78			0.181	1Q98	AUU	1998
EW011AU	4.72			0.181	1Q98	AUU	1998
EW011AU	5.96			0.181	2Q98	AUU	1998
EW011AU	6			0.161	4Q98	AUU	1998
EW011AU	11.6			0.0929	2Q99	AUU	1999
EW011AU	12.1			0.0905	3Q99	AUU	1999
EW011AU	11.9			0.0905	4Q99	AUU	1999
EW011AU	5.9			0.15	1Q00	AUU	2000
EW011AU	5.3			0.15	2Q00	AUU	2000
EW012AU	10.4			0.0854	1Q97	AUU	1997
EW012AU	8.28			0.0854	2Q97	AUU	1997
EW012AU	4.5			0.3	3Q97	AUU	1997
EW012AU	6.45			0.108	4Q97	AUU	1997
EW012AU	6.33			0.108	4Q97	AUU	1997
EW012AU	6.18			0.181	1Q98	AUU	1998
EW012AU	5.62			0.181	2Q98	AUU	1998
EW012AU	5.58			0.161	4Q98	AUU	1998
EW012AU	4.4			0.5	1Q99	AUU	1999
EW012AU	4.4			0.5	1Q99	AUU	1999

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW012AU	5.29			0.0929	2Q99	AUU	1999
EW012AU	4.83			0.0905	3Q99	AUU	1999
EW012AU	4.77			0.0905	4Q99	AUU	1999
EW012AU	4.6			0.15	1Q00	AUU	2000
EW012AU	3.9			0.15	2Q00	AUU	2000
EW012AU	6.3			0.15	3Q00	AUU	2000
EW013C	4.3			0.5	1Q99	L	1999
EW013C	4.57			0.0929	2Q99	L	1999
EW013C	4.58			0.0905	3Q99	L	1999
EW013C	4.42			0.0905	4Q99	L	1999
EW013C	2.4			0.15	1Q00	L	2000
EW013C	2.7			0.15	2Q00	L	2000
EW013C	4.2			0.15	3Q00	L	2000
EW013C	4			0.15	3Q00	L	2000
EW014A	1			0.5	1Q99	U	1999
EW014A	0.801			0.0929	2Q99	U	1999
EW014A	0.83			0.0905	3Q99	U	1999
EW014A	1.36			0.0905	4Q99	U	1999
EW014A	1			0.15	3Q00	U	2000
EW015A	1.6			0.5	1Q99	U	1999
EW015A	1.86			0.0929	2Q99	U	1999
EW015A	1.52			0.0905	3Q99	U	1999
EW015A	1.59			0.0905	4Q99	U	1999
EW015A	2.1			0.15	1Q00	U	2000
EW015A	0.69			0.15	3Q00	U	2000
EW016A	1.3			0.5	1Q99	U	1999
EW016A	1.66			0.0929	2Q99	U	1999
EW016A	1.99			0.0905	3Q99	U	1999
EW016A	1.78			0.0905	4Q99	U	1999
EW016A	1.3			0.15	1Q00	U	2000
EW016A	1.4			0.15	2Q00	U	2000
EW016A	1.7			0.15	3Q00	U	2000
EW017A	1.8			0.5	1Q99	U	1999
EW017A	2.21			0.0929	2Q99	U	1999
EW017A	1.99			0.0905	3Q99	U	1999
EW017A	1.46			0.0905	4Q99	U	1999
EW017A	1.5			0.15	1Q00	U	2000
EW017A	1.4			0.15	2Q00	U	2000
EW017A	1.4			0.15	2Q00	U	2000
EW017A	0.45	J		0.15	3Q00	U	2000
EW018A	2.7			0.5	1Q99	U	1999

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW018A	3.23			0.0905	3Q99	U	1999
EW018A	3.78			0.0905	4Q99	U	1999
EW018A	3.8			0.15	1Q00	U	2000
EW018A	3.6			0.15	2Q00	U	2000
EW018A	2.6			0.15	3Q00	U	2000
EW019A	6			0.5	1Q99	U	1999
EW019A	7.13			0.0929	2Q99	U	1999
EW019A	6.2			0.0905	3Q99	U	1999
EW019A	7.78			0.0905	4Q99	U	1999
EW019A	6.9			0.15	1Q00	U	2000
EW019A	6.9			0.15	1Q00	U	2000
EW019A	6.6			0.15	2Q00	U	2000
EW019A	2.3			0.15	3Q00	U	2000
EW020A	8.8			0.5	1Q99	U	1999
EW020A	8.14			0.0905	3Q99	U	1999
EW020A	10.9			0.0905	4Q99	U	1999
EW020A	9.2			0.15	1Q00	U	2000
EW020A	8.8			0.15	2Q00	U	2000
EW020A	11			0.15	3Q00	U	2000
EW021A	7.4			0.5	1Q99	U	1999
EW021A	9.25			0.0929	2Q99	U	1999
EW021A	7.25			0.0905	3Q99	U	1999
EW021A	7.16			0.0905	3Q99	U	1999
EW021A	7.27			0.0905	4Q99	U	1999
EW021A	3.1			0.15	3Q00	U	2000
EW022A	2.37			0.0929	3Q99	U	1999
EW022A	3.33			0.0905	4Q99	U	1999
EW022A	4.4			0.15	1Q00	U	2000
EW022A	2.9			0.15	3Q00	U	2000
EW024B	3.45			0.0905	3Q99	M	1999
EW024B	3.95			0.0905	4Q99	M	1999
EW024B	3.3			0.15	1Q00	M	2000
EW024B	3			0.15	2Q00	M	2000
EW024B	3.4			0.15	3Q00	M	2000
EW025B	11.8			0.0905	3Q99	M	1999
EW025B	13.7			0.0905	4Q99	M	1999
EW025B	11			0.15	1Q00	M	2000
EW025B	4.8			0.15	3Q00	M	2000
EW026B	15			0.5	1Q99	M	1999
EW026B	16.9			0.0929	2Q99	M	1999
EW026B	13			0.0905	3Q99	M	1999

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW026B	13.1			0.0905	4Q99	M	1999
EW026B	11			0.15	2Q00	M	2000
EW026B	24			0.15	3Q00	M	2000
EW027B	19.7			0.0929	2Q99	M	1999
EW027B	17.3			0.0905	3Q99	M	1999
EW027B	17.2			0.0905	4Q99	M	1999
EW027B	17.1			0.0905	4Q99	M	1999
EW027B	20			0.15	3Q00	M	2000
EW028B	11			0.5	1Q99	M	1999
EW028B	11.8			0.0929	2Q99	M	1999
EW028B	12.6			0.0905	3Q99	M	1999
EW028B	11.3			0.0905	4Q99	M	1999
EW028B	12			0.15	1Q00	M	2000
EW028B	7.3			0.15	2Q00	M	2000
EW028B	16			0.15	3Q00	M	2000
EW028B	14			0.15	3Q00	M	2000
EW029B	7.6			0.5	1Q99	M	1999
EW029B	8.3			0.0929	2Q99	M	1999
EW029B	6.72			0.0905	3Q99	M	1999
EW029B	6.59			0.0905	3Q99	M	1999
EW029B	5.94			0.0905	4Q99	M	1999
EW029B	7.3			0.15	1Q00	M	2000
EW029B	6.1			0.15	2Q00	M	2000
EW029B	8.5			0.15	3Q00	M	2000
EW030C	2.5			0.3	3Q97	L	1997
EW030C	0			0.3	3Q97	L	1997
EW030C	3.3			0.5	1Q99	L	1999
EW030C	3.52			0.0929	2Q99	L	1999
EW030C	3.42			0.0905	4Q99	L	1999
EW030C	2			0.3	EWB	L	19WB
EW030C	2.6			0.15	3Q00	L	2000
EW031C	8.83			0.0905	3Q99	L	1999
EW031C	8.11			0.0905	4Q99	L	1999
EW031C	17			0.15	3Q00	L	2000
EW032AU	4.9			0.5	1Q99	AU	1999
EW032AU	4.9			0.5	1Q99	AU	1999
EW032AU	4.68			0.0905	3Q99	AU	1999
EW032AU	4.6			0.0905	4Q99	AU	1999
EW032AU	3.8			0.15	1Q00	AU	2000
EW032AU	3.6			0.15	2Q00	AU	2000
EW032AU	4.2			0.15	3Q00	AU	2000

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW033AU	18.9			0.0929	2Q99	AU	1999
EW033AU	25.5			0.0929	3Q99	AU	1999
EW033AU	25.5			0.0905	4Q99	AU	1999
EW033AU	23.5			0.0905	4Q99	AU	1999
EW034AU	33			0.5	1Q99	AU	1999
EW034AU	13.1			0.0905	3Q99	AU	1999
EW034AU	14.5			0.0905	4Q99	AU	1999
EW034AU	20			0.15	1Q00	AU	2000
EW034AU	15			0.15	2Q00	AU	2000
EW034AU	15			0.15	3Q00	AU	2000
EW037AU	1.53			0.0929	2Q99	AU	1999
EW037AU	0.972			0.0929	3Q99	AU	1999
EW037AU	0.831			0.0905	4Q99	AU	1999
EW040AU	6.43			0.0929	2Q99	AU	1999
EW040AU	4.29			0.0929	3Q99	AU	1999
EW040AU	3.88			0.0929	3Q99	AU	1999
EW040AU	2.62			0.0905	4Q99	AU	1999
EW040AU	6.4			0.3	NWC	AU	19WC
EW040AU	1.5			0.15	1Q00	AU	2000
EW040AU	5.7			0.15	2Q00	AU	2000
EW040AU	7.1			0.15	3Q00	AU	2000
EW041AU	9.45			0.0929	2Q99	AU	1999
EW041AU	6.5			0.0905	3Q99	AU	1999
EW041AU	7.03			0.0929	4Q99	AU	1999
EW041AU	6.5			0.3	NWC	AU	19WC
EW041AU	6.1			0.15	1Q00	AU	2000
EW041AU	6.1			0.15	2Q00	AU	2000
EW041AU	7			0.15	3Q00	AU	2000
EW042AU	21			0.0929	2Q99	AU	1999
EW042AU	14.1			0.0905	3Q99	AU	1999
EW042AU	7.95			0.0929	4Q99	AU	1999
EW042AU	15			0.3	NWC	AU	19WC
EW042AU	8.4			0.15	1Q00	AU	2000
EW042AU	7.5			0.15	1Q00	AU	2000
EW042AU	6.1			0.15	2Q00	AU	2000
EW042AU	6			0.15	3Q00	AU	2000
EW043AU	8.16			0.0929	2Q99	AU	1999
EW043AU	7.86			0.0905	3Q99	AU	1999
EW043AU	6.28			0.0929	4Q99	AU	1999
EW043AU	7			0.3	NWC	AU	19WC
EW043AU	5.8			0.15	1Q00	AU	2000

TABLE D.2 (Continued)
HISTORICAL TCE CONCENTRATIONS AT EXTRACTION WELLS
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	TCE Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit	Event	Monitor Zone	Year
EW043AU	4.9			0.15	2Q00	AU	2000
EW043AU	5.8			0.15	3Q00	AU	2000
EW044AU	9.56			0.0929	2Q99	AU	1999
EW044AU	8.98			0.0905	3Q99	AU	1999
EW044AU	7.65			0.0929	4Q99	AU	1999
EW044AU	6.6			0.3	NWC	AU	19WC
EW044AU	6.4			0.3	NWC	AU	19WC
EW044AU	6.8			0.15	1Q00	AU	2000
EW044AU	5.9			0.15	2Q00	AU	2000
EW044AU	5.9			0.15	3Q00	AU	2000

TABLE D.3
STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW002AU	0.192	X	J	0.00674	1Q97	AUU	1997
EW002AU	0.22			0.00264	2Q97	AUU	1997
EW002AU	0.2			0.005	3Q97	AUU	1997
EW002AU	0.183			0.00231	4Q97	AUU	1997
EW002AU	0.187			0.00217	1Q98	AUU	1998
EW002AU	ND	NDR		0.00303	2Q98	AUU	1998
EW002AU	0.193			0.00303	2Q98	AUU	1998
EW002AU	0.178			0.00296	4Q98	AUU	1998
EW002AU	0.1			0.09	1Q99	AUU	1999
EW002AU	0.121			0.00226	2Q99	AUU	1999
EW002AU	0.123			0.00217	4Q99	AUU	1999
EW002AU	0.14			0.0204	1Q00	AUU	2000
EW002AU	0.13			0.0225	2Q00	AUU	2000
EW002AU	0.13			0.0202	2Q00	AUU	2000
EW002AU	0.098	J		0.0237	3Q00	AUU	2000
EW002AU	0.094	J		0.0234	3Q00	AUU	2000
EW003	0.139	X	J	0.00681	1Q97	U	1997
EW003	0.116			0.00261	2Q97	U	1997
EW003	0.11			0.00256	2Q97	U	1997
EW003	0.1		J+	0.005	3Q97	U	1997
EW003	0.14			0.00231	4Q97	U	1997
EW003	0.111			0.00205	1Q98	U	1998
EW003	ND	NDR		0.00309	2Q98	U	1998
EW003	ND	NDR		0.00306	2Q98	U	1998
EW003	0.105			0.00306	2Q98	U	1998
EW003	0.102			0.00309	2Q98	U	1998
EW003	0.107			0.00302	4Q98	U	1998
EW003	0.1			0.09	1Q99	U	1999
EW003	0.0985			0.00452	2Q99	U	1999
EW003	0.0925			0.00573	4Q99	U	1999
EW003	0.11			0.0204	1Q00	U	2000
EW003	0.098		J	0.0208	2Q00	U	2000
EW003	0.1			0.0208	3Q00	U	2000
EW004AU	ND	NRX		0.00359	1Q97	AUU	1997
EW004AU	0.112			0.00267	2Q97	AUU	1997
EW004AU	ND	NR		0.00213	1Q98	AUU	1998
EW004AU	ND			0.00316	2Q98	AUU	1998
EW004AU	ND	NDR		0.00316	2Q98	AUU	1998
EW004AU	0.0695			0.00305	4Q98	AUU	1998
EW004AU	0.101			0.00448	2Q99	AUU	1999
EW004AU	0.0602			0.00244	3Q99	AUU	1999

TABLE D.3 (Continued)
:STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW004AU	0.0743			0.00562	4Q99	AUU	1999
EW004AU	0.074	J		0.0199	1Q00	AUU	2000
EW004AU	0.065		J	0.0202	2Q00	AUU	2000
EW004AU	0.05	J		0.0227	3Q00	AUU	2000
EW005AU	0.128			0.00247	2Q97	AUU	1997
EW005AU	ND			0.00394	2Q98	AUU	1998
EW005AU	0.0864			0.00636	2Q99	AUU	1999
EW005AU	ND	NR		0.00215	4Q99	AUU	1999
EW005AU	0.035	J		0.0199	1Q00	AUU	2000
EW005AU	0.031		J	0.0199	2Q00	AUU	2000
EW005AU	ND	U		0.0229	3Q00	AUU	2000
EW006AU	ND	NR		0.00362	1Q97	AUU	1997
EW006AU	ND	NR		0.00251	2Q97	AUU	1997
EW006AU	ND			0.005	3Q97	AUU	1997
EW006AU	ND			0.005	3Q97	AUU	1997
EW006AU	ND	NR		0.00464	4Q97	AUU	1997
EW006AU	ND	NR		0.00205	1Q98	AUU	1998
EW006AU	ND	NR		0.00313	2Q98	AUU	1998
EW006AU	ND	NDR		0.00313	2Q98	AUU	1998
EW006AU	ND	NR		0.00329	4Q98	AUU	1998
EW006AU	ND	NR		0.00221	3Q99	AUU	1999
EW006AU	ND	NR		0.00236	4Q99	AUU	1999
EW006AU	ND	U		0.0204	3Q00	AUU	2000
EW007A	ND	U		0.021	3Q00	U	2000
EW008A	ND	NR		0.00233	3Q99	U	1999
EW008A	ND	NR		0.00224	4Q99	U	1999
EW008A	ND	U		0.0199	1Q00	U	2000
EW008A	ND		U	0.0197	2Q00	U	2000
EW008A	ND	U		0.0202	3Q00	U	2000
EW009B	ND	NR		0.00224	4Q99	M	1999
EW009B	0.036		J	0.0204	2Q00	M	2000
EW009B	0.035	J		0.0234	3Q00	M	2000
EW010AU	ND	ND		0.09	1Q99	AUU	1999
EW010AU	ND	NR		0.00249	3Q99	AUU	1999
EW011AU	ND	NR		0.00249	3Q99	AUU	1999
EW011AU	ND	< DLK		0.00224	4Q99	AUU	1999
EW011AU	ND		U	0.0204	2Q00	AUU	2000
EW012AU	ND	ND		0.09	1Q99	AUU	1999
EW012AU	ND	ND		0.09	1Q99	AUU	1999
EW012AU	ND	NR	UJ	0.00238	3Q99	AUU	1999
EW012AU	ND	NR		0.00228	4Q99	AUU	1999

TABLE D.3 (Continued)
:STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW012AU	ND	U		0.0202	1Q00	AUU	2000
EW012AU	ND		U	0.0202	2Q00	AUU	2000
EW012AU	ND	U		0.0199	3Q00	AUU	2000
EW013C	ND	ND		0.09	1Q99	L	1999
EW013C	ND	< DLK		0.00622	2Q99	L	1999
EW013C	ND	ND		0.00643	3Q99	L	1999
EW013C	ND	< DLK		0.00636	3Q99	L	1999
EW013C	ND	ND		0.00568	4Q99	L	1999
EW013C	ND	U		0.0202	1Q00	L	2000
EW013C	ND		U	0.0197	2Q00	L	2000
EW013C	ND	U		0.0199	3Q00	L	2000
EW014A	ND	ND		0.09	1Q99	U	1999
EW014A	ND	< DLK		0.00665	2Q99	U	1999
EW014A	ND	ND		0.00629	3Q99	U	1999
EW014A	ND	ND		0.00218	4Q99	U	1999
EW014A	ND	U		0.0197	3Q00	U	2000
EW015A	ND	ND		0.09	1Q99	U	1999
EW015A	ND	ND		0.00622	2Q99	U	1999
EW015A	ND	ND		0.00244	3Q99	U	1999
EW015A	ND	ND		0.00208	4Q99	U	1999
EW015A	ND	U		0.0202	1Q00	U	2000
EW015A	ND	U		0.0199	3Q00	U	2000
EW016A	ND	ND		0.09	1Q99	U	1999
EW016A	ND	ND		0.00603	2Q99	U	1999
EW016A	ND	ND		0.00221	3Q99	U	1999
EW016A	ND	ND		0.002	4Q99	U	1999
EW016A	ND	U		0.0208	1Q00	U	2000
EW016A	ND		U	0.0202	2Q00	U	2000
EW016A	ND	U		0.021	3Q00	U	2000
EW017A	ND	ND		0.09	1Q99	U	1999
EW017A	ND	< DLK		0.00562	2Q99	U	1999
EW017A	ND	ND		0.00629	3Q99	U	1999
EW017A	ND	ND		0.00218	4Q99	U	1999
EW017A	ND	U		0.0197	1Q00	U	2000
EW017A	ND		U	0.0202	2Q00	U	2000
EW017A	ND	U		0.0204	3Q00	U	2000
EW018A	ND	ND		0.09	1Q99	U	1999
EW018A	ND	ND		0.00643	3Q99	U	1999
EW018A	ND	ND		0.00214	4Q99	U	1999
EW018A	ND	U		0.0197	1Q00	U	2000
EW018A	ND		U	0.0199	2Q00	U	2000

TABLE D.3 (Continued)
:STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW018A	ND	U		0.0202	3Q00	U	2000
EW019A	ND	ND		0.09	1Q99	U	1999
EW019A	ND	ND		0.00622	2Q99	U	1999
EW019A	ND	ND		0.00236	3Q99	U	1999
EW019A	ND	ND		0.00214	4Q99	U	1999
EW019A	ND	U		0.0195	1Q00	U	2000
EW019A	ND		U	0.0202	2Q00	U	2000
EW019A	ND	U		0.0204	3Q00	U	2000
EW020A	ND	ND		0.09	1Q99	U	1999
EW020A	ND	ND		0.00236	3Q99	U	1999
EW020A	ND	ND		0.00557	4Q99	U	1999
EW020A	ND	U		0.0199	1Q00	U	2000
EW020A	ND		U	0.0197	2Q00	U	2000
EW020A	ND	U		0.0208	3Q00	U	2000
EW021A	ND	ND		0.09	1Q99	U	1999
EW021A	ND	NR		0.00665	2Q99	U	1999
EW021A	ND	NR		0.00236	3Q99	U	1999
EW021A	ND	NR		0.00218	4Q99	U	1999
EW021A	ND	NR		0.00224	1Q00	U	2000
EW021A	ND	U		0.0206	3Q00	U	2000
EW022A	ND	< DLK	UJ	0.00591	3Q99	U	1999
EW022A	ND	< DLP		0.00228	4Q99	U	1999
EW022A	ND	U	UJ	0.0195	1Q00	U	2000
EW022A	ND	U		0.0208	3Q00	U	2000
EW024B	ND	ND		0.00233	3Q99	M	1999
EW024B	ND	ND		0.00579	4Q99	M	1999
EW024B	ND	U		0.0195	1Q00	M	2000
EW024B	ND		U	0.0199	2Q00	M	2000
EW024B	ND	U		0.0199	3Q00	M	2000
EW025B	ND	ND		0.00233	3Q99	M	1999
EW025B	ND	ND		0.00568	4Q99	M	1999
EW025B	ND	U		0.0197	1Q00	M	2000
EW025B	ND	U		0.0206	3Q00	M	2000
EW026B	ND	ND		0.09	1Q99	M	1999
EW026B	ND	NR		0.00585	2Q99	M	1999
EW026B	ND	NR		0.00236	3Q99	M	1999
EW026B	ND	NR		0.00568	4Q99	M	1999
EW026B	0.032		J	0.0193	2Q00	M	2000
EW026B	0.028	J		0.0227	3Q00	M	2000
EW027B	ND	NR		0.00597	2Q99	M	1999
EW027B	0.0584			0.00236	3Q99	M	1999

TABLE D.3 (Continued)
:STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW027B	0.0515			0.00221	4Q99	M	1999
EW027B	0.039	J		0.0229	3Q00	M	2000
EW028B	ND	ND		0.09	1Q99	M	1999
EW028B	0.0675			0.00597	2Q99	M	1999
EW028B	0.0636			0.00236	3Q99	M	1999
EW028B	0.0612			0.00609	4Q99	M	1999
EW028B	0.083	J		0.0214	1Q00	M	2000
EW028B	0.081		J	0.0197	2Q00	M	2000
EW028B	0.081		J	0.0195	2Q00	M	2000
EW028B	0.063	J		0.0229	3Q00	M	2000
EW029B	ND	ND		0.09	1Q99	M	1999
EW029B	ND	NR		0.00603	2Q99	M	1999
EW029B	ND	NR		0.00246	3Q99	M	1999
EW029B	ND	NR		0.00629	4Q99	M	1999
EW029B	ND	U		0.0197	1Q00	M	2000
EW029B	ND		U	0.0222	2Q00	M	2000
EW029B	0.027	J		0.0237	3Q00	M	2000
EW030C	ND	ND		0.09	1Q99	L	1999
EW030C	ND	NR		0.00609	2Q99	L	1999
EW030C	ND	NR		0.00591	4Q99	L	1999
EW030C	ND	U		0.0202	3Q00	L	2000
EW031C	ND	ND		0.00233	3Q99	L	1999
EW031C	ND	ND		0.0021	4Q99	L	1999
EW031C	ND	U		0.0204	3Q00	L	2000
EW032AU	ND	ND		0.09	1Q99	AU	1999
EW032AU	ND	ND		0.09	1Q99	AU	1999
EW032AU	ND	NR		0.00236	3Q99	AU	1999
EW032AU	ND	NR		0.00597	4Q99	AU	1999
EW032AU	ND	U		0.022	1Q00	AU	2000
EW032AU	ND		U	0.0195	2Q00	AU	2000
EW032AU	ND	U		0.021	3Q00	AU	2000
EW033AU	ND	< DLK		0.119	2Q99	AU	1999
EW033AU	ND	ND	UJ	0.00657	3Q99	AU	1999
EW033AU	ND	ND	UJ	0.0117	4Q99	AU	1999
EW034AU	ND	ND		0.09	1Q99	AU	1999
EW034AU	ND	ND		0.00233	3Q99	AU	1999
EW034AU	ND	ND		0.00233	4Q99	AU	1999
EW034AU	ND	U		0.0216	1Q00	AU	2000
EW034AU	ND		U	0.0199	2Q00	AU	2000
EW034AU	ND	U		0.0202	3Q00	AU	2000
EW037AU	ND	ND		0.00597	2Q99	AU	1999

TABLE D.3 (Continued)
:STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW037AU	ND	ND	UJ	0.00657	3Q99	AU	1999
EW037AU	ND	ND		0.00241	4Q99	AU	1999
EW040AU	0.1			0.005	NWC	AU	1999
EW040AU	0.0633			0.00597	2Q99	AU	1999
EW040AU	0.0693			0.00224	3Q99	AU	1999
EW040AU	ND	NR		0.00616	4Q99	AU	1999
EW040AU	ND	NR		0.00223	4Q99	AU	1999
EW040AU	0.032	J		0.0199	1Q00	AU	2000
EW040AU	0.03	J		0.0199	1Q00	AU	2000
EW040AU	0.085		J	0.0195	2Q00	AU	2000
EW040AU	0.071	J		0.021	3Q00	AU	2000
EW041AU	ND		U	0.005	NWC	AU	1999
EW041AU	0.0953			0.00228	2Q99	AU	1999
EW041AU	0.0556			0.00224	3Q99	AU	1999
EW041AU	0.0907			0.00216	4Q99	AU	1999
EW041AU	0.0665		J-	0.00597	4Q99	AU	1999
EW041AU	0.075	J		0.0199	1Q00	AU	2000
EW041AU	0.075		J	0.0208	2Q00	AU	2000
EW041AU	0.077	J		0.0204	3Q00	AU	2000
EW042AU	0.12			0.005	NWC	AU	1999
EW042AU	0.211			0.00616	2Q99	AU	1999
EW042AU	0.151			0.00597	3Q99	AU	1999
EW042AU	0.0752			0.00216	4Q99	AU	1999
EW042AU	0.0702		J-	0.00223	4Q99	AU	1999
EW042AU	0.0664			0.00616	4Q99	AU	1999
EW042AU	0.052			0.00597	4Q99	AU	1999
EW042AU	0.14			0.0202	1Q00	AU	2000
EW042AU	0.09		J	0.021	2Q00	AU	2000
EW042AU	0.086		J	0.0195	2Q00	AU	2000
EW042AU	0.067	J		0.0206	3Q00	AU	2000
EW043AU	ND		U	0.005	NWC	AU	1999
EW043AU	0.107			0.0065	2Q99	AU	1999
EW043AU	0.099		J-	0.00228	3Q99	AU	1999
EW043AU	0.0878			0.00236	4Q99	AU	1999
EW043AU	0.076	J	J-	0.0206	1Q00	AU	2000
EW043AU	0.081		J	0.0199	2Q00	AU	2000
EW043AU	0.089	J		0.0202	3Q00	AU	2000
EW043AU	0.074	J		0.0195	3Q00	AU	2000
EW044AU	0.14			0.005	NWC	AU	1999
EW044AU	0.145			0.00616	2Q99	AU	1999
EW044AU	0.124			0.00218	3Q99	AU	1999

TABLE D.3 (Continued)
STORICAL DIELDRIN CONCENTRATIONS AT EXTRACTION WELI
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Well ID	Dieldrin Concentration (mg/L)	Data Flag	EPA Flags	Detection Limit (mg/L)	Event	Monitor Zone	Year
EW044AU	0.12			0.00236	4Q99	AU	1999
EW044AU	0.11			0.0202	1Q00	AU	2000
EW044AU	0.13			0.0204	2Q00	AU	2000
EW044AU	0.1			0.0206	3Q00	AU	2000

TABLE D.4
VOC MASS REMOVAL BY WELL FISCAL YEAR 1999
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA

Location	Extraction Rate (gpm)[a/]	Extraction Rate (gal[b/]/quarter)	Quarters Operated	Total Volume Removed	Average TCE Concentration (µg/L)[c/]	TCE Mass Removal (lb)[d/]	TCE Effective Efficiency	Percentage of Total Removed	Average PCE Concentration (µg/L)	PCE Mass Removal (lb)	PCE Effective Efficiency	Percentage of Total Mass Removed
EW002AU	31	4151520	4	16606080	5.17	0.73	22,641,445	3.72	7.31	1.04	16,020,475	11.39
EW003A	23	3080160	4	12320640	1.96	0.21	59,722,586	1.05	2.44	0.26	48,072,390	2.82
EW004AU	7	937440	1	937440	1.18	0.01	99,509,438	0.05	1.25	0.01	93,296,707	0.11
EW005AUA	0	0	0	0	10.80	0.00	0	0.00	10.10	0.00	0	0.00
EWOO6AU	28	3749760	3	11249280	5.56	0.53	21,072,236	2.71	2.93	0.28	39,950,945	3.09
EW007A	3	401760	0	0	3.38	0.00	0	0.00	3.08	0.00	0	0.00
EW008A	5	837000	1	837000	2.68	0.02	43,677,712	0.10	0.25	0.00	459,645,035	0.02
EW009B	0	0	0	0	25.80	0.00	0	0.00	10.75	0.00	0	0.00
EW010AU	8	1339200	2	2678400	0.00	0.00	0	0.00	1.81	0.04	64,671,972	0.46
EW011AU	3	502200	1	502200	9.90	0.04	11,823,866	0.22	0.00	0.00	0	0.00
EW012AU	54	9039600	4	36158400	5.03	1.55	23,294,780	7.88	6.68	2.06	17,536,520	22.65
EW013C	46	7700400	3	23101200	4.48	0.88	26,109,205	4.49	1.49	0.29	78,561,254	3.23
EW014A	13	2176200	3	6528600	0.88	0.05	133,524,261	0.25	0.00	0.00	0	0.00
EW015A	26	4352400	3	13057200	1.66	0.19	70,515,825	0.94	0.00	0.00	0	0.00
EW016A	53	8872200	3	26616600	1.65	0.38	70,943,193	1.91	0.00	0.00	0	0.00
EW017A	64	10713600	3	32140800	2.00	0.55	58,528,134	2.79	0.00	0.00	0	0.00
EW018A	17	2845800	3	8537400	3.24	0.24	36,165,686	1.20	0.00	0.00	0	0.00
EW019A	52	8704800	3	26114400	6.44	1.44	18,167,036	7.30	0.19	0.04	613,931,480	0.47
EW020A	33	5524200	3	16572600	9.28	1.31	12,613,822	6.67	1.00	0.14	117,056,269	1.56
EW021A	11	1841400	3	5524200	7.97	0.38	14,693,256	1.91	5.25	0.25	22,282,285	2.72
EW022A	2	334800	2	669600	2.85	0.02	41,072,375	0.08	2.60	0.01	45,021,642	0.16
EW024B	4	669600	3	2008800	3.70	0.06	31,636,829	0.32	0.00	0.00	0	0.00
EW025B	2	334800	2	669600	12.75	0.07	9,180,884	0.37	0.00	0.00	0	0.00
EW026B	37	6193800	3	18581400	14.97	2.38	7,821,132	12.06	6.98	1.11	16,770,239	12.17
EW027B	41	6863400	3	20590200	18.50	3.25	6,327,366	16.52	8.19	1.44	14,301,316	15.82
EW028B	57	9541800	3	28625400	11.80	2.89	9,920,023	14.65	4.08	1.00	28,713,721	10.95
EW029B	21	3515400	3	10546200	7.50	0.68	15,607,503	3.43	2.48	0.22	47,263,635	2.45
EW030C	22	3682800	2	7365600	3.41	0.21	34,327,352	1.09	0.93	0.06	126,456,178	0.64
EW031C	6	1004400	2	2008800	8.83	0.15	13,256,656	0.77	2.04	0.04	57,380,524	0.38
EW032AU	7	1171800	2	2343600	4.79	0.10	24,437,634	0.49	3.43	0.07	34,177,013	0.75
EW034AU	14	2343600	3	7030800	23.05	1.38	5,078,363	7.03	12.35	0.74	9,478,240	8.15

[a/] gpm = gallons per minute.

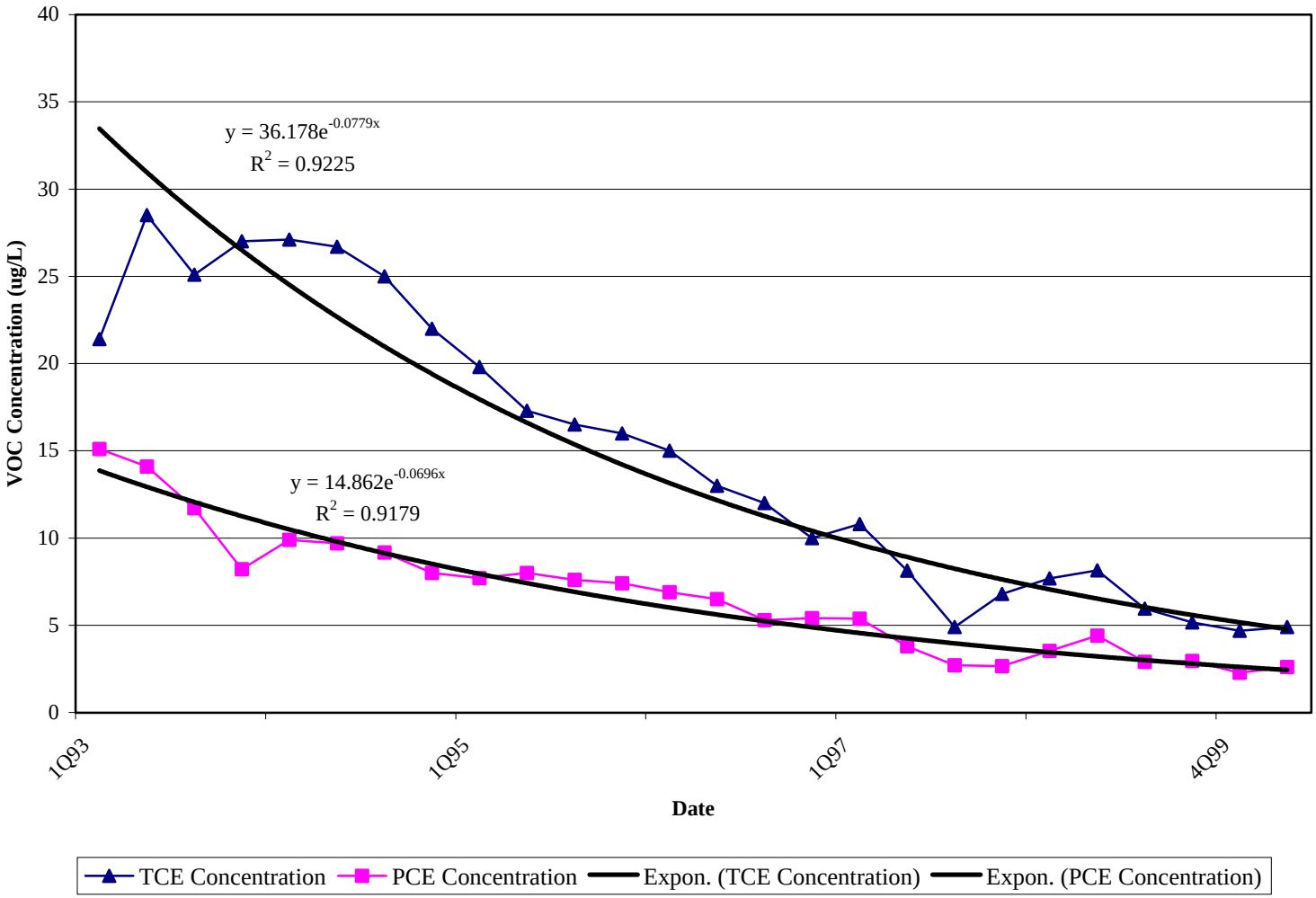
[b/] gal = gallons.

[c/] µg/L = micrograms per liter.

[d/] lb = pound.

[e/] gal/lb = gallons per pound.

FIGURE D.1
EW006AU
FIRST-ORDER COC CONCENTRATION DECAY PLOT
REMEDIAL PROCESS OPTIMIZATION
DDJC-TRACY, CALIFORNIA



S:\es\remed\rpo\ddjc-tracy\phase 2 report\conc_decay_curves.xls\Chart1

APPENDIX E

SUPPORTING COST DATA

PARSONS ENGINEERING SCIENCE, INC.

Client: AFCEE/DLA | Job No. | Sheet ___ of ___

Subject: DOJC-Tracy GW Treatment Alternatives | By: D Downey | Date

Checked | Rev.

Ref Calgon Carbon (412) 787-6700

Assume 150 GPM / 5ppb TCE / 5ppb PCE

Recommend Model 8 System w/ 20,000 lbs Carbon

Capital Cost $115,000

Install $10,000

$125,000

Calgon Estimates 4 pounds per day carbon use x 365 days = 1460 lbs/yr

Carbon Replacement Cost $2/lb x 1460 = $2920/yr

Shipping, Etc $1000/yr

$3920/yr

Air Stripper Power

15 HP x 1.25 Efficiency x .735 kw/HP x 24 hr/day x 365 days

= 120,723 kw-hr

@ .07/kw-hr = $8450/yr

Cleaning Air Stripper

120 hrs @ $70/hr = $8400/yr

Chemicals/Equipment = $1600/yr

$10,000/yr

APPENDIX F

DLA RESPONSES TO
URS, CEHNC, AND DTSC COMMENTS
ON THE
DRAFT RPO PHASE II EVALUATION REPORT
FOR DDJC-TRACY
(DATED FEBRUARY 2000)

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

REVIEWER: TOM CUDZILO

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
1	2	2-9	11-12	There is an outlet from the Stormwater Detention Pond to an irrigation district pipeline. Water is pumped to the pipeline only in winter months after intense storms, and is permitted under NPDES.	Concur. This correction will be made in the final report.
2	2	2-33	12-13	There seems to be little evidence of a “discontinuity” in the TCE plume. Figures 2.16 to 2.18 suggest a smooth curve of concentrations paralleling the gradient in the area. The only evidence lacking is results east of Banta Rd were DDJC has not been able to collect data.	The cited text (lines 12-13) refers *only* to the extension of TCE contamination in groundwater east of Banta Road. Figures 2.10, 2.17, and 2.18 best illustrate the apparent discontinuity in the TCE plume between concentrations above the ACL west of Banta Road and the recurrence of such concentrations about 0.25 mile east of Banta Road, with all intervening concentrations (represented by the CPT sampling locations on Figure 2.18) being less than the ACL of 5 µg/L. As discussed on page 2-31 (lines 16 through 28), the RPO data collected at temporary groundwater monitoring points on the Annex (Figure 2.13) generally corroborate the on-Annex plume interpretations presented by URS in the 1999 Annual Monitoring Report (ARM).
3	2	2-43	6-7	See comment 2.	See response to comment 2.

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
4	2	2-43	11-12	The plume in the Middle Horizon depth was present long before EW024 and EW025 were installed.	Concur.
5	2.5	All	All	The present presentation methods of plumes and concentration data in the current annual report format illustrates changes in plume shape and extent from 1994 to “last year” to “current year”. The focus most appropriately of this is on the capture and reduction in size of the plumes. In other figures of annual reports the higher concentration volumes are now illustrated by areas with “isoconcentration contours” of increasing value. Changes in concentration are shown by arrows and other details. The presentation has been clear and acceptable to regulatory personnel. The advantage of Figure 2.19 to currently used report presentations is not apparent.	The recent revisions in the ARM data presentations are commended. The suggested advantages to the alternative presentation strategy proposed in the RPO report are enumerated in the text in Section 2.5.

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
6	3	3-12	9-15	Although the Jury model was pioneering work applied to VOCs in soil in the early 1980s, it cannot account for all mechanisms affecting VOC transport and it does not allow for variations in soil type or parameters. The 2-D VapourT model and even the 1-D VLEACH numerical models are more appropriate for the heterogeneous soils of the Central Valley, and the models only take a few hours to setup for simulation. We doubt that Jury model results would persuade regulatory personnel, who are well aware of numerical modeling.	The heterogeneity of the subsurface at DDJC-Tracy is recognized, and is discussed at some length in the draft RPO report (*c.f.*, Section 2.2.2). Note that soil heterogeneity occurs in three dimensions – laterally as well as vertically. Hence, even if the subsurface were sufficiently characterized in a single location at DDJC-Tracy so as to permit the construction of a numerical model that accurately depicted subsurface conditions at that location (it is not), conditions even a few feet away from that location would likely be sufficiently different that the numerical model would no longer adequately represent the subsurface. Thus, the degree of heterogeneity of soils in the subsurface actually presents a rather compelling argument for using a homogeneous representation of the soil column in the vadose zone that incorporates the "bulk", or "average" characteristics of the heterogeneous subsurface materials. Refer to Section C2.2 (Appendix C of the Phase II RPO report): *"In a mathematical model of dissolved contaminant migration within the unsaturated zone, leachate flow and contaminant transport are coupled through an advective transport term in the equation describing conservation of mass. The transport term may be complicated by seasonal and climatic effects, leading to time-variant*

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					leachate flow. However, use of an average annual effective infiltration rate in the mass transport equation can provide a reasonable approximation of actual transient flow and resulting contaminant transport (Destouni, 1991; Maidment, 1993). Therefore, use of an analytical solution describing aqueous solute transport under conditions of steady-state flow is appropriate for screening-level calculations. *"Water percolation through the soil column is computed using the Hydrologic Evaluation of Landfill Performance (HELP) code (Schroeder et al., 1994).* [**Interjected note**: the HELP model solves Richards' equation directly, can incorporate soil heterogeneities to any degree of detail desired, and is not subject to the numerical instabilities that can result from attempting to solve two non-linear systems of equations (unsaturated percolation of water and chemical transport) iteratively. This approach may therefore be preferable to using a single numerical code that solves for unsaturated infiltration of water and chemical migration simultaneously.] *Site-specific soil and climatic data are incorporated into the model in which vertical, Richards-type unsaturated movement of liquid water is assumed to occur primarily due to gravitational forces. The percolation out of the bottom*

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					layer of the soil column simulated in the HELP model represents the amount of liquid water flux (recharge) to the groundwater system. *"Because the vadose zone comprises variably saturated pore spaces (i.e., pore spaces are not completely filled with water), an analytical solution to the one-dimensional (1-D), unsaturated, contaminant-mass transport equation was used to evaluate the potential migration of PCE and TCE in the subsurface at SWMUs 1, 66, and 68 at DDJC-Tracy. Using the "Jury" model (Jury et al., 1983 and 1984), chemical migration in the aqueous phase can be examined, and because the porous medium contains some proportion of air in the pore spaces, vapor-phase transport also is accounted for. The solution to the equations describing 1-D, unsaturated transport is in the form of a partitioning model that distributes a chemical species in equilibrium among its possible phases (dissolved in water, sorbed to soil, and in soil vapor) in accordance with its chemical properties and local conditions in the subsurface.* *Use of a 1-D analytical solution of this type is appropriate for the following reasons:* • *"The analytical solution considers the effects of the*

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					principal physical and chemical mechanisms that contribute to chemical migration and environmental attenuation: advection, diffusion, dispersion, volatilization, sorption, decay, and source-mass depletion. • *"Use of two-dimensional (2-D) or three-dimensional (3-D) variably saturated flow and transport codes (e.g., SESOIL) requires that the subsurface be characterized in considerable detail, in order to provide the quality and quantity of input data required for accurate numerical modeling. The required level of detail (centimeter-scale) generally is not available.* • *"Because a conservative, site-specific average infiltration rate can be estimated, and because accurate modeling of transient infiltration is problematic, it may be appropriate to disregard numerical simulations of flow, and instead use a calculation method that requires only steady-state seepage velocity as a primary input.* • *"Analytical solutions are simpler (and less expensive) to implement, have fewer sources of error, and are easier to verify than comparable numerical solutions.*

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					Their use is preferable in cases where available data are insufficient to take advantage of a numerical solution's greater flexibility." The "Jury model" is an analytical solution describing the movement of chemicals through the vadose zone in the sorbed, dissolved, and vapor phases, and is based on the exact solution (an "analytic" solution) of a series of partial differential equations derived by Jury *et al*. (1983 and 1984). The same (or similar) systems of equations could likewise be solved using numerical methods, but because the conceptualization of chemical migration and fate, and the mathematical descriptions of these processes are identical (or nearly so), the method of solution of the systems of equations (analytical or numerical) is immaterial to the final result. The primary processes and mechanisms that affect chemical migration in the unsaturated zone include dissolution, advective migration with infiltrating water, hydrodynamic dispersion in the dissolved phase, volatilization with subsequent migration in the vapor phase, chemical diffusion, and sorption. Jury *et al.'s* (1983 and 1984*)* description of vadose-zone migration (the "Jury model") incorporates all of

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					these mechanisms and processes with the exception of hydrodynamic dispersion. As noted by Jury *et al.:* *"Many modelers of chemical transport in soil include a dispersion term in the flux equation to account for solute spreading due to water velocity variations. At low average water fluxes in uniform soil, this term is relatively unimportant, but it becomes dominant over the diffusion term at high water fluxes or in structured soil where substantial variation in water velocities exists. Because we will be using our model in uniform, idealized scenarios, the influence of spatially variable water velocities on transport is not part of the screening tests, and we will not be including a dispersion coefficient. The relative influence of dispersion on transport should be similar to that of diffusion between different chemicals* [**Parsons ES note**: i.e., small], *unless large structural voids are present."* In light of the very low velocities calculated for percolation of water through the vadose zone at DDJC-Tracy (approximately 0.0015 centimeter per day [cm/day] to 0.002 cm/day; Appendix C of the Phase II RPO report), the effects of hydrodynamic dispersion are expected to be negligible.

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					The primary fate processes of VOCs in the vadose zone are volatilization and chemical decay. Both of these processes are incorporated in the Jury model. Although volatilization and migration of a chemical can occur at any point throughout the one-dimensional soil column in the Jury model, volatilization *losses* from the Jury model occur at the upper boundary of the model domain only (which represents the interface between ground surface and the atmosphere), and occur at rates that are dependent upon site-specific relative humidity and evaporation rates (which establish the height of the stagnant-air boundary layer above land surface – a parameter that controls the rate of volatilization). Chemical decay is assumed to occur as a first-order process; rates can vary through the entire range of 0 (no decay) to 1 (instantaneous decay). The capabilities of the Jury solution in describing chemical migration and fate may be compared with those of the supposedly more sophisticated finite-difference code VLEACH (Ravi and Johnson, 1997). Like the Jury solution, the structure of the VLEACH code assumes that movement of water through the vadose zone occurs at a steady rate (“steady-state” infiltration conditions); and hydrodynamic dispersion is neglected. Volatilization from the boundaries

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					of the soil column either is completely unimpeded or completely prevented (there is no site-specific rate dependency). Chemical degradation (potentially the most significant fate process) is assumed not to occur. Therefore, chemical migration processes are treated in exactly the same manner in the VLEACH code as they are in the Jury solution; and chemical fate processes are significantly more restricted in the VLEACH code than in the "simpler" Jury analytical solution.
7	3	3-13 throug h 3-14	23- end of section	The RPO contractor should be aware that models are not always trusted to predict reality. Regulatory personnel are aware of the SVE operations at DDJC-Sharpe and other Central Valley installations at which the mass of VOC in soils and its time of removal was not well predicted by analytical or numerical models. The application of the STOP protocol will be applied; however, our experience indicates use of the protocol does not assure early shutdown.	Concur.
8	4.1.3.1	4-15	All	Although the approach of re-evaluating VOC impacts on groundwater is good practice, it is not assured that the regulatory	The soil VOC data collected during the RPO investigations at DSERTS 68/Area 3 were intended to complement (not

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				agencies will accept soil data for VOCs instead of soil vapor data or the use of the analytical Jury model. In the past, Cal-EPA has been reluctant to accept VOC analytical results from soil samples; the agency preference as recently as Fall 2000 has been soil vapor measurements	replace) the soil vapor data for this site, and to provide a means of checking the potential ranges of concentrations of sorbed PCE/TCE remaining in the subsurface. The relatively low concentrations of these COCs detected in site soils suggest that most of the solvent release is present in the vapor and dissolved phases, and that SVE should be highly effective in minimizing further migration of VOCs to the water table.
9	4.2.2.3	4-27	12-13	We disagree that analysis of capture along the northern depot boundary is not useful. The wells there are closer to the source areas than downgradient wells. Although portions of the plume have passed these wells, evaluation of the depot boundary wells should not be dropped.	Non-concur. The FY99 ARM (paragraph 5.6.2) recommends shut down of three of the northern Depot boundary wells (EW003, EW004AU, and EW008A) because flow from these wells was thought to be diluting COC influent concentrations to TP-1. The RPO review of COC monitoring data indicated that PCE, TCE, and/or dieldrin concentrations had exceeded the ACLs at two of these wells (EW003 and EW004AU) in the 12-month period from 4Q99 through 3Q00. Because these two wells are achieving some degree of mass removal, it was inferred that URS's recommendation to shut these boundary wells down reflected a position that COCs migrating past these wells (i.e., past the northern Depot boundary) at concentrations greater than the ACLs would be intercepted by downgradient extraction wells (e.g., Above Upper wells

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					EW032AU and, once they are on line, the new EW040AU, EW041AU, EW043AU, and EW044AU, and Upper well EW022A). Per the 3Q99 capture analysis presented in the 1999 ARM, there appears to be capture redundancy in all horizons downgradient from all boundary extraction wells, and capture-zone analysis for the wells further downgradient would be more relevant for optimizing the system than continued analysis of capture by most wells along the boundary.
10	4.2.2.5	4-46	All	We agree that the removal of VOCs at each well should be *one* of the primary criteria for determining effectiveness; however, the hydraulic contatinment of the plumes is equally important to DDJC and regulatory agencies. Therefore, a number of the wells that have been producing water with less than ACL concentrations have not been recommended for shutdown because of their role in hydraulic capture. When the full OU 1 system is fully operational, the total hydraulic effect of the system can be evaluated, and wells that are not removing VOC mass or producing hydraulic control can be shutdown.	While continued extraction of "clean" groundwater at the eastern Annex boundary beyond the downgradient extent of the TCE plume certainly ensures the eventual containment effectiveness of the boundary extraction wells (for the on-Annex part of the TCE plume), and is conservative (i.e., "safe"), such extraction may not be necessary based on data collected to date during monitoring at the Banta Road extraction and monitoring wells. Low to nondetectable TCE concentrations in groundwater samples from locations along Banta Road north of well EW019A suggest that TCE is not migrating off-Annex through this area at concentrations that exceed the ACL of 5 µg/L, and the role of these wells in containing the on-Annex plume may be inconsequential. Contaminant trends at upgradient monitoring wells in the

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					Upper horizon (LM068A, LM072A, and LM074A) appeared to be flat or decreasing through 3Q99. Because rebound monitoring is recommended before a shutdown decision would be appropriate, and because monitoring at boundary and upgradient monitoring wells should serve to track any significant changes in plume migration and contaminant concentrations, eliminating pumping at the Banta Road wells listed in Table 5.2 of the RPO report could have positive impacts on the problems currently associated with effluent discharge and disposal, while continuing to prevent off-Annex migration of COCs at elevated concentrations.
11	4.3.2.1	4-68	Fig. 4-16	It is interesting that this logic diagram does not provide a frequency for sampling a well as does the current DDJC-Tracy logic diagram. It is not clear how this logic would reduce frequencies of sampling on a regular basis, for example annually. The focus of the logic is eliminating wells from monitoring. Agency personnel have accepted the format of the currently used monitoring logic, which clearly states what the recommended frequency is on its one page. Additional iterations are not needed.	The decision logic diagram provided in the RPO report is intended to complement the decision logic in place for DDJC-Tracy (and Sharpe), and in fact does include optimization of sampling schedule (i.e., frequency) as options at the decision points between the qualitative and temporal, and temporal and spatial analysis logic trees. At these decision points, the sampling frequency logic currently in use could be applied. The text will be clarified in the final report to indicate that the proposed diagram can supplement the current logic.

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
12	4.3.2.1	4-75	13-19	Kriging analyses are most effectively used and have been developed for predicting mining ore grades and other "fixed" values. Acceptable application to non-fixed values that change with time as well as among locations may be questioned by regulatory personnel, for example, concentrations in groundwater that is migrating. The applications of the contractors suggested spatial analysis to OU D at McClellan AFB or to the subset of DDJC-Sharpe wells have not been presented for review.	It is certainly true that geostatistical techniques historically were developed for use in predicting ore grades for the mining industry. However, in the years since the initial development of geostatistical methods in the 1960s and 1970s, spatial statistical techniques (including geostatistics) have been extended to such diverse applications as examining migration patterns of human populations (Brown, 1995), assessing regional fertility rates (Feng, 1995), examining urban population densities (Griffith and Can, 1995), agronomy (Long, 1995), evaluation of the extent of radionuclides in soil at a nuclear test site (Gilbert and Simpson, 1984), evaluation of geochemical data collected in conjunction with a regional mineral-exploration program (Zhou, 1987), evaluation of aquifer hydraulic characteristics on a regional scale (Orr and Dutton, 1983; Eggleston *et al*., 1996), hydrostratigraphic interpretation (Johnson and Dreiss, 1989), evaluation of air pollution (Carletti *et al*., 2000), and evaluation of the extent of dissolved contaminants in groundwater (Cooper and Istok, 1988a and 1988b). These efforts largely have been successful, because spatial statistical methods can be applied to *any* variable or combinations of variables that are related in space. The spatial relationship among variables is expressed in terms of a *semivariogram*; and if the

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					semivariogram exists, it can be demonstrated that under all conditions, the kriging system based on this semivariogram produces the best linear unbiased estimator describing the spatial distribution of the variable (Clark, 1979). There are many hydrogeologic variables that can be viewed as spatiotemporal phenomena. For example, measurements of hydraulic potential, monthly rainfall, and contaminant concentrations in groundwater samples exhibit random aspects in both time and space. The estimation of such variables at unsampled spatial locations or at unsampled times requires extending the usual geostatistical techniques into the space/time domain (Rouhani and Myers, 1990). The generic problem is to develop an estimator to predict the value of a variable in space and time. This can be accomplished by treating time as another dimension, and applying the standard kriging system to a 2- , 3- , or 4-dimensional space (Cressie, 1991). Unfortunately, hydrogeologic data usually are concentrated in time, but sparse in space; as a consequence of the imbalance of information, simply treating time as another dimension can lead to models or statistical structures having significantly different levels of reliability in space and time (Rouhani and Myers, 1990). In practice, this difficulty is addressed by using temporal periodicities to interpret the space/time data

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					as multiple realizations. First, the data (chemical concentrations, hydraulic heads) collected during a single event are examined. Typically, the single event having the most extensive and intensive spatial coverage is selected, to provide the largest data set (in the spatial sense) possible. These data are used to generate a semivariogram, which is examined to determine whether the variable(s) of interest exhibit a spatial relationship. If a relationship is present, the semivariogram then is used in the kriging system, which can produce estimates of the value of the variable at any point in the spatial domain (the sampled area), *together with an estimate of the uncertainty associated with each estimated value* (Clark, 1979). This last is of critical importance, as the calculated uncertainty provides an indication of the value of information associated with a particular sampling location – the greater the uncertainty, the higher is the value of actual information collected at that location. Points having relatively higher information values represent potentially "worthwhile" sampling locations.
13	4.3.3.3	4-83	16-19	The sample size and sample interval (one event) are insufficient to demonstrate the comparability of diffusion samplers to low flow. Why were no analyses performed for inorganic species or for dieldrin? Can the diffusion sampler be used to obtain samples	The pilot test of the diffusion sampler technology was designed as a limited-scale demonstration. The data collected and the results of the comparison of results with those obtained by URS during 4Q00 sampling of the same

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by; submitted 03/01/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				for dieldrin? Can the diffusion sampler be used to obtain samples for those analytes?	wells for VOCs are valid with the exceptions noted in the draft report. A large-scale (approximately 45 wells) demonstration of passive diffusion samplers for monitoring VOCs in groundwater has been scoped for DDJC-Sharpe, with implementation scheduled to begin during the summer of 2001. It is expected that the results from this expanded demonstration also will be relevant for monitoring program optimization at DDJC-Tracy, based on similarities in the sampling programs, target analytes, hydrogeology, monitoring well design, and dedicated in-well micro-purge equipment at the two facilities. As noted in the RPO work plan and on pages 4-85 (lines 7 through 15) and 4-88 (line 12), the diffusion sampler technology used in the demonstration at DDJC-Tracy currently is regarded as proven for VOCs and fuel hydrocarbons only. Because the primary and most widespread COCs in OU1 groundwater are PCE and TCE, this technology is appropriate for a significant subset of all wells routinely sampled at DDJC-Tracy (and DDJC-Sharpe).

References Cited

Brown, D.G.. 1995. *Spatial Statistics and GIS Applied to Internal Migration in Rwanda, Central Africa,* in *Practical Handbook of Spatial Statistics,* S.L. Arlinghaus, ed. CRC Press, Inc. Boca Raton, Florida.

Carletti, R., Picci, M., and D. Romano. 2000. Kriging and bilinear methods for estimating spatial pattern of atmospheric pollutants. *Environmental Monitoring and Assessment* 63(2):341-359.

Clark, I. 1979. *Practical Geostatistics*. Elsevier Applied Science Publishers, Inc. New York, NY.

Cooper, R.M., and J.D. Istok. 1988a. Geostatistics applied to groundwater contamination – I. Methodology. *Journal of Environmental Engineering* 114(2):270-286.

Cooper, R.M., and J.D. Istok. 1988b. Geostatistics applied to groundwater contamination – I. Application. *Journal of Environmental Engineering* 114(2):287-299..

Cressie, N.A.C. 1991. *Statistics for Spatial Data*. John Wiley & Sons, Inc. New York, NY.

Destouni. 1991. Applicability of the steady state flow assumption for solute advection in field soils. *Water Resources Research* 27(8):2129-2140.

Eggleston, J.R., Rojstaczer, S.A., and J.J. Peirce. 1996. Indentification of hydraulic conductivity structure in sand and gravel aquifers – Cape Cod data set. *Water Resources Research* 32(5):1209-1222.

Feng, H.M. 1995. *Spatial Statistical Modeling of Regional Fertility Rates: As Case Study of He-Nan Province, China,* in *Practical Handbook of Spatial Statistics,* S.L. Arlinghaus, ed. CRC Press, Inc. Boca Raton, Florida.

Gilbert, R.O., and J.C. Simpson. 1984. Kriging for estimating spatial pattern of contaminants – Potential and problems. *Environmental Monitoring and Assessment* 1(1):113-135.

Griffith, D.A., and A. Can. 1995. *Spatial Statistical/Econometric Versions of Simple Urban Population Density Models,* in *Practical Handbook of Spatial Statistics,* S.L. Arlinghaus, ed. CRC Press, Inc. Boca Raton, Florida.

Johnson, N.M., and S.J. Dreiss. 1989. Hydrostratigraphic interpretation using indicator geostatistics. *Water Resources Research* 25(12):2501-2510.

Jury, W.C., W.F. Spencer, and W.J. Farmer. 1983. Behavior assessment model for trace organics in soil – I: Model description. *Journal of Environmental Quality.* 12(4):558-564.

Jury, W.C., W.J. Farmer, and W.F. Spencer. 1984. Behavior assessment model for trace organics in soil – II: Chemical classification and parameter sensitivity. *Journal of Environmental Quality.* 13(4):567-579.

Long, D.S. 1995. *Spatial Statistics for Analysis of Variance of Agronomic Field Trials,* in *Practical Handbook of Spatial Statistics,* S.L. Arlinghaus, ed. CRC Press, Inc. Boca Raton, Florida.

Maidment, D.R. 1993. *Handbook of Hydrology*. McGraw-Hill Publishers, Inc. New York, New York.

Orr, E.D., and A.R. Dutton. 1983. Application of geostatistics to determine regional ground-water flow in the San Andres Formation, Texas and Mexico. *Journal of Ground Water* 21(15):619-624.

Ravi, V. and J.A. Johnson. 1997. *VLEACH – A One-Dimensional Finite Difference vadose Zone Leaching Model. Ver. 2.2.* U.S. Environmental Protection Agency, Office of Research and Development. Center for Subsurface Modeling Support.

Rouhani, S. and D.E. Myers. 1990. Problems in space-time kriging of geohydrological data. *Mathematical Geology* 22(5):611-623.

Schroeder, P.R., T.S. Dozier, P.C. Zappi, B.M. McEnroe, J.W. Sjostrom and R.L. Peyton. 1994. The *Hydrologic Evaluation of Landfill Performance (HELP) Model*. EPA/600/R-94/168b, U.S. Army Corps of Engineers, Waterways Experiment Station.

Zhou, D. 1987. Robust statistics and geochemical data analysis. *Mathematical Geology* 19(3):207-218.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

REVIEWERS: RANDY MARX, BOB PEDLAR, MIKE THOMAS, & GRAHAM SHARPE

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
1	Exec. Summary	ES-1 – ES-8	All	The comments below on the Executive Summary (ES) should also be applied to the appropriate sections within the document. The OU-1 groundwater treatment system optimization discussions and analyses are presented with an implied inadequacy of the existing groundwater system without making a clear statement that the optimization evaluation is based on an immature operating system. The SVE system analyses are similarly based on pre-operation data. This is due to: • The fully constructed OU-1 groundwater treatment system has been on-line since 1998 but operation has been intermittent since the initial prove out period due to significant equipment and original construction deficiencies. Consequently, the numbers stated in the summary may be misleading. • The SVE systems were not constructed at the time of the optimization evaluation. There is a brief mention in the last sentence of page ES-2 about the operation of the ETI system beginning in 1998, but it is presented as a drawback to completing a thorough optimization review rather than in the context of it being too early to assess the overall effectiveness of the system.	Comment acknowledged.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				Recommend that the sentence in Section 4, first paragraph, beginning with "However….", be included in the ES text and the above points be clarified in the beginning of the ES that clearly qualifies the conditions and observations. Recommend that the last paragraph in Section 1, page 1-14, be added in content to the ES to further explain the extent of the evaluation performed.	The text of the ES will be revised to better clarify that the evaluation of the groundwater extraction/treatment/ infiltration (ETI) system should be considered preliminary based on the short performance period and the as-yet incomplete system operations.
2	Exec. Summary	ES-1	26-28	It should be clarified that the 1996 Site-Wide Comprehensive ROD superceded and referenced the earlier OU-1 ROD and includes a comprehensive evaluation of all groundwater issues.	Per the Decision Summary and Section 4 of the 1998 Comprehensive ROD, the Comprehensive ROD "modified and reaffirmed" the decision of the previous 1993 OU1 groundwater ROD. Because it is not clearly stipulated that the later ROD supersedes the earlier ROD, Parsons ES inferred that the 1993 ROD remains in force, as modified by the 1996 ESD, for the volatile chemicals of concern (COCs), and that the subsequent ROD is specific to selecting the final OU1 remedy for dieldrin (refer to Sections 7.3.2 and 7.3.3 of the 1998 ROD).
3	Exec. Summary	ES-2	5	There is only one (singular) private well that has been effected by measurable levels of VOC at or below action level (Rose Property). Though below action level, this well has been equipped with a GAC unit.	Concur. The text will be revised to indicate that only one private well has been affected by contamination (i.e., TCE) attributed to DDJC-Tracy sources, and also will note that point-of-extraction treatment with GAC has been implemented for that well.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
4	Exec. Summary	ES-2	11-22	The summary of contaminant removal as being less successful overlooks the fact that the system has yet to function fully as constructed and overlooks an element of the original design. The area associated with SWMU 68 (more correctly DSERTS 68 or Area 3 – this site was not formally identified as a SWMU) was addressed in the RI phase and is included in the groundwater modeling system evaluation (Montgomery- Watson , Aug 1995) . This area was designed to be contained by the Southern Infiltration Gallery system (infiltration at the southern galleries was designed to create a gradient to encourage migration in this area northeastward) with removal by the downgradient extraction well system located north of the gallery system. Furthermore, due to the proximity to the All Pure Chemical Company groundwater contaminant plumes, any extraction in this vicinity was considered to be detrimental. This consideration is acknowledged by the RPO Phase II Report as a potential effect in paragraph 2.3.2.2, page 2-31, line 26.	Non-concur. The preliminary nature of the evaluation is noted in several places throughout the report (as pointed out in Comment 1), and the fact that the system has not yet been fully operational also is noted and will be further emphasized, per the response to Comment 1. Area 3 as originally characterized during the Phase I RI was at the extreme southeastern end of the current DSERTS 68 site, where soil and soil vapor concentrations of TCE and PCE were relatively low compared to more northwesterly portions of the site. Note that this incomplete delineation of Area 3 persists in the 1999 Annual Monitoring Report (ARM) (e.g., Figures 4.2-1 and 4.2-2), and the DSERTS 68 site is not labeled as such. Based on Radian's 1998 soil vapor survey and the October 2000 RPO investigations, the more concentrated source of VOC contamination in groundwater is apparently located upgradient from well LM032AU, at a distance of approximately 0.5 mile west-northwest (crossgradient) from the All Pure/Pioneer facility, and at least 1,300 feet west-northwest (crossgradient) from extraction well EW035AU (presumably installed to control migration of the plume associated with the originally defined Area 3). Based on the plume interpretations and groundwater flow directions presented in the 1999 ARM, and on the data collected downgradient from DSERTS 68/well LM032AU during the RPO Geoprobe investigation, the

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					PCE/TCE plume emanating from the DSERTS 68 source area is migrating to the north-northeast such that it will intersect Banta Road north of the southern infiltration galleries. This migration pathway appears to be established west of (and independent of influence from) the hydraulic barrier induced by the infiltration galleries. Moreover, the elevated PCE/TCE concentrations at and near well LM032AU appear to be laterally localized and largely confined to the Above Upper horizon (shallow saturated zone), making this area a good candidate for focused extraction to remove COC mass before it migrates into underlying portions of the Upper Tulare Aquifer. The presence of TCE concentrations in Upper horizon well LM147A, east- southeast of Area 3, which are slightly higher than those along the apparent flow path of the plume in the AU horizon (e.g., at well LM144AU), may be attributable to historic operation of agricultural well AG-3, which was located just east of the southeastern end of Area 3. The text also notes that this apparent deflection of the plume also could be related to an additional source of contamination to the southeast of Area 3, or possibly to operation of the private wells PW002 and PW003. The “SWMU” designations for DSERTS 66 and 68 will be corrected throughout the document.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				The description of the off- Annex characterization as "incomplete" is correct in that work is ongoing, yet implies an element of no ongoing action. Recommend that the statement be revised to state "characterization efforts are ongoing of this recently identified area of contamination which precludes….".	Concur. This point is made in subsequent discussions in the report. The text of the ES will be revised for clarity.
				The term "inconsistent" as it applies to the sampling programs has an undefined meaning. Recommend the statement be more specifically stated as to what elements of the sampling program are inconsistent with what other elements. Did the RPO team review the existing sampling frequency decision logic diagram contained in the annual monitoring report and annual monitoring work plans, and the sample selection tables in the annual monitoring work plan?	Concur. The sentence beginning on line 20 will be revised to read, "Variations in the wells included in individual sampling events during implementation of the monitoring program also have constrained…" The sampling decision logic for the FY98 and FY99 monitoring programs were reviewed, and all sampling points monitored during calendar years 1992, 1994, 1996, and 3Q00 were plotted (see Figures 2.15 through 2.19) to assess the comparability of sampling locations through time.
5	Exec. Summary	ES-2	26	Effluent is not discharged to the sewage lagoon. This has not been supported by the agencies and is not advisable due to potential for detrimental effect on the pesticides in this area. No discharge pipeline exists to direct flow to this lagoon. Recommend the "and percolation from a sewage lagoon" statement be deleted.	The information on discharge of TP-1 effluent to the sewage lagoon during FY99 was taken from Section 5.0 of the 1999 ARM. The text in the referenced section states that each treatment plant has "effluent piping to the infiltration galleries, chimney drain, sewage lagoons, and storm drain holding pond" (paragraph 5.2.1), and further states that under "WDR Order 96-021," treated water from TP-1 "can also be discharged to

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					the sewage lagoons under emergency conditions" (paragraph 5.2.3), and "Two infiltration gallery wells (IG-1 and CD-1) and sewage lagoons accept its [TP-1's] effluent" (paragraph 5.2.4). Figure 5.2-2 shows effluent discharge can be routed from TP-1 to the sewage lagoon, CD-1, and IG-1. Paragraph 5.3.1.2 states that "eighteen percent" of TP-1 effluent "was discharged to the sewage lagoons," though the reason(s) for this diversion are not specified. Table 5.3-1 of that report indicates that 8,149,000 gallons of effluent from TP-1 was discharged to the sewage lagoons during the reporting period. Because discharge to the sewage lagoons also occurred in 1997 (per paragraph 5.1.7 of the 1998 ARM), Parsons ES stated in the RPO report that such discharges occur "periodically." Note that the WDR Order reviewed during the RPO Phase II evaluation is Order 98-053, which rescinded and superseded the previous Order 96-022 (not 96-021, as stated in the FY99 ARM) on March 4, 1998. There is no mention of the sewage lagoon as an emergency discharge point for treated effluent from OU1 TPs in the 1998 Order, nor is the sewage lagoon mentioned in such a capacity in the summary of the 1996 Order provided in the 1998 Order (see Item 4 on the first page of Order 98-053). Parsons ES did not review the rescinded 1996 Order during the RPO study. The 1998 Order does allow discharge of treated effluent to the "storm water evaporation/percolation pond" under certain conditions.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					Per discussions during the recent RPO briefing at DDJC-Tracy on March 13, 2001, the discharge to the sewage lagoons during FY99, and the existence of effluent piping to the lagoons, as reported in the 1999 ARM, may have been in error. Therefore, DLA requests that URS resolve any reporting discrepancies and notify Parsons ES so that the existence of effluent piping to alternate discharge points (i.e., the sewage lagoons and/or the storm water pond), and the discharge point for the 8.1 million gallons during FY99, can be clarified in the final RPO report.
			29	The statement that the ETI has been operational only since November 1998 should be amended to recognize that it has been only *partially operational*, or otherwise qualified as less than fully operational.	Concur. The last sentence on page ES-2 (line 29) will be revised to read, "Because the full-scale extraction/treatment/injection (ETI) system has been only partially operational since TP-2 was bought on-line in November 1998, …."
6	Exec. Summary	ES-3	6	The final SWMU 4 baseline ecological risk assessment and regulatory acceptance remains incomplete, though, based on recent dialog, regulatory concurrence is anticipated. There remains a small possibility that an ecological risk may exist at SWMU 4. This statement may need amending to recognize lack of finality at SWMU 4.	Per discussions during the recent RPO briefing at DDJC-Tracy on March 13, 2001, regulatory concurrence with a recommendation for institutional controls and monitoring as the final remedy for SWMU 4 sediment has been granted. This change in the selected remedy will be effected via an ESD to the ROD (currently in preparation). The text will be updated to reflect this recent change.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
7	1	1-2	24-28	Recommend the 1996 Site-Wide Comprehensive ROD be addressed first as the primary ROD document. It superceded the OU-1 ROD that came earlier.	See response to Comment 2.
8	1	1-3	23	The current Baseline Ecological Risk Assessment, Explanation of Significant Difference, and ROD Amendments initiated in 1999 and currently in final stages also met this objective. The coordination of these actions should be noted.	Concur. At the time of the RPO Scoping Visit (RSV) in May 2000, the BERA was still in preparation, and DLA specifically requested a review of the draft BERA during the RPO Phase II evaluation. Parsons ES was not aware of the ongoing ESD/ROD Amendment effort until late fall 2000. The text will be revised to acknowledge that these efforts are underway.
9	1	1-4	12-20	Hopefully, a review of the Annual Monitoring Reports and Final Design of the OU-1 GWTP construction were also performed. review of these significant documents should be added to the listing.	The AMRs and other historical documents were reviewed as part of the general data review (referenced in bullet number 2 on page 1-4, lines 7-9). The items listed in lines 14 through 20 of this page of the draft report were recently completed work products for work elements underway or about to be implemented at DDJC-Tracy, and as such were specifically identified for evaluation in order to provided input that could potentially be incorporated into remedial actions during the implementation stage. As was noted during the RSV, the Administrative Record for DDJC-Tracy is incomplete and in

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					need of maintenance. Several key documents were missing from the facility archives, and a current master inventory list of documents was not available. Though URS was able to provide most of the missing reference materials, several historical and some very recent documents were not included in the document review for the RPO evaluation.
10	1	1-10	Table 1.1	Recommend references to "overland flow pilot study" include the term "disposal" after "flow" to better explain the term throughout the document. The following milestones should be added as being significant: SVE design submitted, removal actions completed for the Small Excavation Sites, and the Child Care Center removal action completed.	The terminology used to reference the overland flow report and scale-up pilot study was taken directly from those documents. For consistency, this terminology generally will be retained, with occasional clarifications in the final report. Please provide the appropriate dates for the listed milestones for incorporation into the final RPO report.
11	1	1-13	Table 1.2	The SVE system was installed in Winter 2000, not Fall 2000. the revised Ecological Risk Assessment was completed in March 2001, not Fall 2000.	The installation of the SVE system at DSERTS 68 was observed to be underway during the RPO field effort at that site in October 2000, hence the fall date for that site. The dates will be revised as requested to reflect completion dates for the installations. The revised final BERA was issued after the draft RPO report was released. The date of the latest iteration of the BERA report will be updated in the final

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					report.
12	1	1-14	7	Treatment plant effluent is NOT periodically discharged to the sewage lagoons. No discharge conveyance exists and the addition of treated groundwater is discouraged due to regulatory and technical reasons. Some water was discharged in July and August 1999 on an interim basis to facilitate construction modifications to TP-1. This is not routine nor desired.	See response to Comment 5.
13	2	General		The proposed consolidation of the Upper, Middle and Lower horizons may have merit at initial review, however, the discontinuous nature of the depositional environment of the entire San Joaquin Valley would fall into this category, in general. The occurrence of contaminants and the resulting plumes require placement of monitoring wells and extraction wells with screens in the appropriate horizon, regardless of how the hydrogeology is conceptually presented. Treating the entire "below Above Upper" units as one unit suggests that assessment of vertical migration is of diminished importance - a position to which the regulatory agencies would likely take exception.	It is acknowledged that the Upper Tulare Aquifer in the vicinity of DDJC-Tracy is complex and highly heterogeneous. The “horizon” concept that may be applicable along primary drainage courses in the Central Valley tends to break down with distance from those drainages, and discrete horizons become blurred as the degree of heterogeneity within horizons increases. An examination of hydrogeologic cross-sections presented in the AMRs confirms this complexity, and reflects the difficulties inherent in attempting to reliably target perceived horizons with monitoring (and extraction) well screens; many wells assigned to the same horizon are screened in sediments of differing permeability, or the screens penetrate

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					more than one horizon (e.g., see Figure 2.6 of the draft RPO report). The intent of refining the CSM is to better acknowledge these difficulties while encouraging a "whole plume" view of dissolved contamination in the subsurface. The model is not intended to diminish the importance of vertical migration so much as to clarify the vertical and lateral extents of the plumes independent of difficult-to-characterize channels of greater permeability amid multiple discontinuous layers and stringers of finer-grained sediments. The primary purpose of the refined CSM is to facilitate reporting of groundwater monitoring and extraction-system performance results while elucidating the comprehensive evaluation of where contamination currently exists and where it appears to be migrating within the Upper Tulare Aquifer. The general lack of contamination in the Lower horizon suggests that monitoring and extraction are justifiably concentrated in the overlying portions of the saturated zone.
14	2	2-4	15	Since the DDJC data system has been created and referenced under the EDMS acronym, recommend the following clarification be added: "..database, also known as the DDJC Environmental Data Management System, or EDMS, in project documentation."	Concur. The recommended revision will be made.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
15	2	2-23	17	Actually, the Dieldrin plume is not yet well defined. Due to real estate access issues, the plume boundary along the north edge of the Annex property in the northwest corner is uncertain.	Concur. The text will be revised to note this remaining characterization data gap.
			27	Note that wells LM56C and LM81C are actually along the western edge of the Annex, not the eastern edge. Please correct this reference.	Concur. This error will be corrected in the final report.
16	2	2-24	14	It is doubtful that flood irrigation has had much influence on plume migration. It is a discontinuous operation that occurs only seasonally and percolation is intended to extend only to the root zone. A stronger record exists for historical irrigation well influences as mentioned beginning on line 25. Recommend that the Line 14 reference be to historical irrigation extraction well operation (e.g. AG Well 2).	Government agencies and other entities have expended considerable effort to evaluate the efficiencies of various types of irrigation systems (Younts and Klocke, 1985). Irrigation efficiency (or application efficiency) is defined (Heerman *et al*., 1990) to be the ratio of the volume of irrigation water required by a particular crop to the volume of irrigation water delivered to the field: $$E_a = \frac{V_{crop}}{V_{irrigation}} \times 100$$ where E_a = irrigation (or application) efficiency

Item	Section	Page	Line	Comment	Response
					[percent], V_{crop} = volume of water required by crop [L^3], and $V_{irrigation}$ = volume of irrigation water delivered to the field [L^3]. If an irrigation delivery system is 100-percent efficient (E_a = 100), the volume of water delivered to a field during an irrigation period is just that volume of water required to sustain crop growth in an unstressed state. Lower efficiencies indicate that more water is being delivered to a field than is required to sustain the crop. The excess water contributes to seepage, runoff, or direct evaporation (plants cannot evapotranspire more water than they take in through their root system). For the purpose of subsequent discussion, we assume that evaporative losses are minimal (evaporation rates from tilled earth are typically low, as compared with crop evapotranspiration); therefore, in the absence of significant runoff, all water in excess of that required to sustain plant growth percolates to the groundwater system as seepage losses from irrigation. Most surface irrigation systems have efficiencies ranging from less than 50 percent to about 80 percent. The most efficient surface distribution systems, based on center-pivot sprinklers, have efficiencies of about 85 percent. By contrast, furrow

Item	Section	Page	Line	Comment	Response
					(flood) irrigation systems are the least efficient, with a typical furrow irrigation systems having an efficiency of about 45 percent. Therefore, more than one-half the water delivered to irrigated agriculture in the Tracy Annex and surrounding areas probably has percolated to the water table. Row crops in California typically require application of about 30 to more than 48 inches of water to sustain plant growth during a typical growing season. Therefore, if the irrigation efficiency is less than 50 percent, approximately 6 to 8 feet of water per acre is applied to an individual field; and approximately 3 to 4 feet of water per acre (about 3 to 4 acre-feet, or 130,000 to 175,000 gallons per acre) percolates to the groundwater table each growing season. Introduction of substantial volumes of water to the groundwater system via seepage losses from irrigated agriculture therefore is likely to have some perceptible hydrologic effects. The lateral widening of the COC plumes beneath the Annex relative to their geometries on-Depot and beneath un-irrigated areas of the Annex seems to provide some evidence of this phenomenon.
17	2	2-31	24	The agricultural and commercial wells in the vicinity of the DDJC-Tracy site have been cataloged. No commercial or irrigation wells are known to be operating to the south of DDJC-Tracy to draw the plume southward. Did the RPO	The referenced commercial wells (PW002 and PW003) are located east of DDJC-Tracy (not southeast, as stated in the draft report). Per discussions at the March 14, 2001 RPO meeting, apparently at least one commercial well (at Pioneer)

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				team confirm a different condition? The lack of operating DDJC extraction wells in this area and the placement of the southern galleries was designed to prevent drawing a known contaminant plume at the All Pure Chemical site toward DDJC-Tracy.	and one new residential well may be operating in this area. The text will be revised to clarify this issue.
18	3	3-5	25	The WDR allows discharge to either the storm pond or the sewage lagoons. However, the regulatory agencies discourage these options and would allow discharge only with limitations.	See response to Comment 5.
		3-6	3	Treatment plant effluent is not discharged to the sewage lagoons. No discharge conveyance exists and the addition of treated groundwater is discouraged due to regulatory and technical reasons. Some water was discharged in July and August 1999 on an interim basis to facilitate construction modifications to the TP-1 system. No other discharge has occurred. This is not routine nor desired. The description should be revised to reflect the actual conditions of use.	See response to Comment 5.
			6	In fact there is an off-site discharge capability. The storm pond receives storm drain runoff from the industrial areas of the Depot. There is a pumping station that can discharge the storm pond water from the Depot to the irrigation canal and thence to the San Joaquin River system in emergency conditions of excess storm pond volume. This discharge is allowed under the conditions of the National NPDES permit. This section should be revised accordingly.	This correction will be made in the final report.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				Recently (January 2001) discussions with the agencies have been initiated to pursue an NPDES permitted discharge of groundwater off the DDJC property. Initial efforts are underway to address the regulatory and technical (conveyance) issues associated with this option. The off-site and overland flow disposal options are proposed to be included in a revised WDR application and Rod Amendment later this year.	Comment acknowledged.
19	3	3-12	20	Reference to the application of a 3-D model for vadose zone modeling by URS appears to be in error. All modeling for these SWMUs was completed during the remedial design phase for the existing SVE systems utilizing the VapourT computer model. The only modeling effort in progress is that being developed by the USACE Waterways Experiment Station and it is strictly a groundwater model development project. Determination of alternate cleanup standards were specified by the RWQCB and although the simplified application of Henry's Law was specified, it is understood that the criteria is consistent with the ROD cleanup level for groundwater of 5 ppb.	Concur. This reference, which should have been to a 2-D rather than a 3-D model, was based on a comment made by Steve Nohrstedt (CEHNC) on the RPO work plan in which Mr. Nohrstedt indicated that a 2-D modeling effort was being conducted by URS. Based on discussions at the March 2001 RPO meetings, the 2-D modeling effort referenced in the comment apparently was the VapourT simulations that were completed during SVE system design. The text will be revised accordingly.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
20	4	General		Generally, the discussion about mass removal and containment appears to be inter-mixed and little to no recognition is provided about the "non" operation period of many of the wells and the TP2 system in general. As an example, for EW014A, as identified on Page 4-41, second paragraph, focuses on how little mass is removed when this well has a containment function and is not intended for source control.	The containment discussion is presented in Section 4.2.2.3 and is referenced elsewhere in the extraction system evaluation, as appropriate. The non-operation or reduced operation of individual extraction wells is noted at the beginning of the evaluation in Section 4.2.1, is summarized in Table 4.5, and is referenced throughout Section 4.2 (e.g., see second paragraph of Section 4.2.2; all of Section 4.2.2.1; and the last sentence of the first paragraph on page 4-33). The partially operational status of the ETI system will be reiterated at the end of Section 4.2.2 (page 4-23) with the following statement: "Because the ETI system is not yet fully operational, results of this evaluation should be considered preliminary for the system as a whole, and for partially operational extraction wells." The sentence immediately preceding the one in which well EW014A is referenced specifically notes that mass removal is not the primary objective of wells installed for the purpose of containment (see lines 22-23, page 4-41). In fact, well EW014A is presented as an example to document the lower mass removal expected for containment wells.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
21	4	4-1	13	Specifically, though the ETI system has been operational for only 2 years, during these 2 years the system has yet to operate at full capacity for more than a few months and has yet to establish a steady state operating condition. Recommend this clarification be added to the text.	Concur. This point will be clarified in the referenced passage.
22	4.2.4	4-62	17	The stated capacity of the IG system, based on past performance, of 1,045 gpm, does not appear to be accurate based the current performance of the IG system in the winter of 2000.	The data presented were taken from the scale-up work plan for the overland flow pilot study. The recently observed decline in the performance of the infiltration galleries will be acknowledged in the final report.
23	4.2.4	4-63	2	The overland flow disposal pilot study was one month in duration, not one year, as stated in the text.	Concur. This typographical error will be corrected in the final RPO report.
24	4.2.4	4-64	15	The text notes that the overland flow system may not provide a benefit to plume control as water levels did not substantially change during the pilot test. However, in the current scale-up study test, we have noted that upper aquifer groundwater levels have increased approximately 3-4 feet in the area of the study, indicating the potential for plume control.	Comment acknowledged. Note that an increase of 3 to 4 feet in the water table in the vicinity of the northern infiltration galleries likely will further impair performance of those galleries. Based on the extent of PCE and TCE contamination in groundwater, as depicted in the 1999 AMR, the COC plumes do not appear to be migrating toward the northern IGs in the Upper horizon, which is the interval into which effluent

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
					is being infiltrated. The northernmost extensions of the plumes in the Middle horizon appear to be being contained by EW021A/026B.
			29	This section concludes by stating that the existing infiltration gallery (IG) system should have adequate capacity to dispose of treated groundwater, and that the overland flow system may not be necessary to supplement the IG system. This does not appear to be the case based on current operations. The IG system appears to be unable to handle current rates of treated groundwater, in part due to suspected scaling problems. The current full scale study period will operate for one year (through December 2001) and the reduced capacity of the IG system is currently being investigated. In the fall of 2001, data will be available to fully evaluate the viability and need for the overland flow disposal system.	Concur. As the draft report notes, the long-term effects of overland flow discharge on the water table, on flood irrigation in the adjoining fields, on infiltration gallery capacity, and on permeability of the soils within the test cells will be assessed during the 1-year pilot test. During a tour of the overland flow plot on March 14, 2001, no effluent was being discharged due to a shut down of TP-2, and during the few weeks since the pilot study began, effluent had been sufficient to cover only about one-third of the first of four discharge cells. Mr. Dale Clemens (DDJC-Tracy) indicated that the system is still in the proveout/optimization phase.
25	5	5-17	5-6	The WDRs need to additionally be revised to allow discharge to the overland flow system.	The report will be revised to indicate that WDR revisions are being considered for overland flow effluent disposal, pending final concurrence on the ESD and ROD amendment (currently in preparation).

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
26	5 & Exec. Summary	General		The following comments apply to the discussion in Section 5 and the table summarizing the RPO Phase II Report Recommendations Tables in Section 5 and the ES. Estimated Cost to Implement – It is evident that the costs in the far right column in the Table must be placeholders in virtually all cases. The cost to implement most of the recommendations is far greater than the nominal amounts indicated. The cost of labor to negotiate the changes with regulatory agency personnel alone will exceed the estimates provided in cases requiring agency concurrence or approval. Also, in some cases, technical implementation costs are required and seem low, e.g. Recommendation 11. If the estimates are not placeholders, recommend that a full evaluation of the implementation costs include all elements of cost, including agency negotiation and documentation preparation as needed.	Per DLA, negotiation of changes with regulatory agencies is a DLA/DDC function. Therefore, contactor labor hours were not considered in the estimated costs to implement. The costs for Recommendation 11 are based on minor retrofitting of TP plumbing to allow addition of AQUA MAG™ to the effluent stream. Based on discussions at the recent RPO briefing at DDJC-Tracy, an earlier scaling study conducted tests using AQUA MAG and found it to be effective at the DDJC-Tracy TPs. The earlier scaling study currently is being updated. Therefore, costs to assess the effectiveness/feasibility of altering current scale control methods are already funded, and are excluded from the estimated cost to implement. Nonetheless, it is acknowledged that all costs presented, including the estimated annual cost savings for each recommendation, are at best order-of-magnitude estimates and are intended to demonstrate relative potential cost savings rather than specific costs. This caveat will be added to the footnotes for Tables ES-1 and 5.1.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
27	5 & Exec. Summary	Recommenda-tion 1		As stated in Comment Item 4, the proposed consolidation of the Upper, Middle and Lower horizons may have merit at initial review, however, the discontinuous nature of the depositional environment of the entire San Joaquin Valley would fall into this category, in general. The occurrence of contaminants and the resulting plumes require placement of monitoring wells and extraction wells with screens in the appropriate horizon, regardless of how the hydrogeology is conceptually presented. Treating the entire "below Above Upper" units as one unit suggests that assessment of vertical migration is of diminished importance – a position to which the regulatory agencies would likely take exception.	See response to comment 13.
28	5 & Exec. Summary	Recommenda-tion 2		Evaluation and characterization efforts downgradient of SWMU (DSERTS) 68, while useful additional data, has provided no further understanding than previously understood by investigation efforts conducted over 5 years ago. However, additional data may also be available from the All Pure Chemical investigation efforts believed to be underway. Additional characterization data has been planned for the past few years for the east side of Banta Road, but lack of real estate access has prevented the installation of planned monitoring wells in this area. The pursuit of real estate access is ongoing under conditions of	Non-concur. Per the content of comment 4, and based on contouring of the COC contaminant plumes centered on well LM032AU, as presented in the ARMs, the data provided by the RPO sampling are, in fact, valuable, and have contributed to clarifying the extent and source magnitude of the DSERTS 68 plume. As noted in the response to Comment 4, the location of the DSERTS 68 groundwater hot spot is sufficiently distant (about 0.5 mile) from the All Pure/Pioneer facility that placement of an extraction well, screened in the shallow saturated zone (i.e., the AU horizon), at this hot spot would not create a gradient sufficient to encourage migration

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				an uncooperative landowner. It appears that the RPO team may have overlooked a review of the original system design that utilized the beneficial effects of the Southern Infiltration galleries and the conscious avoidance of extraction well placement in this area. Recently however, infiltration gallery performance has been problematical due to reduced capacity. As the reasons for this are evaluated, the potential need to re-evaluate the design intention of the southern gallery influence on the DSERTS 68 area will be confirmed.	of contamination associated with the All Pure/Pioneer source. Also, the migration path from the apparent DSERTS 68 main source area suggests that the plume is not migrating toward the southern IGs, but rather would likely be intercepted by the southernmost extraction wells along Banta Road (north of the IGs). Installation of an extraction well to remove COC mass at the hot spot could help prevent migration of contamination from this source to the boundary wells. However, there may be a secondary source of TCE/PCE southeast of DSERTS 68 (e.g., as evidenced by FY99 COC detections at LM035AU, LM017AA, and LM119A) that could be contributing to the southeastern-most extension of the COC plume onto the Annex (i.e., closer to the southern IGs). We therefore concur that loss of the IG hydraulic barrier intended to deflect eastward-migrating contamination to the north could be of some concern.
				Evaluation of the East Annex area downgradient of the Tracy Annex is an on-going effort. Access to public right-of-way has been secured but full access to private ,and areas is pending real estate negotiations. The optimization efforts, as noted, are incorporated as part of the current program strategy.	Comment acknowledged.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
29	5 & Exec. Summary	Recommenda-tion 3		This alternative method may provide additional value. The difficulty of implementation however, should be considered "moderate" as it will require regulatory concurrence. Cost of implementation will be much higher due to this moderate difficulty.	Non-concur. The method of data presentation may require regulatory concurrence, but as long as the presentation is accurate, it is unclear what additional costs would be incurred in efforts to persuade the regulators. Because the method presented is flexible, it could be used to present data in series (by monitoring event) for variables of concern to the regulators.
30	5 & Exec. Summary	Recommenda-tion 4		No comment.	No response required.
31	5 & Exec. Summary	Recommenda-tion 5		This recommendation is already contracted and will be implemented. The recommended strategy for SVE system operation is already incorporated as part of the design and operation plan. An optimization work plan will be prepared for regulatory and DDJC concurrence that will include focused extraction among other actions in support of an efficient close-out strategy. This process is consistent with actions completed at DDJC-Sharpe.	Concur.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
32	5 & Exec. Summary	Recommenda-tion 6		Vapor phase carbon application has been used for both the Tracy SVE system design as well as the Sharpe SVE systems. It is already understood that it's use is potentially not required due to discharge limitations and is in-place as a policy decision by DDJC. However, it's initial use is a preventative measure to ensure against unexpected conditions (i.e., higher VOC concentrations) and it's continued use does not present the cost liability as estimated in the RPO report. Carbon use at the Sharpe facility, operating the same SVE trailer system in use at Tracy on a total of five SVE sites, has been limited to one disposal event, amounting to a cost of less than $5,000 in a total of two-plus years of operation.	Concur that the initial use of GAC vapor treatment during SVE proveout is an appropriately conservative measure. The low cost for GAC at DDJC-Sharpe likely is a result of the low VOC concentrations encountered, and the low VOC mass removed. These low numbers underscore the rationale for eliminating this treatment process once prove out confirms that VOC emissions from the SVE systems are within regulatory limits.
33	5 & Exec. Summary	Recommenda-tion 7		Concur that passive "barometric" pumping of the SVE sites during periods of "rebound" would be of potential benefit. The implementation difficulty should be considered Low requiring regulatory concurrence, not approval.	The recommended revision will be made in the final RPO report.
34	5 & Exec. Summary	Recommenda-tion 8		Concur with contaminant trend monitoring at well heads, combined with assessment of "containment", a practice already utilized in the current annual monitoring program. This recommendation is partially implemented as 4	Concur that a phased approach to reducing the numbers of extraction wells and the volume of groundwater extracted may be appropriate, particularly along Banta Road. However, because 1) available data indicate that significant COC mass

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				extraction wells have been recommended to be taken off-line with regulatory concurrence. However, due to the lack of steady state operation of the majority of existing extraction well systems due to significant equipment and original construction deficiencies, convincing operational data is limited to broaden the implementation. Upon successful demonstration of capture to the regulatory agencies, optimization with further elimination of extraction wells can be negotiated.	(i.e., at concentrations above the ACLs) is not migrating past the northernmost of the Banta Road wells; 2) monitoring wells upgradient from the boundary extraction wells can serve as sentry wells for detecting elevated plume concentrations migrating toward Banta Road; and 3) rebound monitoring rather than shut- down is recommended, there should be opportunities for reducing the extraction of "clean" groundwater at the wells identified in Table 5.2 without jeopardizing attainment of ROD objectives. Because numerous wells in the extraction system have been out of operation for extended periods of time, these operational hiatuses provide rebound data that strengthen the arguments for suspension of pumping at the identified wells while maintaining a vigilant monitoring program.
35	5 & Exec. Summary	Recommenda-tion 9		Non-concur. The area associated with SWMU 68 (more correctly DSERTS 68 or Area 3 – this site was not formally identified as a SWMU) was addressed in the RI phase and is included in the groundwater modeling system evaluation (Montgomery- Watson , Aug 1995) . This area was designed to be contained by the Southern Infiltration Gallery system (infiltration at the southern galleries was designed to create a gradient to encourage migration in this area northeastward) with removal by the downgradient extraction well system	See response to comments 4 and 28.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				located north of the gallery system. Furthermore, due to the proximity to the All Pure Chemical Company groundwater contaminant plumes, any extraction in this vicinity was considered to be detrimental. This consideration is acknowledged by the RPO Phase II Report as a potential effect in paragraph 2.3.2.2, page 2-31, line 26.	
36	5 & Exec. Summary	Recommenda-tion 10		As previously noted, the intermittent and limited operation of many treatment system components, including extraction wells has prevented acquisition of a full data set to fully evaluate system performance. This recommendation is also predicated on the assumption of reduced flow and mass removal. Future use of aqueous phase carbon may have value once adequate data is acquired to support it's implementation and agency concurrence. The original design also envisioned that the OU1 system will be altered to combine the TP1 flow into the TP2 system at such time as the effectiveness of the TP1 is no longer realized. The hydraulic capability has been designed into the system.	Comment acknowledged.
37	5 & Exec. Summary	Recommenda-tion 11		Concur - sequestration has been identified and recommended for use in all DDJC air stripping systems in the 1996 scale study at the DDJC-Sharpe facility (Radian,	The AQUA MAG™ cost data from the pilot test will be noted in the discussion in Section 4.2.3.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				1996). Aqua Mag™ was utilized in a 9-month pilot test on the TP1 system in 1997 and proved effective. The implementation cost is significantly low – the annual expense for product is expected to be in the $30K range. An update to the scale study is currently underway.	
38	5 & Exec. Summary	Recommenda-tion 12		This recommendation should be revised to recognize the need for WDR revision to allow an off-site discharge under an NPDES permit and overland flow disposal. These options have already been discussed with the agencies with tentative agreement on the possibility of favorable consideration. The option of sewage lagoon disposal is not desired due to the potential for negative plume impact. Difficulty of implementation is moderate due to the need for regulatory approval.	Concur. See responses to Comments 18 and 25.
39	5 & Exec. Summary	Recommenda-tion 13		This initiative has been performed at the DDJC-Sharpe site in previous years. It was performed with regulatory concurrence once a steady state condition was reached with the groundwater treatment systems operating. The steady state condition has not yet been reached at DDJC—Tracy , but a monitoring network optimization is planned when operating conditions will support the effort. Implementation	Concur that the timing of the optimization evaluation can be scheduled to coincide with improved ETI system operating conditions, which should better support the effort. The difficulty of implementation will be revised as suggested.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				difficulty has been shown (at DDJC-Sharpe) to be low, but regulatory concurrence (not approval) is necessary for greatest benefit.	
40	5 & Exec. Summary	Recommenda-tion 14		It is important to realize that there has been no maintenance costs associated with the low flow systems in two years of operation and the systems are under a 10 year warrantee. The cost analysis should fully consider the extremely low cost impact of operating the low flow systems to-date and fully evaluate the labor time spent at each well using each technology. Also, based on past applications of diffusion sampling systems, the agencies are likely to demand a more formal pilot study than that performed as part of the RPO effort which should be included in the implementation costs.	The cost estimates provided in the RPO report were based on available data. Actual costs incurred for sampling using the low-flow method should be compiled for comparison to the diffusion sampler costs presented to more accurately assess potential cost savings. A large-scale pilot study of the use of passive diffusion samplers for VOC sampling is planned for DDJC-Sharpe during 2001. The results of this study should provide the necessary data to satisfy regulatory concerns with the method at both Sharpe and Tracy, given the similarities in well construction, target analytes, monitoring programs, and current sampling methods at the two DDJC facilities.
41	5 & Exec. Summary	Recommenda-tion 15		A market survey and laboratory audit are currently performed each year. The market survey reviews the costs of a number of laboratories certified to perform USACE work in California and evaluates the span of analytical methods needed 9not just VOCs) as well as all elements of service, to include data delivery and sample handling performance, data validation and QAPP compliance	Comment acknowledged; no response required.

DEFENSE LOGISTICS AGENCY
RESPONSE TO URS COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: URS Corporation (Prepared by Randy Marx, Bob Pedlar, Mike Thomas, & Graham Sharpe; submitted 03/02/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted 04/12/01)

Item	Section	Page	Line	Comment	Response
				experience, and other past performance criteria. Based on this broad based cost and performance assessment, the current laboratory has been found to be competitive. The annual audit is performed by both prime contractor and government personnel.	

References Cited

Heerman, D.F., Wallender, W.W., and M.G. Bos. 1990. Irrigation efficiency and uniformity, in *Management of Farm Irrigation Systems*, Hoffman, G.J., Howell, T.A., and K.H. Solomon, eds. American Society of Agricultural Engineering Monograph.

Yonts, C.D., and N.L. Klocke. 1985. *Irrigation Scheduling Using Crop Water Use Data*. USDA Soil Conservation Service Nebraska Irrigation Guide. July.

DEFENSE LOGISTICS AGENCY
RESPONSE TO USACE COMMENTS

REVIEWERS: STEVE NOHRSTEDT, BILL CRAVEN, & MORGAN RUTHER

DEFENSE LOGISTICS AGENCY
RESPONSE TO USACE COMMENTS

SITE: DDJC-Tracy

DOCUMENT: Draft Remedial Process Optimization Phase II Evaluation Report for the Tracy Defense Distribution Depot, San Joaquin, California - February 2001

REVIEWER: USACE CEHNC (Prepared by Steve Nohrstedt, Bill Craven, & Morgan Ruther; submitted 3/09/01)

RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.; submitted on 04/12/01)

Item	Section	Page	Line	Comment	Response
1	General			We have reviewed the report and feel many of the recommendations relate to strategies that are already being used, many represent a wish list that will only work with regulatory approval, and a few represent a new approach which may represent actual additional savings for DDJC.	Comment acknowledged; see responses to specific comments from URS.
2	ES-7 & ES-8	Table ES.1	All	This table should be split into two tables, one which contains recommendations which DDJC has control over and another which contains recommendations which are ultimately controlled by the regulatory agencies. This would allow DDJC to easily see cost savings that are obtainable by their action versus the costs associated with attempting to get regulatory approval which may never happen. The recommendations that don't need regulatory approval should further be separated into actions which are already being used or are planned to be implemented, which most are, or those which are new concepts and could be implemented. Table ES.1 as presented shows the potential for large savings which does not exist in reality.	Final determination of which recommendations require regulatory concurrence/acceptance will be made by DLA and the agencies. Because the decision process likely will be ongoing (i.e., will continue beyond the date that the RPO report will be finalized), the table will not be revised to segregate DDJC and regulatory decisions. However, revisions will be made in accordance with the responses to specific comments provided by URS. The CEHNC reviewers are referred to responses to those comments.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

REVIEWER: MICHAEL FINCH

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
The Geologic Services Unit (GSU) of the Sacramento Office of the Department of Toxic Substances Control (DTSC) was asked to review the Draft remedial Process Optimization Phase II Evaluation Report (Report) for the Tracy Defense Distribution Depot San Joaquin, California, dated February, 2001 and prepared by Parsons Engineering Science. The following are the technical comments of the GSU.					
1	General			The GSU agrees with the overall goals of the Report of ground water extraction optimization at the Tracy Defense Distribution Depot (Site), however, the GSU considers contamination plume containment equally important as optimization of volatile organic compound (VOC) mass removal. The Report did not provide a detailed capture zone analysis, which is essential for determining plume containment. Recommendation: Provide/conduct a detailed capture zone analysis prior to any recommendations for extraction well shutdown or removal.	DLA concurs that optimization of mass removal and containment of groundwater contamination by the groundwater ETI system, as required in the facility ROD, are equally important objectives. The RPO Phase II evaluation is, by design, a third-party review of available site information prepared by others for DDJC-Tracy. The draft report is intended for use primarily by DLA and DDC as a strategy document for improving the effectiveness and efficiency of remedial systems operating at the Depot, and therefore assumes that the reviewers have a fairly intimate familiarity with the environmental restoration program and ROD compliance documents. For this reason, the report relies heavily on citation of documents included in the Administrative Record, and reviewed by the regulating authorities (i.e., DTSC, the Central Valley RWQCB, and USEPA Region 9). This approach avoids cumbersome redundancy of presentation for study results provided in full detail in other reports.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
					For DDJC-Tracy, the incumbent environmental contractor, URS Corporation, conducts capture-zone analyses on extraction wells annually, and presents their results in the Annual Monitoring Reports (ARMs) for groundwater. The wells selected for annual analysis presumably are chosen in concert with the facility RPMs. At the time the RPO evaluation for DDJC-Tracy commenced, the most complete available recent information on capture zones for the groundwater extraction system was presented in the 1999 ARM. These data are the basis for discussion in the RPO report, and the source document, which has been reviewed by DTSC, RWQCB, and USEPA, is liberally cited. Since the RPO effort began, the 2000 ARM has been released by URS. The reviewer is referred to those ARMs for complete information on capture-zone analyses. However, the RPO report also noted that until the downgradient extent of the dissolved TCE plume is characterized, the effectiveness of the current extraction system for plume containment cannot be fully assessed (e.g., see third paragraph on page 4-26 of the draft RPO report).

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
2	General			The GSU strongly agrees with the report that the full extent of contamination PCE and TCE be determined to the east of the Site. Normally, except for interim or emergency response measures, the GSU does not recommend beginning any ground water extraction before the full and complete three dimensional characterization of all Site related contamination, including soil, vadoze zone (soil vapor), and ground water (all water-bearing zones). Recommendation: Complete a full site-wide assessment of all contamination (soil, vadose, and water--both ground and surface) before recommending any changes to the current ground water extraction system. This characterization should be conducted for all possible site-related contamination to non-detect levels (not to MCLs or cleanup standards) and should be conducted in all directions, not just to the east. Alternatively, background or upgradinet levels are acceptable if a complete background or up-gradient constituent level report is agreed to by the GSU. Any claims	The remedies for source areas and for OU1 groundwater at DDJC-Tracy are specified in the 1998 Comprehensive Site-Wide ROD, and were based on characterization information available at that time. As additional information becomes available through compliance monitoring or in the course of remediation, remedy (or cleanup goal) modifications are considered by the RPMs, and when appropriate, an ESD or a ROD amendment may be prepared. An example of such a case is revision of the remedy for SWMU 4 (stormwater retention pond) based on the recent ecological risk assessment (see Section 3.2 of the draft RPO report). The 1998 ROD incorporates natural attenuation as the remedy for the downgradient, off-Annex extension of the dissolved TCE plume thought to be sourced at DDJC-Tracy. It was only recently ascertained that dissolved VOC contamination downgradient from Banta Road appears to be more extensive than was previously thought. URS is in the process of collecting supplemental data to define the downgradient extent of TCE contamination. The RPO report suggests the potential for additional sources of TCE east of Banta Road, based on hydrogeologic and contaminant data.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
				of off-site sources for contamination require complete detailed three-dimensional analysis before acceptance by the GSU.	
3	General			Water supply wells often contribute to the spread of ground water contamination into deeper water-bearing zones. The GSU notes that contamination appears to deeper zones as it moves further off-site. Recommendation: Conduct or re-conduct a production well canvass of all current and former production wells at or down-gradient of the Site. Improperly decommissioned wells can also act as contamination conduits. Recently, the GSU discovered several previously unknown former production wells at two defense sites (Mather Field and Mare Island) by examining records at the Department of Water Resources.	URS monitors accessible private wells as part of the groundwater-monitoring program. DDJC-Tracy was recently made aware of a new private well that has been installed east of the Depot, north of the All Pure/Pioneer chemical plant.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
4	General			The GSU agrees with contaminant rebound studies for soil gas and ground water contamination. Rebound of ground water contamination should be conducted after providing a detailed ground water capture zone analysis with the goal of stabilizing contamination plumes, and after completing a full three-dimensional assessment of ground water contamination. Recommendation: Conduct ground water contamination rebound studies after completing the full extent of ground water contamination and providing the GSU with an adequate plume capture zone analysis.	Concur. Also see response to General Comment 1 regarding the availability of capture-zone analyses.
5	General			Because this Site contains both VOC soil gas and ground water contamination and appears to have fairly corse-grained surface soils, air sparging should be considered as a remedial option. Recommendation: Consider air sparging, perhaps using existing ground water wells.	See response to General Comment 2 regarding remedy selection and modification. Currently, SVE is the selected remedy for vadose-zone soils at DSERTS 68, and groundwater ETI is the remedy for groundwater. The RPO report recommends installing a new groundwater extraction well at the DSERTS 68 source area to reduce continuing impacts on groundwater.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
6	General			The GSU does not consider dilution and dispersion of contamination to be "Natural Attenuation" of contamination especially when potential off-site sources of similar compounds can have additive effects on ground water quality. The GSU considers "Natural Attenuation" to involve the complete removal or destruction of the chemical constituent. Recommendation: The Report should not consider dilution or dispersion as methods of "Natural Attenuation."	The USEPA (1998) definition of natural attenuation includes both destructive and nondestructive processes that limit the mass, persistence, or mobility of chemicals in the subsurface. The DDJC-Tracy Comprehensive ROD (page 9-3, paragraph 9.5.3) documents the decision, approved by parties to the FFA on 29 January 1996, to expand the ETI remedy for OU1 groundwater to include "dispersion" for "the TCE and PCE plume east of Banta Road."
7	General			Normally, the GSU does not recommend beginning micro-purging sampling methods until full and complete site characterization. Diffusion sampling methods go even a step beyond micro purging methods and require even more detailed site-wide contamination assessment. Furthermore, diffusion sampling methods are not appropriate for all chemical constituents, and are	The potential benefits and deficiencies of diffusion sampling are reviewed in the draft RPO report (Section 4.3.3.5). DLA respectfully disagrees that use of diffusion sampling for VOCs is dependent on the degree of characterization of VOCs at a given facility, and believes that this technology can provide a useful and cost-effective means of monitoring VOCs in groundwater.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
				new to the industry and not as fully understood as conventional ground water sampling methods. Recommendation: The GSU does not recommend using diffusion sampling methods at this Site except for pure scientific research purposes.	
8	General			One alternative to disposing of treated ground water in infiltration galleries that keep clogging, is blending the treated water with standard irrigation water used by the local agricultural community. The GSU is aware of possible adverse affects from excessive naturally occurring boron and TDS, however, blending the treated ground water with existing supplies can provide supplemental irrigation water. This reviewer, who himself is involved in extensive farming in Colusa and Yolo Counties, would welcome any free supplemental water in these times of rising costs.	Alternative effluent disposal methods are the subject of intensive, ongoing research. An ESD currently is being prepared by URS to incorporate viable options, as determined based on the research to date, for managing/disposing of treated groundwater.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
				Recommendation: Approach local irrigation districts and individual growers with the prospect of free supplemental treated irrigation water to blend with their existing supplies.	
1	Detailed			State law and regulation (Geologists and Geophysics Act) requires all geologic reports to be signed by a California Registered Geologist even if draft. The exception of the federal government from meeting state licensing requirements applies only to actual federal employees and not to private consultants working for the federal government such as Parsons Engineering Science. Recommendation: The Report should be signed by a California Registered Geologist.	A Geologist registered in the State of California will sign the final version of the RPO evaluation report. Mr. John Anthony, R.G. (#6127) will sign the report.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
2	Detailed			The GSU notes that given the average ground water velocity of 464 feet/year for the Middle water-bearing zone as stated on Table 2.1, contamination could have gone more than five miles down gradient since the Annex opened. Recommendation: Full site ground water characterization should have the first priority before recommending any changes to the extraction system.	If contaminants were released directly into the Middle horizon in 1941, if the horizon were a homogeneous matrix, and if natural attenuation and chemical-specific factors are ignored, it would be conceivable that solutes could have traveled the distance noted in the comment. However, the hydrogeology of the known source areas located on the Depot suggests that contaminants were released into the upper saturated intervals (i.e., the Above Upper and possibly the Upper horizons). The uppermost portion of the saturated zone beneath the Depot has lower hydraulic conductivity due to finer-grained sediments. This would have delayed penetration of contaminants, likely released episodically from multiple sources over the course of decades, to the more permeable saturated layers. As noted in Section 2 of the RPO report, even the "more permeable" zones are highly heterogeneous, and contaminant migration likely is affected by a multitude of cultural/temporal, physical, and geochemical factors.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
3	2	2-21		On page 2-21 the GSU noted that soil samples for VOCs did not use encore, methanol or similar preservation methods. The GSU has found that soil cores that did not observe these methods (or an on-site mobile laboratory) can loose up to 50% of their original VOC components. Recommendation: Use encore, methanol (or similar field preservative) or have an on-site mobile laboratory for all future soil characterization. Given that up to 50% of the VOC contaminates may have been lost, the full extent of soil contamination should be revisited.	The method of soil sample collection using capped sections of polybuterate Geoprobe liners was described in the RPO work plan. This method is typically considered acceptable for collection of soil samples for VOC analysis as the samples are not disturbed by transfer to a separate sample container in the field, and thus handling (and the potential for loss of VOCs) before laboratory processing and analysis is minimized.
4	2	2-25 & 2-26		On Figures 2.10 and 2.11 the extent of TCE and PCE in ground water is shown without plotting the extraction wells on the same figures. Also a capture zone analysis is missing for the extraction wells. Recommendation: Provide the location of extraction wells on the figures and a capture zone analysis for the ground water extraction system.	As cited in the draft report, these figures were taken from the 1999 ARM. Additional graphics provided in that report (e.g., the figures presented in Section 4.3) display the distribution of groundwater contaminants relative to extraction wells. Also see response to General Comment 1 regarding capture-zone analyses.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
5	2 & 3	2-33 & 3-11		On page 3-11 the Report includes chemical and biological degradation as natural attenuation mechanisms that are working at the Site, yet on page 2-33 the Report gives a low potential for chemical and biological degradation at the Site. The GSU agrees that there is a low potential for chemical and biological degradation, and that (as stated in the General Comments above) dilution and dispersion are not "Natural Attenuation." Also the low numbers for TOC suggest a low potential for soil sorbtion. Only volatilization appears to be a significant natural attenuation mechanism at the Site. Recommendation: Change the Report to state that only volatilization appears to be a significant natural attenuation mechanism at the Site.	The passage cited on page 3-11 is a listing of all attenuation processes that "are capable" of reducing contaminant mass or mobility; this statement is general, and is taken from the USEPA (1998) natural attenuation protocol document. Conversely, the discussion beginning on page 2-33 is specific to DDJC-Tracy, and is based on an evaluation of site-specific indicator parameters as presented in Table 2.2 of the report. The effect of the low measured TOC is noted on page 2-39 (lines 23-25). Also see response to General Comment 6.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
6	3	3-14		The GSU agrees with pulsed operation and rebound studies of soil gas contamination as stated on page 3-14. Recommendation: Propose a detailed plan for soil gas rebound study and pulsed soil vapor extraction.	URS will prepared plans for SVE system optimization as performance data from system operation become available.
7	4	4-5 & 4-6		Tables 4.1 through 4.4 give design extraction rates and costs for SVE systems. These figures should be checked by a qualified DTSC engineer. Recommendation: Have a DTSC engineer check tables 4.1 through 4.4.	Design data were taken from the 100-percent SVE design document prepared by URS (Radian, 2000). The design document was reviewed and accepted by the regulatory RPMs.
8	4	4-19		On page 4-19 the Report should consider using one-way air check valves (“Barro Balls”) as air injection points in the SVE system. Recommendation: Consider the use of “Barro Balls” in the SVE system.	The use of such check valves is recommended for consideration on page 4-19 (line20). This recommendation will be passed along to URS for their consideration.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
9	4	4-22		Page 4-22 lists extraction wells EW005AU, EW009A, EW007A, and EW009B as not operable but gives no reason. Likewise page 4-23 lists other inoperable extraction wells: EW001AU, EW036AU, EW033AU, EW035AU, and EW037AU. Some of these points also correspond to high values for contamination and should be either put on-line or replaced. Recommendation: The report should give the reasons that extraction wells are inoperable, and these wells should be brought on-line or replaced when high contamination levels are detected.	The information presented was taken from documents available for review during the RPO evaluation. Reasons for the inoperable status of extractions wells were not always provided in the referenced material. This comment should be referred to URS for resolution. As noted in Section 4 and summarized in Table 5.2, we concur that some inactive wells (i.e., EW009B and EW033AU) should be turned on to enhance attainment of ROD objectives.
10	4	4-26		Page 4-26 mentions a capture zone analysis that is not included in the Report. The elements of the capture zone analysis should be an essential part of any report that attempts to optimize a site"s ground water extraction system. Recommendation: Include a complete capture Zone analysis in the Report.	See response to General Comment 1.

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
11	4	4-27		Page 4-27 the GSU disagrees with the Report that the remedial objectives are being achieved through natural attenuation and the assertion that "...it can be inferred that the contamination RAO is being achieved if on-Annex contamination is no longer contributing to off-Annex TCE contamination." The report has not made this demonstration and this statement should be deleted. Recommendation: Delete the above statement from the Report.	The passage cited is a conditional one, and thus is not incorrect. The inference in fact can be made if on-Annex contamination is not migrating east of Banta Road. The report notes in several places that a full assessment of the effectiveness of plume containment by the Banta Road extraction well network cannot be made until the downgradient extent of contamination is more thoroughly characterized. Nonetheless, data collected during monitoring of both monitoring and extraction wells upgradient from and along Banta Road demonstrate that contaminant concentrations at these locations are low, and when TCE concentrations greater than the ACL were detected along Banta Road, data for immediately downgradient wells were consistently below ACLs (e.g., see Figures 2.18 and 2.19). The apparent discontinuity between the on-Annex TCE plume and the TCE detected 0.25 mile east of Banta Road (see Figure 2.18 of the draft report) is noted as suspicious, given the hydrogeology of the area, and further investigation of the plume in this area is recommended (and underway by URS).

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
12	4	4-27		On page 4-27 the GSU disagrees that "Analysis of plume capture by existing wells along the northern Depot boundary will not provide useful information for assessing ROD compliance, as the plumes extend beyond this point and COC concentrations at these wells are declining." A complete capture zone analysis must be the key feature of any recommendation to modify or remove existing ground water extraction systems. Recommendation: Delete the above statement from the Report.	See response to General Comment 1. Per the 3Q99 capture analysis presented in the 1999 ARM, there appears to be capture redundancy in all horizons downgradient from all boundary extraction wells, and capture-zone analysis for the wells further downgradient would be more relevant for optimizing the system than continued analysis of capture by most wells along the boundary. Moreover, the FY99 ARM (Radian, 2000; paragraph 5.6.2) recommends shut down of three of the northern Depot boundary wells (EW003, EW004AU, and EW008A) because flow from these wells was thought to be diluting COC influent concentrations to TP-1. The RPO review of COC monitoring data indicated that PCE, TCE, and/or dieldrin concentrations had exceeded the ACLs at two of these wells (EW003 and EW004AU) in the 12-month period from 4Q99 through 3Q00. Because these two wells are achieving some degree of mass removal, it was inferred that URS's recommendation to shut these boundary wells down reflected a position that COCs migrating past these wells (i.e., past the northern Depot boundary) at concentrations greater than the ACLs would be intercepted by downgradient extraction wells (e.g., Above Upper wells EW032AU and, once they are on line, the new EW040AU, EW041AU, EW043AU, and EW044AU, and Upper well EW022A).

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
13	4	4-41		On page 4-41 lines 14 through 16 should be reworded to state that 39% of the ground water pumped was below cleanup standards. The water may still need to be pumped for contaminant containment. Recommendation: Reword lines 14 through 16 on page 4-41 of the Report.	The cited passage indicates that 39 percent of groundwater extracted in FY99 "did not need to be pumped for treatment of COCs." Comparison of the data presented on Figures 4.7 (average extraction rates per well), 4.9 (relative TCE mass removal by well), and 4.11 (estimated volume of extracted water to remove 1 lb of TCE) clearly shows that the least efficient well for mass removal (i.e., and groundwater with COC concentrations requiring treatment) are in fact the Banta Road boundary wells (EW014A – EW019A), which were installed primarily for containment.
14	5	5-7		Page 5-7 recommends changing the soil vapor cleanup levels upwards without adequate justification. Recommendation: Delete Recommendation 4 on page 5-7 of the Report.	The justification for the recommendation is provided in considerable detail in Section 4.1 and Appendix C of the draft RPO report. Note that the recommendation does not promote any particular site-specific cleanup goals (including the ones developed in Appendix C using the Jury et al. model). Rather, the report presents evidence that use of site-specific parameters governing transport of contaminants in the vadose zone to develop site-specific cleanup goals is scientifically defensible, and likely would resulting in higher cleanup goals than those presented in the ROD, and therefore in shorter times to achieve

DEFENSE LOGISTICS AGENCY
RESPONSE TO DTSC-GSU COMMENTS

FACILITY: DDJC-Tracy

DOCUMENT: Draft RPO Phase II Evaluation Report

REVIEWER: California Department of Toxic Substances Control, Geological Services Unit (Comments prepared by Michael Finch)
RESPONDENT: DLA (Prepared by Parsons Engineering Science, Inc.)

Item	Section	Page(s)	Line(s)	Comment	Response
					cleanup (at lower cost).
15				Table 5.2 recommends abandoning and shutting down several extraction wells. Without an adequate capture zone analysis the GSU cannot support this recommendation. Recommendation: Delete well shut down and abandonment from Table 5.2.	See response to General Comment 1.
16				On page 5-18, the GSU disagrees with the use of diffusion samplers. Recommendation: Delete Recommendation 14 on page 5-18.	See response to General Comment 7.