Second Five-Year Review of Remedial Actions

Van Waters & Rogers Inc.
3301 Edmunds Street Site
Albuquerque, New Mexico

14 September 2000

PREPARED FOR
Van Waters & Rogers Inc.

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Figures

Tables

Tables (Continued)

Appendices

Appendices (Continued)

LIST OF ACRONYMS

1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
1,1,1-TCA	1,1,1-trichloroethane
AEHD	Albuquerque Environmental Health Department
AGC	American Groundwater Consultants
AG&M	ARCADIS Geraghty & Miller, Inc.
BTEX	benzene, toluene, ethylbenzene, xylene
DWMS	D'Appolonia Waste Management Services
EDB	ethylene dibromide
ELCR	excess life time cancer risk
G&M	Geraghty & Miller, Inc.
gpm	gallons per minute
HLA	Harding Lawson Associates, Inc.
MCLs	maximum contaminant levels
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
OVA	organic vapor analyzer
PCE	tetrachloroethene
PLC	programmable logic controller
ppb	parts per billion
PRPs	potentially responsible parties
RAP	remedial action plan
ROD	Record of Decision
scfm	standard cubic feet per minute
TCE	trichloroethene
TPHs	total petroleum hydrocarbons
µg/L	micrograms per liter
URM	Underground Resources Management
USEPA	United States Environmental Protection Agency
VES	vapor extraction system
VOCs	volatile organic compounds
VW&R	Van Waters & Rogers Inc.

EXECUTIVE SUMMARY

On behalf of Van Waters & Rogers Inc. (VW&R), ARCADIS Geraghty & Miller, Inc. (AG&M) has prepared this second five-year review of remedial actions at the VW&R facility located at 3301 Edmunds Street (the "site") in Albuquerque, New Mexico (Figure 1), as specified in Section VII paragraph 24 of the Consent Decree in the matter of the United States vs. Univar Corporation (USEPA, 1989). The purpose of this report is to summarize the remedial actions during the five year period since the previous five-year review completed November 8, 1995 (G&M, 1995), evaluate the effectiveness of the remedial action at meeting the remedial objectives, and show that the remedial action remains protective of public health and the environment, as agreed to by the United States Environmental Protection Agency (USEPA). This report summarizes the installation, operation, maintenance, and monitoring of the remedial system, the addition of the vapor extraction system (VES), and monitoring of the groundwater and presents all analytical and operation data collected during the five-year period from January 1995 through January 2000.

This five-year review was conducted pursuant to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) Section 121(c), 42 U.S.C. § 9621(c), the National Contingency Plan (NCP) (40 CFR § 300.430 (f)(4)(ii)), Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-02 (May 23, 1991), OSWER Directive 9355.7-02A (July 26, 1994), OSWER Directive 9355.7-03A (December 21, 1995), and draft OSWER Directive 9355.7-03B-P (draft Comprehensive Five-Year Review Guidance).

Section 121(c) of CERCLA requires that "*If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each 5 years after initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented.*" Under the NCP, the Federal regulations which implement CERCLA, USEPA is required to conduct five-year reviews of a remedial action whenever, under the remedial action, "*hazardous substances, pollutants, or contaminants are remaining at the site above levels that allow unlimited use and unrestricted exposure.*"

This five-year review has been approved by the Director of the Superfund Division, USEPA Region 6. Although CERCLA Section 121(c) authorizes "the President" to undertake five year reviews, the President's authority was delegated to the Administrator of the USEPA by Executive Order 12580 (52 Fed. Reg. 2926, January

29, 1987), and this authority was further delegated to the USEPA's Regional Administrators on September 13, 1987, by EPA Delegation No. 14-8-A. Finally, the authority was delegated to the Director of the Superfund Division by USEPA Region 6 Delegation No. R6-14-8-A on August 4, 1995.

The triggering action for this statutory review is the first five-year review, dated September 30, 1995. This review is required because hazardous substances, pollutants, or contaminants remain in the subsurface at concentrations that are above levels that allow for unrestricted use of groundwater and for unrestricted exposure to groundwater.

The remedial action for the site was designed as specified in the Record of Decision for the Edmunds Street Groundwater Operable Unit (USEPA, 1988c), and consists of pumping and treating groundwater to remediate impacts of the following site-related volatile organic compounds (VOCs): 1,1-dichloroethene (1,1-DCE); 1,1,1-trichloroethane (1,1,1-TCA); trichloroethene (TCE); and tetrachloroethene (PCE). The treated water is returned to the aquifer through an infiltration system. The objective of the remedial action is to reduce the concentrations of the site-related VOCs in the groundwater to concentrations which would pose an excess life-time cancer risk (ELCR) of less than one in one million (1×10^{-6}) should the groundwater be used as a drinking water supply. These treatment goals address the State of New Mexico Water Quality Control Commission (NMWQCC) regulations which govern discharges to the State's groundwater resources. The groundwater treatment system, which utilizes an aeration technology, was designed to reduce the concentrations of site-related VOCs in the absence of petroleum-related compounds. In addition to meeting the groundwater discharge criteria specified by the NMWQCC, air emissions associated with the groundwater treatment system must not exceed an ELCR of 1×10^{-6} under a prescribed exposure scenario, as required by the Albuquerque Environmental Health Department.

In addition to operation of the groundwater remedial system, the remedial action for the site includes a groundwater monitoring program, which was designed to monitor the effectiveness of the remedial action. This monitoring program also provides the necessary data to monitor the movement of groundwater impacted by petroleum-related compounds originating north and west of the site.

Construction of the remedial system was completed in January 1990. The pilot program and pilot program extension were conducted from June 4 through September 10, 1990 and the results of these programs showed that the remedial system could achieve the designed removal efficiencies and that the treatment unit effluent met the groundwater discharge limitations. The system startup program was conducted from

September 10, 1990 through January 1991. The results of this program showed that the remedial system would meet the remedial objectives stated in the Consent Decree (USEPA, 1989) and the remedial action plan (RAP) (G&M, 1990d) at flow rates between 80 and 140 gallons per minute (gpm). The analytical results from these programs also confirmed that the concentrations of site-related VOCs detected in the treatment unit influent samples were below the concentrations necessary to meet the air discharge criteria. The long-term remedial system operation, maintenance, and monitoring program has been conducted at the site since January 1991. During operation of the remedial system from June 1990 through January 2000, a total of 493,455,100 gallons of groundwater have been recovered, treated, and returned to the subsurface at an average flow rate of 100 gpm. Operational problems and maintenance of the remedial system were temporary and were resolved as they were discovered.

The remedial system has successfully treated site-related VOCs to below the groundwater discharge criteria. An evaluation of the analytical results for samples collected from the treatment unit influent shows that the total concentration of site-related VOCs reached a maximum of 925 micrograms per liter (µg/L) in October 1990 and have steadily declined to 86 µg/L in October 1999, an overall decrease of 91 percent. Based on the annual average air emission rates calculated for the remedial system, approximately 713 pounds of the site related VOCs have been removed from the groundwater through January 2000. The results of the air emission calculations and the air dispersion modeling show that the air discharges from the remedial system were well below the air discharge criteria from June 1990 through January 2000.

In November 1998, a VES was constructed at the site to improve effectiveness of the existing remedial system and more quickly reduce dissolved constituent concentrations to the maximum degree practical. Vapor samples were taken in October 1998 and January 1999 to determine the concentrations of site-related VOCs in the vapors in contact with underlying groundwater. An air quality permit to operate the VES was submitted to the City of Albuquerque Environmental Health Department, Air Quality Division on March 19, 1999 and was approved on July 16, 1999. The VES pilot study was started on August 31, 1999. As of the January 2000 sampling, the VES had been operating for approximately 20 weeks. Changes in concentrations were observed although no trends or conclusions can be made at this time.

The analysis of groundwater elevations shows that the remedial system has contained the area of groundwater impacted by the site-related VOCs. The analysis also showed that groundwater elevations declined at a rate of approximately one foot per year until 1997 when the groundwater elevations stabilized.

The results for the long term groundwater monitoring showed that the area of highest concentrations of site-related VOCs in samples collected from the groundwater have remained stationary in the vicinity of monitoring wells GM-09S and GM-02 and recovery wells RW-01 and RW-02. A decrease in the overall aerial extent of the groundwater impacted by the site-related VOCs also is illustrated by these results. The concentrations of 1,1-DCE, 1,1,1-TCA, TCE, and PCE detected in the center of mass have decreased by approximately 95, 98, 81, and 72 percent, respectively, based on the long term groundwater quality monitoring results. Petroleum related compounds continue to be detected in samples collected from the groundwater in several monitoring wells.

The Safe Drinking Water Act and the NMWQCC Regulations were reviewed to determine if any changes had been made in the standards since the ROD was completed (USEPA, 1988c). Two changes were identified. The Cleanup Goal as stated in the ROD for trans-1,2-dichloroethene is 70 parts per billion (ppb). According to the National Primary Drinking Water Regulations, the maximum contaminant level (MCL) for trans-1,2-dichloroethene is 100 ppb. This change has not made the standard more stringent. The Cleanup Goal as stated in the ROD for PCE is 20 ppb (USEPA, 1988c). According to the National Primary Drinking Water Regulations, the current maximum contaminant level (MCL) for PCE is 5 ppb. This change does make the standard more stringent.

Representatives of USEPA, VW&R, and AG&M took part in a site inspection on February 24, 2000. During the site inspection, the remedial system was observed. The remedial system was found to be operating and functioning properly with no signs of damage.

There have not been any changes in exposure pathways and no changes in toxicity or other factors for constituents of concern. No deficiencies were discovered during this second five-year review. No additional information has come to light that could call into question the protectiveness of the remedy. The following are the recommendations or follow-up activities suggested at this time:

- An additional groundwater monitoring well should be installed between monitoring wells GM-20 and GM-12R to ensure that the southern most component of the plume is being captured.

- The vapor extraction system should be expanded to incorporate the area defined by monitoring wells GM-01 and GM-22R to the north, GM-12R to the south, and I-25 to the east.

The remedial system at the site is protective of human health and the environment. The ELCR associated with the operation of the treatment unit during the ninth year of operation (June 1998 to June 1999) was 1.2×10^{-9} with a cumulative risk of 2.5×10^{-7} for the first nine years of operation (June 1990 to June 1999). These risks are well below the USEPA guidance of an RLCR of 1.0×10^{-6}, the maximum air discharge requirements specified by the RAP (G&M, 1990d). Additionally, the plume has been captured by the recovery wells and has not migrated further downgradient. The installation of the expanded VES is expected to improve the effectiveness of the existing remedial system and more quickly reduce dissolved constituent concentrations to the maximum degree practical.

Based on the data presented, the remedial action selected for the site achieves all of the remedial objectives and therefore, remains protective of human health and the environment.

The next five-year review will be conducted in 2005 in accordance with policy.

Five-Year Review Summary Form

SITE IDENTIFICATION

Site name (from WasteLAN): South Valley Superfund Site (Edmunds Street OU #3)

EPA ID (from WasteLAN): NMD 980745558

Region: EPA Region 6	**State:** NM	**City/County:** Albuquerque/Bernalillo

SITE STATUS

NPL Status: ☒ Final ☐ Deleted ☐ Other (specify):

Remediation status (choose all that apply): ☐ Under Construction ☒ **Operating (LTRA)** ☐ Complete

Multiple OUs? ☒ Yes ☐ No	**Construction completion date:** PCOR on 9/30/96

Has site been put into reuse? ☒ Yes ☐ No **Site is an operating Facility**

REVIEW STATUS

Reviewing agency: ☒ EPA ☒ State ☐ Tribe ☐ Other Federal Agency:

Authors: Greg Lyssy, Susan Morris, Stephanie Armijo, Kathryn Brantingham

Review period: 1995-2000

Date(s) of site inspection: February 24, 2000

Type of review:
- ☒ **Statutory**
- ☐ Policy
- ☐ Post-SARA ☐ Pre-SARA ☐ NPL-Removal only
- ☐ Non-NPL Remedial Action Site ☐ NPL State/Tribe-lead
- ☐ Regional Discretion

Review number: ☐ 1 (first) ☒ **2 (second)** ☐ 3 (third) ☐ Other (specify):

Triggering action:
- ☐ Actual RA Onsite Construction at OU# ____
- ☐ Actual RA Start at OU# ____
- ☐ Construction Completion
- ☒ **Recommendation of Previous Five-Year Review Report**
- ☐ Other (specify):

Triggering action date (from WasteLAN): First Five Year Review was signed on September 30, 1995

Due date (five years after triggering action date): September 30, 2000

Deficiencies:
No deficiencies were noted during the review.

Recommendations and Follow-up Actions:
An additional ground water monitoring well should be installed between GM-20 and GM-12R to ensure that the southern-most component of the plume is being captured.

Protectiveness Statement(s):

The results of the review indicate that the remedial Action at OU #3 has been, and is expected to continue to be, protective of human health and the environment. Overall, the remedial actions have been functioning as designed, and have been operated and maintained in an appropriate manner. No deficiencies were noted in remedial action implementation at the Site.

1.0 INTRODUCTION

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In addition to operation of the groundwater remedial system, the remedial action for the site includes a groundwater-monitoring program, which was designed to monitor

the effectiveness of the remedial action. This monitoring program also provides the necessary data to monitor the movement of groundwater impacted by petroleum-related compounds originating north and west of the site.

2.0 SITE CHRONOLOGY

On June 22, 1988, the ROD for the Edmunds Street Groundwater Operable Unit was filed. In January 1989, the Remedial Investigation and Feasibility Study reports were submitted to the USEPA and New Mexico Environment Department (NMED). The Remedial Action Plan (RAP) was submitted to the USEPA and NMED on September 7, 1990. The system start-up program was conducted September 10, 1990 through January 14, 1991. On November 8, 1995, the first five-year review for the site was completed. In March 1996, USEPA and NMED gave verbal approval of modifications to the remedial system. These modifications included using Columbia Analytical Services as a laboratory, lower reporting limits, and elimination of analysis for benzene, toluene, ethylbenzene, and xylene (BTEX) and 1,2-dichloroethane (1,2-DCA) by USEPA Methods 8010 and 8020. Two groundwater monitoring wells were installed in March 1998, one as a replacement well (GM-22R) and one new well (GM-25). In November 1998, a VES was installed at the site. The air quality permit to operate the VES was submitted on March 19, 1999 and approved on July 16, 1999. The VES pilot study was stated on August 31, 1999. A complete site chronology is included as Appendix A.

3.0 BACKGROUND

3.1 Physical Characteristics

The site consists of approximately 6.5 acres located at in an industrial area in the southern portion of Albuquerque, New Mexico (Figure 1). The site is located approximately one-half mile west of the Albuquerque International Airport and approximately one-half mile east of the Rio Grande.

3.2 Land and Resource Use

The site has been used for various industrial and commercial purposes for approximately 30 years. In 1965, Edmunds Chemical Company purchased the land. Edmunds and its successor, SEC Corporation, distributed various industrial chemicals in addition to selling dry ice, chlorine, and ammonia gas. In 1971, SEC sold the industrial chemical portion of its business to VW&R and SEC continued in the business of selling dry ice, chlorine, and ammonia gas. VW&R began leasing the

eastern portion of the property for its activities, while SEC continued to occupy the rest of the site. In 1974, VW&R enhanced a naturally occurring shallow depression (now called the SV-10 area) to control storm-water runoff on the eastern portion of the site.

In 1977, AmeriGas acquired SEC Corporation and continued the dry ice, chlorine, and ammonia gas operation, while VW&R remained as a tenant. AmeriGas sold the property in 1982 to Dixie Chemical, and re-acquired the property later that same year. Since 1985, only VW&R has been active at the site. In June 1988, VW&R purchased the property from AmeriGas and has owned and operated the site since that time.

3.3 History of Contamination

Early in 1978, unpleasant taste and odor were noted in the water from well A-1, an on-site well which supplied the water to the site. This well is completed to a depth of 132 feet below land surface and screened from 112 to 132 feet below land surface. A water sample from well A-1 was subsequently analyzed and several halogenated VOCs were detected. After detection of the VOCs, bottled water was provided for drinking at the site; however, the water from well A-1 was used for non-consumptive purposes until the well was removed from service. This well was replaced by well A-2 in 1980. Well A-2 was completed to a depth of 522 feet below land surface and screened from 510 to 522 feet below land surface.

Also in 1978 the City of Albuquerque analyzed samples from the San Jose and Miles municipal well fields. Wells SJ-3 and SJ-6 (in the San Jose well field) and Miles-1 (in the Miles well field) were temporarily taken out of service following the detection of low levels of contamination in their waters. Well Miles-1 was returned to service as repeated chemical analysis failed to confirm the presence of any contaminants.

In 1981, the USEPA and NMED (formerly the Environmental Improvement Division of the New Mexico Health and Environment Department) designated a 1-square mile area around SJ-6 as a Superfund site (SJ-6 Study Area) which was added to the National Priorities List. In order to locate potential sources of ground-water contamination in the vicinity of SJ-6, the NMED conducted a regional study, entitled "Organic Ground-Water Pollutants in the South Valley of Albuquerque, New Mexico, December 1982."

As a result of the investigation, the USEPA and NMED identified the following six potential source locations in the South Valley: GE/Air Force, Chevron, Texaco, Duke City Distributing, Whitfield Tank Lines, and the Edmunds Street property. The owner of these sites were identified as potentially responsible parties (PRPs). As part of the

Superfund process, the USEPA and NMED conducted what is characterized as a focused feasibility study to evaluate remedial measures for Well SJ-6 (USEPA, 1984), and two phases of site characterization conducted in 1984 and 1985. Based on these investigations, the USEPA published a remedial investigation report (USEPA, 1988a) and a feasibility study (USEPA, 1988b) which concluded that the trace concentrations of solvents in the vicinity of SJ-6 "do not pose a threat to public health or the environment" provided that the SJ-6 remedial action as described in the ROD for the South Valley is implemented.

In the early 1980's, three site-specific investigations of groundwater contamination were conducted at the Edmunds Street site for Dixie Chemical, AmeriGas, and VW&R by Underground Resource Management (URM, 1982), American Ground-Water Consultants (AGC, 1983), and D'Appolonia Waste Management Services (DWMS, 1983 and 1984), respectively.

In 1985, Geraghty & Miller conducted a Source Control Investigation to locate on-site sources of VOCs and to preliminarily define the nature and extent of the contaminated soil and groundwater (G&M, 1985). The source control investigation involved installing eight monitoring wells, taking water-level measurements, collecting two rounds of groundwater samples, performing geophysical logging of selected wells, and conducting an aquifer test on well A-1.

Based on the initial results of the source control investigation, a work plan was prepared to investigate potential off-site migration. The work plan was submitted to the USEPA and NMED on March 26, 1987 and received final approval on July 5, 1987. The purpose of the off-site investigation was to determine the extent of the VOC contamination in groundwater east of the site and involved a soil-gas survey and the installation of additional monitoring wells.

Based on additional studies, including the site remedial investigation (G&M, 1989a), feasibility study (G&M, 1989b), and a public health evaluation prepared by Harding Lawson Associates (1989), the USEPA issued a ROD (USEPA, 1988c) which stated that the source of site-related VOCs no longer exists at the Edmunds Street site. Only the groundwater plume of site-related VOCs required remediation, as agreed in the Consent Decree between Univar Corporation and the USEPA and NMED (USEPA, 1989). A special report prepared by Geraghty & Miller and Harding Lawson, which was accepted by the USEPA and NMED, demonstrated that site-related VOCs did not travel northwestward from the site and were not implicated in the contamination of Well SJ-6 (G&M/HLA, 1989). Ultimately, the VW&R site was removed as a PRP from the SJ-6 Operable Unit.

In accordance with the terms established in the ROD (USEPA, 1988c) and Consent Decree (USEPA, 1989), the RAP (G&M, 1990d) and quality assurance project plan, created as an appendix to the RAP (G&M, 1990c), were prepared. Recovery wells were installed in 1989 and the treatment unit was constructed during the first quarter of 1990. A pilot program was conducted during the third quarter of 1990 and the treatment system stabilized and was fully operational by the end of 1990. Additional information regarding the operation of the treatment unit is provided later in this report.

4.0 REMEDIAL ACTIONS

4.1 Remedy Selection

As stated in the ROD (USEPA, 1988c), the remedial action selected consisted of the following parts " containment and collection of the contaminated groundwater through the use of an extraction well system, treatment of the recovered groundwater through packed tower aeration, and return the treated water to the aquifer through infiltration galleries." The ROD also states "The selected remedy would also include monitoring of both groundwater, treated water and ambient air to ensure the effectiveness of the remedy." The selected remedial action was implemented in accordance with the Consent Decree (USEPA, 1989) and a description of the proposed design and operational information is included in the RAP (G&M, 1990d) and the Remedial Design Report (G&M, 1990a). A groundwater monitoring plan to determine the effectiveness of the remedial actions also was included in the RAP (G&M, 1990d).

4.2 Remedy Implementation

Extraction wells RW-01, RW-02, RW-03, and RW-04 were installed in October and November 1989 at the locations shown on Figure 2. These recovery wells were completed at depths of 155, 166, 180 and 200 feet below land surface, respectively, in the intermediate aquifer. The original design of the recovery well system was based on groundwater modeling scenarios.

The installation of the water conveyance lines, electrical lines, treatment unit, and infiltration gallery was completed by January 1990. The groundwater treatment unit utilizes the aeration treatment method to remove the site-related VOCs from the groundwater influent. Once the groundwater is processed through the treatment unit, the treated effluent is discharged to an on-site infiltration gallery located immediately west of the treatment unit building. The infiltration gallery was originally designed using a single horizontal perforated pipe in a gravel envelope and has since been

modified to include a second horizontal perforated pipe in a gravel envelope. Both systems work concurrently.

The operating requirements for the remedial system were identified during the development of the applicable, relevant, and appropriate requirements as part of the remedial investigation and feasibility study. The cleanup objective for the groundwater impacted by site-related VOCs are defined as the USEPA's and NMWQCC's maximum contaminant levels (MCLs) for drinking water supplies. In addition, the groundwater and air discharges from the treatment unit must meet the groundwater discharge criteria specified by the NMWQCC and the air discharge criteria specified by the AEHD.

As the treatment system was not designed to treat petroleum related compounds, the appearance of these compounds in the recovered groundwater from off-site sources was expected to interfere with and reduce the efficiency of the treatment system's ability to remove site-related VOCs, or cause the system to violate air or water discharge limits established under the Consent Decree (USEPA, 1989). Such interference or violation of discharge limits were identified in Section XXXVIII the Consent Decree (USEPA, 1989) as causes for termination of the groundwater remediation program.

To determine the effectiveness of the remedial system at achieving the remedial objectives, routine treatment unit monitoring, water-level measurements, and groundwater monitoring is conducted at the site. The data collected pursuant to operation and maintenance of the remedial system are appended to this report. The data have been evaluated and are discussed in detail in this report.

4.3 System Operation and Maintenance

The groundwater treatment system for the site has been operating since June 4, 1990. The remedial system was started using a phased approach to insure compliance with discharge criteria. A six-week pilot program was conducted and was followed by a four week pilot program extension due to incorrect analysis by the laboratory of the samples collected during the pilot program. The pilot program was followed by an 18-week startup program conducted to determine the optimum range of flow rates for the remedial system. Long-term operation, maintenance and monitoring of the system have continued since completion of the startup program. An overview of each of these programs is provided in the following section.

4.3.1 Pilot Program

The air stripper pilot program was conducted, as proposed in the work plan (G&M, 1990b), from June 4, 1990 to July 18, 1990. The analytical results for the samples collected during this period of time were determined to be invalid after the analytical data were formally validated by AG&M. The invalid data resulted from analytical calibration procedures performed by the laboratory which were inconsistent with those established by the USEPA contract laboratory program procedures. Therefore, a pilot program extension was approved by the USEPA and NMED and conducted at the site from August 20 to September 10, 1990, as documented in the air stripper pilot program report (G&M, 1990e).

The objective of the pilot program, and subsequent pilot program extension, was to collect water quality data to determine whether the treatment unit would achieve the removal efficiencies specified in the Remedial Design Report (G&M, 1990a). In addition, equipment operational data were collected to complete the operation and maintenance manual for the remedial system (G&M, 1991a).

The analytical results for samples collected during the pilot program extension confirmed that the site-related VOCs were present in the extracted groundwater as measured in the treatment unit influent stream. In addition, 1,2-DCA, methylene chloride, and acetone were detected in samples collected from the influent stream. The analytical results for the samples collected from the treatment unit effluent during the pilot program indicated that the treatment unit achieved the design removal efficiencies specified in the Remedial Design Report (G&M, 1990a) and that effluent from the treatment unit met the groundwater quality discharge limitations specified in the RAP (G&M, 1990d). The analytical results also confirmed that concentrations of site-related VOCs detected in samples collected from the treatment unit influent were below the concentrations necessary to meet the air discharge criteria. Additionally, no significant operational or maintenance problems were encountered. Based on the results of pilot program extension, the treatment unit operation was continued under the system startup program as described in the following section.

4.3.2 System Startup Program

The system startup program began on September 10, 1990 and continued through January 14, 1991 as proposed in the RAP (G&M, 1990d). The objective of the startup program was to operate the treatment unit at varying flow rates to determine the optimum flow rate of the system, to ensure that the effluent water quality from the

treatment unit was in compliance with the discharge criteria and to ensure that the capture zone of the recovery system would contain the area of groundwater impact.

The treatment unit was operated for an 18-week period at flow rates of 120 gallons per minute (gpm), 130 gpm, and 140 gpm with each flow rate being sustained for 6 weeks. Samples of the treatment unit influent and effluent were collected and groundwater levels were measured prior to starting the remedial system, after one full week of operating at a consistent flow rate, and just prior to increasing each incremental flow rate.

Samples were collected from the treatment unit influent and effluent to determine the efficiency of the treatment system and to verify that the effluent process stream was in compliance with the groundwater discharge criteria. The samples were analyzed for VOCs, total petroleum hydrocarbons (TPHs), and major cations and anions.

The VOCs consistently detected in samples collected from the influent of the treatment unit during the system startup included the four site-related VOCs, 1,2-DCA, and methylene chloride. The results of the VOC analyses verified that, for each flow rate, all VOC concentrations in the treatment unit effluent were below laboratory reporting limits and met the discharge criteria. Additionally, the analytical results also confirmed that concentrations of site-related VOCs detected in samples collected from the treatment unit influent were below the concentrations necessary to meet air discharge criteria.

Samples collected from the treatment unit influent and effluent also were analyzed for TPHs to determine whether the petroleum impacted groundwater plume adjacent to the site was affecting the operation of the remedial system. TPHs compounds were detected in samples collected from the treatment unit influent suggesting that the petroleum-impacted groundwater had reached the recovery system. However, no TPH compounds were detected in samples collected from the treatment unit effluent, indicating that the treatment unit was effective in removing the TPH compounds at these concentrations.

The analytical results for cations and anions indicated that low concentrations of these ions are dissolved in the groundwater, the concentrations of these ions in the influent and effluent process streams were essentially identical, and little mass was being precipitated in the system. This was supported by visual observations in the field that revealed that precipitates were not rapidly forming on the packing in the air stripper nor causing any operational difficulties.

The capture zone of the remedial system was evaluated using a groundwater elevation map prepared from the water-level measurements collected on January 14, 1991 (at the end of the system startup program). This evaluation indicated that the capture zone generated from the final 140 gpm flow rate test was larger and more extensive than the capture zone predicted by groundwater modeling at 80 gpm, and extended downgradient to a location between monitoring well clusters GM-14 and GM-15 (G&M, 1991b).

The results of the startup program indicated that each flow rate was capable of achieving the containment objectives of the remedial design, so the selected operational flow rate for the system was determined by optimizing the efficiency of each of the recovery well pumps. Manufacturer's data indicated the pumps operated most efficiently at approximately 35 gpm. Therefore, the final proposed optimal combined flow rate for the recovery system was 140 gpm, with any flow between 80 gpm and 140 gpm meeting the containment objectives. The proposed optimal flow rate of 140 gpm was discussed and accepted by the regulatory agencies in a conference call between USEPA, NMED, VW&R, and AG&M on January 18, 1991.

In summary, the analytical results of the system startup program consistently demonstrated that the treatment unit effluent complied with the effluent discharge criteria specified in the RAP (G&M, 1990d). In addition, the capture zone generated from the recovery wells operating between 80 and 140 gpm encompassed the area of groundwater impacted by site-related compounds identified in the Remedial Investigation (G&M, 1989a). Therefore, the results of the system startup program indicated that the treatment unit would meet the objectives of the Consent Decree (USEPA, 1989) and the RAP (G&M, 1990d) at any flow rate between 80 and 140 gpm. Based on the results of the system startup program, operation of the remedial system was continued at the proposed optimal flow rate of 140 gpm and the long term operation, maintenance, and monitoring program was conducted as specified in the RAP (G&M, 1990d) and as described in the following section.

4.3.3 Long Term Remedial System Operation and Maintenance

Long term operation and maintenance of the remedial system has been conducted since completion of the system startup program in January 1991. Routine operation and maintenance of the remedial system was conducted from January 1991 through January 2000, as specified in the RAP (G&M, 1990d). The following is a summary of the average flow rates for each year from 1995 through 2000, as well as any operational problems that occurred. A more detailed chronology of events is included in Appendix A.

The remedial system operated at an average flow rate of 113 gpm with minimal down time reported during the sixth year of remedial system operation (June 1995 to June 1996). Operational problems that occurred throughout the year included a broken pulley on the remedial system, reversed wiring on recovery well RW-02, blown fuses on recovery well RW-04, and a crushed junction box and partially cut electric line for recovery well RW-04. The pumps and pipes for all recovery wells were cleaned, the pumps and motors were replaced in recovery wells RW-02 and RW-03, and all the recovery wells were chlorinated.

The remedial system operated at an average flow rate of 123 gpm during the seventh year operation (June 1996 to June 1997). Operational problems that occurred throughout the year included replacement of the pump and motor in recovery well RW-04, periodic shutdowns due to a frozen float valve, shut down of program logic controls on recovery well RW-01 due to a loose control wire, and a frozen and burst influent supply line.

During the eighth year of operation (June 1997 to June 1998), the remedial system operated at an average flow rate of 124 gpm. Operational problems occurred throughout the year. From June through August, the remedial system periodically shut down due to power outages caused by weather conditions. In February 1998, recovery well RW-04 shut down due to a short in the electrical line under Interstate 25. The pump was not restarted, as agreed to by the USEPA and NMED. Additionally, two groundwater monitoring wells were installed in March 1998, one as a replacement well (GM-22R) and one new well (GM-25), and the VES was installed in anticipation of conducting a vapor extraction pilot test.

The remedial system operated at an average flow rate of 91 gpm (with only three recovery wells pumping RW-01, RW-02, and RW-03) from June 1998 to June 1999, the ninth year of remedial system operation. Operational problems included the remedial system shutting down due to weather in September and October 1998 and the remedial system operational information was not recorded in April and May 1999 due to a problem with the remote monitoring system. Additionally, the measuring point elevations for all of the groundwater monitoring wells were resurveyed in April 1999.

The remedial system operated at an average flow rate of 85 gpm from June 1999 through January 2000. Operation problems that occurred during this time period included replacement of the pumps and motors in recovery well RW-01 and RW-02, replacement of the drop pipe in recovery well RW-02, replacement of the fuses for recovery well RW-02, and repairs to the remote monitoring system modem. A leak in

the effluent line for recovery well RW-04 was discovered during the October 1999 sampling event and was repaired in January 2000.

A summary of the remedial system operations and maintenance for the entire tenth year of operation (June 1999 to June 2000) will be included in the 2000 Annual Progress Report to be distributed in July 2000.

4.3.4 Operation and Maintenance Costs

The annual operations and maintenance costs as stated in the ROD (USEPA, 1988c) for the pumps and recovery wells, aeration tower, and infiltration gallery were estimated to be approximately $37,000 per year. Table 1 is a summary of the actual costs from March 1989 through December 1999. Based on the actual costs, the average annual cost for operation and maintenance of the remedial system is approximately $37,700. The costs were higher than this average in 1991 due to the installation of a telemetry system and installation of permanent pumps in selected groundwater monitoring wells. The costs were higher than the annual average in 1994 due to the installation of a second infiltration line, a programmable logic controller for remote monitoring, and the Aqua Mag system for control of calcium carbonate. In 1997, the VES system was installed and in 1998 two additional monitoring wells were installed resulting in a higher than average annual cost.

4.4 Vapor Extraction System Pilot Test

4.4.1 Introduction

This section of the Second Five-Year Review provides documentation of results achieved to date for an on-going VES pilot study. The pilot study was implemented to evaluate the applicability of using a VES to improve the existing remedial action of groundwater extraction/treatment operational at the site.

As summarized in this report, dissolved concentrations of site-related VOCs have declined dramatically since the groundwater extraction/treatment system became operational in June 1990. However, elevated site-related VOC concentrations remain in groundwater as indicated by samples collected from several monitoring wells at the site. Potentially, concentrations of VOCs in the vapors in the unsaturated zone at the site may be acting as a continuing source of groundwater impact. The direct contact between the vapor and the groundwater provides a pathway for the VOCs to move from the vapor phase into the groundwater. In settings with deep unsaturated zones and minimal infiltration, typical at the site, gas phase chemical transport can be a

dominant process by which groundwater becomes impacted (Falta et.al., 1989). This vapor-to-groundwater migration pathway is specifically targeted by the pilot study.

Vapor extraction is a physical process whereby a blower is used to withdraw vapors from wells screened across the unsaturated zone. The volatile constituents are removed in vapor phase, resulting in a reduction of mass in the unsaturated zone. Given the relative ease at which vapors move through the unsaturated zone, mass removal rates achieved through vapor extraction are typically high compared to mass removal rates for technologies relying solely on groundwater withdrawal and treatment. This observation explains the widespread acceptance of this technology for the cleanup of VOCs such as those found at the site.

Implementation of the vapor extraction pilot study at the site is designed to evaluate the potential to improve the effectiveness of the existing remedial system and more quickly reduce dissolved constituent concentrations to the maximum degree practical. This pilot study is designed to confirm the efficacy of VES and provide design details for possible future expansion of the system.

4.4.2 Background

Vapor samples were collected from several monitoring wells in October 1998 and January 1999. Where monitoring well completions allowed, a single monitoring well was sampled by two methods. The first sample collection method was designed to obtain vapor samples from just above the water table. A peristaltic pump was used to remove vapors from the monitoring well at a low rate and provide minimally disturbed vapor samples. The peristaltic pump was placed at the ground surface and a packer was placed within the monitoring well to isolate the screened interval. Silicone tubing was placed into the well to draw the sample from below the well packer up to the ground surface where the sample was collected into a Tedlar™ bag. The analytical results from this sample collection method are assumed to be indicative of vapors in contact with the underlying groundwater. The second sample collection method removed vapors at a higher flow rate using an electrically operated blower placed on top of the monitoring well casing and was designed to provide a "composite" sample of vapors adjacent to the monitoring well. The second method was expected to provide analytical results predictive of vapor composition for an extraction system and, therefore, useful for estimating recovery and emissions for an operating VES.

A summary of the analytical results for the site-specific compounds which exceeded laboratory reporting limits in vapor samples is provided in Table 2. Monitoring well locations are shown on Figures 2 and 3. Due to confusion on former well designations,

four of the site wells have been re-named. The new well designations are summarized in Table 3 and Figure 3. The vapor well referred to as SV-10 during the vapor sampling and throughout the pilot study work plan is now designated VE-3.

Vapor concentrations detected for each of the site-related VOCs using the first sample collection method, designed to isolate and collect vapor samples immediately adjacent to the water table, were higher than vapor concentrations detected using the second sample collection method for 8 of the 12 sets of analytical results available for comparison. Specifically, analytical results for samples collected just above the water table from monitoring wells GM-03, GM-06 [both sampling dates], GM-09S, GM-12R, GM-13, GM-16, and GM-22R using the peristaltic pump technique were higher than analytical results for samples collected from these monitoring wells using the electric blower.

Analytical results for samples collected from monitoring well GM-02 also indicated that vapor concentrations for 1,1-DCE and TCE were higher in samples collected using the first sample collection method than the concentrations detected using the second sample collection method. Analytical results for samples collected from this monitoring well for 1,1,1-TCA and PCE were the same order of magnitude for both sample collection methods.

Analytical results for samples collected from monitoring well GM-05 also indicated that vapor concentrations for 1,1-DCE, 1,1,1-TCA, and TCE were higher in samples collected using the first sample collection method than the concentrations detected using the second sampling method. Analytical results for samples collected from this monitoring well for PCE were the same order of magnitude for both collection methods.

The remaining two sets of data (GM-10-AIR and GM-11S-AIR) did not indicate a significant difference between the two sample collection methods (Table 2). However, it should be noted that vapor analytical results for samples collected by both sample collection methods for these two monitoring wells are relatively low. Similarly, recent groundwater analytical results for samples collected from these two monitoring wells were also relatively low.

Analytical results for vapor samples collected from selected monitoring wells were used to prepare an application for an air quality permit to operate a VES at the site. The application was submitted to the City of Albuquerque Environmental Health Department, Air Quality Division on March 19, 1999. The permit was issued to VW&R on July 16, 1999.

Groundwater samples were collected prior to startup of the VES pilot study during the normally scheduled annual sampling event (April 1999). This sampling event, along with the historical data for the site, provides a baseline for comparison with those groundwater samples collected after start-up of the VES. Groundwater samples were subsequently collected from selected wells during the semi-annual sampling event in October 1999.

In addition to those monitoring wells normally scheduled to be sampled in October 1999, monitoring wells GM-02, GM-04, GM-05, GM-06, GM-08, GM-09S, GM-13, and I-01 were also sampled. This event took place approximately eight weeks after startup of the VES. Monitoring wells GM-02, GM-04, GM-05, GM-06, GM-08, GM-09S, GM-13, and I-01 were also sampled in January 2000 to provide additional data for evaluation of the VES. Comparison of these supplemental analytical results with future groundwater analytical results, will provide an important basis to evaluate the effectiveness of the VES on dissolved-phase groundwater concentrations at the site.

The VES currently installed at the site consists of a self-contained extraction blower, vapor-liquid separator (knockout pot) and associated controls, valves and piping (Figure 4). The system has a maximum throughput of approximately 450 standard cubic feet per minute (scfm). The installed blower consists of a 15-horsepower, rotary-lobe blower equipped with a variable speed drive. The system is housed within a wheel-mounted and locked trailer positioned in the southeast corner of the VW&R property (Figure 3).

The system is currently connected through underground piping to monitoring wells GM-02, GM-05, and GM-09S and vapor well VE-3, although vapors are not currently extracted from monitoring well GM-05. Additionally, vapor well VE-1 was temporarily connected to the system during a portion of the pilot study. The valve configuration of the system can be manipulated to withdraw vapors from each well individually or in any combination.

4.4.3 Pilot Study Protocol

The pilot study is divided into three separate tests: 1) flow response test, 2) vacuum response test, and 3) long-term performance test. These tests are described in detail in the following sections.

4.4.3.1 Flow Response Test

The flow response test was conducted at the site during the two-day period from August 31, 1999 to September 1, 1999. The test was performed to determine the vapor flow characteristics under an applied vacuum (i.e., the rate of induced flow versus the level of applied vacuum) in the unsaturated zone.

The flow response test utilized monitoring wells GM-02, GM-05, and GM-09S, and vapor wells VE-1, and VE-3 as vapor extraction wells (Figure 3). The flow response test was conducted at each well individually. During the flow response test, three vacuum levels were applied to each well (with the exception of monitoring well GM-05), starting at the highest sustainable vacuum level and progressively reducing the vacuum levels by one-third each step. Once conditions stabilized at each of the vacuum levels, the vapor flow rate and vacuum level were recorded.

Vapor flow rates in each pipeline were measured using a digital manometer and Dwyer™ pitot tube to measure the average velocity (measured as pressure in inches of water column). This value is then used to determine the corresponding vapor flow velocity using a slide chart (flow velocity calculator) also obtained from Dwyer instruments. The slide chart provides flow velocity (in feet per minute) based on measured pressure, adjusted for vapor temperature and humidity. The flow velocity is then multiplied by the cross-sectional area of the pipe to calculate the vapor flow rate (in cubic feet per minute).

Vapor samples were collected from each extraction well after the low vacuum level had stabilized and prior to stopping the test. The vapor samples were collected from the well head in a Tedlar™ bag and field screened with an organic vapor analyzer (OVA).

4.4.3.2 Vacuum Response Test

Vacuum response tests were conducted on September 1, 1999 and September 2, 1999, following completion of the flow response test. Vacuum response tests involved the measurement of induced vacuum within the subsurface as a result of an applied vacuum to an individual extraction well. The vacuum response tests were conducted over an approximately 4-hour period for each well. Vacuum response tests were completed on vapor wells VE-1 and VE-3. A vacuum response test was started at monitoring well GM-09S. However, this test was terminated due to a drop in barometric pressure at the time of the test causing anomalous vacuum measurements in the subsurface. Although initially planned, vacuum response tests were not performed

at monitoring wells GM-02 and GM-05 due to insufficient airflow for the system blower when extracting from these wells individually.

The highest vacuum level determined during the flow response test was applied to the selected extraction well during the vacuum response test. Induced vacuum measurements were collected using Magnehelic™ gauges placed at selected wells surrounding the well being tested. A summary of the well configurations used during the vacuum response tests is provided in Table 4.

The induced vacuum measurements, vacuum levels, and vapor flow measurements were recorded on field logs. The data from the vacuum response test will be used to verify the adequacy of the existing well network to address the targeted area and also will be used in the design of a full-scale system.

Vapor samples were collected on two occasions from the extraction wells during the vacuum response test. An initial vapor sample was collected within 20 minutes of the start of the vacuum response test from each extraction well used for the test (i.e., GM-09S, VE-1, and VE-3). A second vapor sample was collected at the end of the vacuum response test from extraction wells VE-1 and VE-3. Each vapor sample was collected in two Tedlar™ bags. One Tedlar™ bag was field screened with an OVA and the second Tedlar™ bag was submitted to Performance Analytical Inc. in Simi Valley, California to be analyzed for VOCs by USEPA Method TO-14.

4.4.3.3 Long-Term Performance Test

The long-term performance test phase of the pilot study is on going. The purpose of this test is to monitor the operation of the VES over an extended period to evaluate the long-term potential for the system to remove site-related VOCs from the unsaturated zone. Further, as the reduction of the vapor mass reduces vapor concentrations in the unsaturated zone, this test will also evaluate the effect of vapor removal on the dissolved-phase VOC concentrations in the groundwater. This part of the pilot study is expected to take up to 12 months to complete. The long-term performance test began upon completion of the vacuum response test on September 2, 1999.

Monitoring wells GM-02 and GM-05, and vapor well VE-3 are currently the only wells being used for vapor extraction. The vapor concentrations were field screened weekly using an OVA during the first month of operation and are currently screened on a monthly basis. During the field screening process, vapor concentrations and flow rates were obtained from each of the three vapor extraction lines individually and then from the combined vapor stream of the system.

Vapor samples were collected from the combined vapor stream of the system for laboratory analysis on September 8, 15 and 22, 1999 to monitor the concentration of VOCs in the extracted vapors. The September 8, 1999 vapor sample was collected in a Tedlar™ bag from the effluent side of the blower and submitted to Performance Analytical for analysis by USEPA Method TO-14. The September 15, 1999 vapor sample was collected from the influent side of the blower using a peristaltic sampling pump to draw the vapor into the Tedlar™ bag. This vapor sample also was analyzed by Performance Analytical by USEPA Method TO-14. The September 22, 1999 vapor sample was collected from the influent side of the blower using a peristaltic pump to fill the Tedlar™ bag. This vapor sample was submitted to Orange Coast Analytical for analysis by USEPA Method 8260 to determine the approximate concentrations that would be expected by analysis using USEPA Method 18.

In accordance with the air permit, compliance sampling was conducted on October 4, 1999 following the field sampling and analytical quality control protocol outlined by USEPA Method 18. Vapor sample collection was observed by a representative from the City of Albuquerque Environmental Health Department, Air Quality Division. Compliance sampling included collection of three separate vapor samples from the combined vapor stream of the system in Tedlar™ bags. These vapor samples were submitted to Orange Coast Analytical for analysis.

During this sampling event, vapor samples were again collected and field screened with an OVA from each of the three extraction lines individually and then from the combined vapor stream of the system. Flow rate measurements were obtained from each of the three extraction lines individually and from the combined vapor stream of the system.

4.4.4 Pilot Study Results

4.4.4.1 Flow Response Test Results

The flow response test included measurements of flow rates at various vacuum levels to determine achievable flow rates for the specific site conditions. The flow rates achieved at the applied vacuum levels during the pilot study are shown in Table 5 and Figure 5.

No measurable vapor flow was achieved from monitoring well GM-05 during the flow response test. Water-level measurements obtained on October 25, 1999 indicate approximately 15 feet of exposed screen at this well. Under an applied vacuum of 10 inches of mercury, the water column would be expected to rise almost 12 feet, leaving

approximately 3 feet of exposed screen for vapor flow. In addition to the limited exposed well screen, the monitoring well may be screened in a non-permeable zone or the exposed well screen may be obstructed. Vacuum was measured at the well head indicating the problem is not associated with the VES piping between the well and the system. Based on the lack of flow from this location, the flow response test was not performed at monitoring well GM-05.

Calculated flow rates for the remaining wells under the highest applied vacuum scenario were as follows: 36 scfm at monitoring well GM-02 (effective screened interval of 4 feet), 60 scfm at monitoring well GM-09S (effective screened interval of 14 feet), 175 scfm at vapor well VE-3 (effective screened interval of 87 feet), and 180 scfm at vapor well VE-1 (effective screened interval of 92 feet).

Higher flow rates were achieved for vapor wells VE-1 and VE-3 as compared to the groundwater monitoring wells which have been adapted for vapor extraction (monitoring wells GM-02, GM-05, and GM-09S). This illustrates that flow rates for vapor extraction wells are a function of the effective screened interval of the well.

4.4.4.2 Vacuum Response Test Results

Vacuums (as well as vapor flow) through the subsurface typically decrease exponentially as the distance from the extraction well increases. Vacuum response test results, summarized in Table 6, demonstrate the expected drop in induced vacuum with increased distance from the extraction well.

During the vacuum response test at vapor well VE-1, induced vacuum measurements were obtained from monitoring wells GM-02, GM-04, GM-09S, GM-05, and GM-08, and vapor wells VE-2 and VE-3. The induced vacuum at vapor wells VE-2 (24 feet from VE-1) and VE-3 (28 feet from VE-1) were 2.7 and 4.4 inches of water, respectively. The higher response at vapor well VE-3 is likely attributable to the comparable screen length between the extraction well (vapor well VE-1) and vapor well VE-3. The induced vacuums measured at monitoring wells GM-02, GM-04, GM-09S, GM-05, and GM-08 are illustrated in Figure 6.

During the vacuum response test at vapor well VE-3, induced vacuum measurements were obtained from monitoring wells GM-02, GM-04, GM-09S, GM-05, and GM-08. The induced vacuum measured at each of these monitoring wells is illustrated in Figure 7. It should be noted the induced vacuum at monitoring well GM-05 is slightly less than what would be expected at given distances from the extraction wells (Figure 6 and

Figure 7). This supports the possibility of an obstructed well screen in monitoring well GM-05 or a localized area of low permeability in the surrounding formation.

As mentioned previously, the vacuum response test at monitoring well GM-09S was terminated prior to completion of the test. Termination of the test was necessary due to dropping barometric pressure at the time the test was conducted. Specifically, as the barometric pressure dropped, vapor pressure increased as the subsurface and atmospheric pressures equilibrated. Monitoring wells closest to monitoring well GM-09S (and exposed to a higher induced vacuum) proportionately were not as influenced by the changing barometric pressure as those wells further from monitoring well GM-09S (the extraction well). However, monitoring wells furthest from the extraction well exhibited positive pressure readings indicating the induced vacuum was not sufficient at that distance to over come the effect of the dropping barometric pressure.

The barometric pressure dropped approximately 0.04 inches of mercury (equivalent to 0.55 inches of water) during the vacuum response test at GM-09S. Induced vacuum beyond 100 feet was not measured above 0.55 inches of water during the vacuum response tests for vapor well VE-3 or vapor well VE-1 (Table 6). Interpretation of the induced vacuum measurements at monitoring well GM-09S is complicated by the changing barometric pressure. However, it should be noted that induced vacuum readings were observed at distances of 150, 160, and 250 feet from the monitoring well GM-09S, the extraction well during this test. This supports that vacuum influence was achieved at these distances, even though the measured vacuums were impacted by the barometric pressure changes.

During the vacuum response test, an induced vacuum was measured at the furthest monitoring points from each of the extraction wells. Specifically, measurable vacuum influence was observed at a distance of 280 feet from vapor well VE-1, 260 feet from vapor well VE-3, and 250 feet from monitoring well GM-09S. Based on this information it can be concluded the actual radius of influence for the VES exceeds 250 feet.

Vapor samples were collected on two occasions during the vacuum response phase of the pilot study (Table 7). The intended use of the analytical results for the vapor samples collected was to characterize the initial rate at which concentrations declined over time. Consistent with other VES systems, lower concentrations were predicted for the second of the two vapor samples. However, the duration of this phase of the project (generally less than 4 hours) was insufficient for this trend to develop. During this test, the latter vapor samples consistently showed higher concentrations than the

initial vapor samples. Subsequent vapor samples have shown a marked decline over time.

4.4.4.3 Long-Term Performance Test Results

Flow rate calculations from the long-term monitoring portion of the pilot study are summarized in Table 5. Under the current extraction well configuration (October 4, 1999), vapor well VE-3 makes up approximately 50% of the total vapor flow through the VES. The remaining vapor flow through the VES is made up from monitoring well GM-09S (approximately 40% of the total vapor flow through the VES) and monitoring well GM-02 (approximately 10% of the total vapor flow through the VES).

Individual field screening results for each extraction well are provided in Table 8. The vapor samples with the highest VOC concentration were generally collected from the groundwater monitoring wells (monitoring wells GM-02 and GM-09S) which were adapted for vapor extraction. The construction of these wells (with open screen extending approximately 16 to 26 feet above static water levels, respectively – see Table 4) promote the withdrawal of vapors near the groundwater surface.

Field screening results provide qualitative data for comparison purposes. Analytical sampling is performed for quantitative results. No analytical sampling was performed on the individual extraction wells during this reporting period. All analytical sampling was performed on the combined vapor stream for the system.

Laboratory analytical results obtained for the vapor samples collected from August 31, 1999 through October 31, 1999 are summarized in Table 7.

The mass recovery rate calculated for each site-related compound identified in the extracted vapor (1,1-DCE, 1,1,1-TCA, TCE, and PCE) and the combined total mass recovery rate for the system are summarized in Table 9. These calculations are based on the analytical results of the extracted vapor (Table 7) and the measured flow rate for that sampling event for the VES (Table 5).

Initial vapor phase concentrations observed during VES pilot studies are typically higher than concentrations recorded later, during continuous VES operation. Once a VES is started and several pore volumes of vapors have been removed, concentrations generally decrease dramatically. Consistent with past experience, this drop in mass removal rates has been observed at the site.

The drop in total mass recovery rate during the period from August 31, 1999 through October 4, 1999 is illustrated in Figure 8. Mass recovery rates between sampling events were estimated using a straight-line interpolation between sampling events.

The distribution of mass removed by constituent through January 19, 2000 is illustrated in Figure 9. As shown on this figure, approximately 977 pounds of VOCs have been removed by the VES, over 75% of which was PCE.

The VES operating at the site is specifically designed to remove vapors documented to contain elevated concentrations of site-related constituents. With the removal of these vapors, the potential migration pathway between vapors and the underlying groundwater is interrupted. By this process, the dissolution of vapor phase constituents into the groundwater would be reduced, ultimately resulting in a reduction in dissolved concentrations in groundwater.

As described previously, groundwater samples collected prior to startup of the system provide baseline analytical data for groundwater quality. The most recent groundwater sampling event conducted prior to startup of the VES occurred in April 1999. After start-up of the VES, groundwater samples were collected from selected monitoring wells in October 1999 and January 2000. As of the January sampling, the VES had been operational for approximately 20 weeks. Changes in concentrations were observed although no trends or conclusions can be made at this time. Additional samples were collected from groundwater monitoring wells in April 2000. Results of the April 2000 groundwater sampling events and comparisons with previous analytical results will be discussed in the 2000 annual report. This data will be used to evaluate the effectiveness of the vapor removal in reducing the dissolved concentrations in the groundwater.

4.5 Progress Since the Last Five-Year Review

Since the first five-year review completed on November 8, 1995, the remedial system has operated as designed and is still protective of human health and the environment. In order to improve the existing remedial action of groundwater extraction/treatment, a VES was installed in November 1998 and the pilot test was started in September 1999. Although changes in concentrations were observed during the October 1999 and January 2000 sampling events, the effectiveness of the VES has not yet been determined. However, plans to expand the VES are currently being considered.

5.0 FIVE-YEAR REVIEW PROCESS

The second five-year review for the site was led by Mr. Greg Lyssy of the USEPA. The following team members assisted in the review:

- Susan Morris, NMED Superfund Section
- George Sylvester, Van Waters & Rogers Inc.
- Kathryn Brantingham, ARCADIS Geraghty & Miller, Inc.
- Stephanie Armijo, ARCADIS Geraghty & Miller, Inc.

This second five-year review consisted of the following activities: a site inspection, a review of relevant documents, and data review.

6.0 FIVE-YEAR REVIEW FINDINGS

6.1 Site Inspection

Representatives of USEPA, VW&R, and AG&M took part in a site inspection on February 24, 2000. During the site inspection, the remedial system was observed. The remedial system was found to be operating and functioning properly with no signs of damage.

6.2 Changes to Standards

The Safe Drinking Water Act and the NMWQCC Regulations were reviewed to determine if any changes had been made in the standards since the ROD (USEPA, 1988c) was completed. Two changes were identified. The cleanup goal as stated in the ROD (USEPA, 1988c) for trans-1,2-dichloroethene is 70 parts per billion (ppb). According to the National Primary Drinking Water Regulations, the MCL for trans-1,2-dichloroethene is 100 ppb. This change has not made the standard more stringent. The cleanup goal as stated in the ROD (USEPA, 1988c) for PCE is 20 ppb. According to the National Primary Drinking Water Regulations, the current MCL for PCE is 5 ppb. This change does make the standard more stringent.

A comparison between the cleanup goals as stated in the ROD (USEPA, 1988c) and the current standards are summarized as follows:

Constituent	Cleanup Goal as stated in the ROD		Current Standards (ppb)	
	Concentration (ppb)	Source	NMWQCC[1]	MCL[2]
acetone	NE	NA	NE	NE
carbon tertrachloride	5	MCL	10	5
chloroform	100	NMWQCC	100	NE
1,2-dichloroethane	5	MCL	10	5
trans-1,2-dichloroethene	70	MCLG	NE	100
1,1-dichloroethene	5	NMWQCC	5	7
methyl chloride	100	NMWQCC	100	NE
tetrachloroethene	20	NMWQCC	20	5
1,1,1-trichloroethane	60	NMWQCC	60	200
trichloroethene	5	MCL	100	5

TABLE NOTES:

NE	not established
NA	not applicable
ROD	Record of Decision
ppb	parts per billion
NMWQCC	New Mexico Water Quality Control Commission discharge regulations
MCL	maximum contaminant level under the Safe Drinking Water Act
(1)	New Mexico Water Quality Control Commission Regulations, November 15, 1996
(2)	National Primary Drinking Water Regulations as of July 24, 200

6.3 Changes in Exposure Pathways, Toxicity and Other Contaminant Characteristics

There were no changes in exposure pathways, toxicity, or other contaminant characteristics.

6.4 Data Evaluation

6.4.1 Remedial System Monitoring

Long term monitoring of the remedial system has continued since completion of the system startup program in January 1991, as proposed in the RAP (G&M, 1990d). Monitoring of the remedial system included collecting samples from the treatment unit influent and effluent, collecting samples from the individual recovery wells, recording the influent flow rate and total amount of water treated, and measuring the depth to groundwater in the recovery wells and monitoring wells. Monthly monitoring of the

remedial system was conducted from February through July 1991, continued on a quarterly basis from July 1991 through April 1995, and then continued semiannually through January 2000. Table 10 summarizes the sampling events from April 1995 through January 2000 and the constituents analyzed during each sampling event. This monitoring information has been summarized in the Annual Progress Reports prepared for the site (G&M 1995, 1996, and 1997, and AG&M 1998 and 2000) and is discussed below.

Samples were collected from the treatment unit influent and effluent and individual recovery wells to monitor the overall efficiency of the treatment unit at achieving the discharge criteria. The analytical results for samples collected from the treatment unit influent and effluent and individual recovery wells have been summarized and the VOC analytical results are included in Tables 11 and 12; the TPHs, BTEX, and 1,2-DCA analytical results are included in Table 13; and the major cations and anions analytical results are included in Table 14. All of the data through April 1995 were validated according to the procedures outlined in the RAP (G&M, 1990d) and from October 1995 through October 1999 were validated according to the protocol approved by the USEPA (Gorrod, 1995). Graphs also were prepared to show time trends in concentrations of the four site-related VOCs (Appendix B).

The analytical results show that the concentrations of site-related VOCs detected in samples collected from the treatment unit influent have gradually decreased since the treatment unit has been in operation (Figure B-43 and Table 11). The concentrations of 1,1,1-TCA in the treatment unit influent decreased to levels below the analytical method detection limit in October 1992 and have remained below the detection limit through October 1999. The maximum concentration of total site-related VOCs (calculated by adding the individual concentrations of the four site-related VOCs in one sample) detected in samples collected from the treatment unit influent reached a maximum during the first year of operation and have continued to decrease over time. The maximum concentration of total site-related VOCs reported in the treatment unit influent has decreased from 925 micrograms per liter (µg/L) in October 1990 and have steadily declined to 86 µg/L in October 1999, an overall decrease of 91 percent.

Concentrations of site-related VOCs remained below reporting limits in the treatment unit effluent from June 1990 through October 1999 (Figure B-41 and Table 11). Based on these results, the treatment unit effluent has been in compliance with the groundwater discharge criteria.

The recovery wells were sampled individually four times from June 1990 through January 1995 and semiannually from April 1995 through October 1999. The analytical

results show that the highest concentrations of site-related VOCs have consistently been detected in samples collected from recovery wells RW-01 and RW-02 and the lowest in samples collected from recovery well RW-04 (Figures B-38 through B-41 and Table 12). The concentrations of VOCs are generally decreasing in samples collected from the recovery wells with some fluctuation.

The analytical results for petroleum related compounds (TPHs, BTEX, and 1,2-DCA) in samples collected from the treatment unit influent and effluent and recovery wells through October 1995 which were analyzed by USEPA Methods 8010 and 8020 and are summarized in Table 13. The BTEX and 1,2-DCA results for samples collected through October 1999 and analyzed by USEPA Methods 8240 and 8260 are summarized in Table 2. These results show that BTEX were never detected above reporting limits in samples collected from the treatment unit influent and effluent or the recovery wells, except for one sample collected in March 1998. This sample had concentrations of BTEX above the reporting limits, however the individual recovery wells did not have concentrations of BTEX above the reporting limits.

In March 1996, USEPA and NMED gave verbal approval for modifications to the remedial system which included the elimination of BTEX and 1,2-DCA analysis by USEPA Methods 8010 and 8020.

Analytical results for cations and anion concentrations are low and have been consistent throughout the operation of the remedial system. These data are summarized in Table 14.

The average annual air emission rates were calculated for each year of treatment unit operations and were reported in the 1995, 1996, 1997, 1998, and 1999 annual progress reports. These average air emission rates have all been lower than those initially calculated, based on a maximum flow rate of 150 gpm with a 100% removal efficiency as presented in the RAP (G&M, 1990d).

Air dispersion modeling also was performed on an annual basis to evaluate both the location and magnitude of maximum exposure to the air stripper emissions from the treatment unit and to verify that the discharges were within the limitations specified in the RAP (G&M, 1990d). These calculations were necessary to ensure that the operation of the treatment unit was not creating an unacceptable health risk to local residents and site employees. As shown in Table 15, the ELCR associated with the operation of the treatment unit during the ninth year of operation (June 1998 to June 1999) was 1.2×10^{-9} with a cumulative risk of 2.5×10^{-7} for the first nine years of operation (June 1990 to June 1999). These risks are well below the USEPA guidance

of an ELCR of 1.0×10^{-6}, the maximum air discharge requirements specified by the RAP (G&M, 1990d).

From June 4, 1990 through January 31, 2000, a total of approximately 493,455,100 gallons of groundwater have been recovered, treated, and returned to the subsurface at an average flow rate of 100 gpm. This flow rate is within the range of flow rates for achieving capture established for the treatment unit (80 to 140 gpm) but less than the optimal instantaneous flow rate of 140 gpm because of down time due to operational and maintenance problems discussed previously. Based on air emission rates calculated for the time period from June 1990 through January 2000, the remedial system removed approximately 713 pounds of the site-related VOCs from the aquifer.

Depth to groundwater measurements were collected monthly from January 1991 to July 1991 and quarterly from July 1991 through January 2000 in all of the recovery wells and monitoring wells. These measurements were converted to groundwater elevations and used to evaluate the hydraulic effects of operating the remedial system. The depth to groundwater measurements and calculated groundwater elevations were summarized for each well and are included in Appendix C. Calculated groundwater elevations through January 2000 also were plotted as a function of time to illustrate groundwater elevation trends and these graphs are in Appendix D. These graphs indicate groundwater elevations at the site have declined at a rate of approximately one foot per year until 1997 when the groundwater elevations stabilized. Monitoring wells GM-19 and GM-20 increased in groundwater elevations upon startup of the remedial system but stabilized in 1996 (Figure D-25 and D-26). These two monitoring wells are located near the southern end of the infiltration gallery (Figure 2) and show the effect of the infiltrated water mounding on the water table.

The groundwater elevations in shallow monitoring wells and the recovery wells were mapped annually to illustrate the configuration of the water-table surface at those times and are included in the annual progress reports. The maps for March 1991, April 3, 1995, April 23, 1996, April 7,1997, March 31, 1998, and April 12,1999 are in Appendix E. The key features of the water-level elevation maps include cones of depression surrounding the recovery wells and a mound on the water table in the area near the infiltration gallery. The resulting groundwater flow lines generally diverge away from the infiltration gallery and converge on the recovery wells and supports there is a hydraulic capture zone that includes the area of documented groundwater contamination from the site.

6.4.2 Groundwater Quality Monitoring

As specified in the RAP (G&M, 1990d), long-term groundwater quality monitoring for the site began in April 1991, continued on a quarterly basis through April 1993, and was conducted on a semi-annual basis (every April and October) through 1999 with additional sampling being conducted in January 1999 and January 2000. This monitoring information has been summarized in the Annual Progress Reports prepared for the site (G&M 1995, 1996, and 1997, and AG&M 1998 and 2000) and is discussed below.

Samples were collected from the monitoring wells to monitor the overall effectiveness of the remedial system in achieving the cleanup objectives. The analytical results for samples collected from the monitoring wells have been summarized and the VOC analytical results are in Table 12. The TPH, BTEX, and 1,2-DCA analytical results for samples collected through October 1995 and analyzed by USEPA Methods 8010 and 8020 are in Table 13. The major cations and anions analytical results are in Table 14. All of the data were validated in accordance with procedures outlined in the 1995 Annual Report (G&M, 1995). The USEPA approved the reduction in data validation on April 20, 1995 (Gorrod, 1995).

To evaluate VOC analytical results for the samples collected from the monitoring wells, graphs were prepared to show time trends in concentrations of the four site-related VOCs (Appendix B). Additionally, distribution maps were prepared for the four site-related compounds in the intermediate aquifer for August 1989 (prior to construction of the remedial system), April 1992, April 1994, April 1995, April 1996, April 1997, April 1998, and April 1999. The distribution maps for 1,1-DCE, 1,1,1-TCA, TCE, and PCE are in Appendices F, G, H, and I, respectively.

The following observations have been made based on the time trends in concentrations of site-related VOCs detected in samples collected from the groundwater monitoring wells (Table 12 and Appendix B):

- Since the startup of the remedial system (June 1990), the concentrations of site-related VOCs have been less than the reporting limits or occasionally just above the reporting limits in samples collected from monitoring wells GM-03, GM-07, GM-09D, GM-11D, GM-14S, GM-14D, GM-15S, GM-17D, GM-17S, GM-19, GM-20, GM-22R, GM-23, GM-24D, GM-24S, GM-25, HL-01, A-1, and A-2.

- Since startup of the remedial action (June 1990), the concentrations of site-related VOCs appear to have peaked and are still decreasing in samples collected from monitoring wells GM-04, GM-05, GM-06, GM-08, GM-10, GM-11S, and GM-16.

- Since startup of the remedial action (June 1990), the concentrations of site-related VOCs appear to have peaked and now are fluctuating in samples collected from monitoring wells GM-01, GM-13, GM-21, and I-01.

- Since startup of the remedial action (June 1990) through July1999, the concentrations of site-related VOCs appear to have peaked and then decreased in samples collected from monitoring wells GM-02, GM-08, and GM-09S. The VES pilot study was stared in August 1999 and these wells were either used as vapor extraction wells or are located next to a vapor extraction well causing an increase in the concentrations of site-related VOCs in samples collected from these monitoring wells.

- TCE was first detected in a sample collected from monitoring well GM-15D in October 1993 at concentrations just above reporting limits and consistently has been detected at this level through January 2000. The source of TCE detected in samples collected from this monitoring well is not known at this time. Because the primary site-related compound is PCE (which occurs in concentrations at least three times the concentrations of TCE) and based on results of capture zone analyses, it does not appear that the site-related plume is the source of TCE detected in samples collected from monitoring well GM-15D.

- Concentrations of site-related VOCs are increasing slightly in samples collected from monitoring wells GM-12R and GM-22. The regional decline in water levels at this site has almost dewatered these two monitoring wells.

- The highest concentrations of the site-related VOCs are consistently detected in samples collected from monitoring wells GM-02, GM-09S, GM-13, and I-01.

The following observations were made regarding the distribution of site-related VOCs detected in samples collected from the intermediate aquifer based on the distribution maps for site-related VOCs for 1989, 1992, 1994, 1995, 1996, 1997, 1998, and 1999 (Appendices F through I):

- The highest concentration of 1,1-DCE in 1989 was detected in the sample collected from monitoring well GM-09S at 760 µg/L (Figure F-1). In 1999, the highest concentrations of 1,1-DCE were detected in samples collected from monitoring wells GM-09S and GM-12R, at 39 µg/L and 53 µg/L, respectively (Figure F-8). In addition, the highest concentrations of 1,1-DCE detected within the groundwater impact area have decreased by approximately 95 percent and the overall areal extent of groundwater impacted by 1,1-DCE also has decreased.

- In 1989 and 1999, the highest concentrations of 1,1,1-TCA were 510 and 9 µg/L, respectively, and were detected in samples collected from monitoring well GM-09S (Figures G-1 and G-8). These data indicate that the groundwater containing the highest concentrations of 1,1,1-TCA has remained stationary in the vicinity of monitoring well GM-09S. The highest concentrations detected within the groundwater impact area have decreased by approximately 98 percent. The overall areal extent of the groundwater impacted by 1,1,1-TCA also has decreased.

- The highest concentration of TCE was detected in a sample collected from monitoring well GM-09S in 1989 at 1100 µg/L (Figure H-1). In 1999, the highest concentration of TCE, 210 µg/L, was detected in a sample collected from monitoring well GM-13, which is located approximately 200 feet east-northeast of monitoring well GM-09S (Figure H-8). These data indicate that the highest concentrations of TCE in groundwater is within the vicinity of monitoring wells GM-09S and GM-13. The highest concentrations detected within the groundwater impact area have decreased by approximately 81 percent. The overall areal extent of TCE contaminated groundwater also has decreased.

- In 1989 and 1999, the highest concentrations of PCE were detected in samples collected from monitoring well GM-09S at 2,500, and 560 µg/L, respectively, and monitoring well GM-02 at 2,000, and 590 µg/L, respectively (Figures I-1 and I-8). These data indicate that the groundwater containing the highest concentrations PCE has remained stationary in the vicinity of monitoring wells GM-09S and GM-02 and that the highest concentrations detected within the groundwater impact area have decreased by approximately 72 percent.

7.0 ASSESSMENT

7.1 Is the remedy functioning as intended by decision documents?

The following section summarizes the effectiveness of the remedial system for the site at achieving the remedial objectives. The objectives of the remedial action are to keep the impacted groundwater from further migration and reduce the concentration of the site-related VOCs in the groundwater and groundwater discharge from the remedial system to concentrations below an ELCR of 1×10^{-6}. In addition to meeting the groundwater and discharge criteria, air emissions associated with the remedial system also must not exceed an ELCR of 1×10^{-6}.

The system has been operating within the limits set by the Consent Decree (USEPA 1989) and the RAP (G&M, 1990d). As discussed in section 4.3.3, routine operations and maintenance of the system has occurred since operation began in January 1991. Additional operation and maintenance problems have been addressed as they have become known. The costs associated with operation and maintenance of the remedial system are within the amount originally estimated in the ROD (USEPA, 1988c).

The analysis of groundwater elevations in monitoring wells at the site show that the remedial system has been effective at preventing further migration of impacted groundwater from June 1990 through January 2000. The analytical results for samples collected from the monitoring wells show the highest concentrations of 1,1-DCE, 1,1,1-TCA, TCE, and PCE detected within the groundwater impact area have decreased by approximately 95, 98, 81, and 72 percent, respectively. The total site-relate VOC concentrations in samples collected from the treatment unit influent have decreased by 91 percent. The analytical results for samples collected from the treatment unit effluent show that treated groundwater met the groundwater discharge criteria from June 1990 through January 2000. The results of the air emission rates calculations and air dispersion modeling show that the air discharged from the remedial system has been well below the air emission criteria.

Based on the data presented above, the remedial action selected for the site achieves all of the remedial objectives and remains protective of human health and the environment.

The system has been operating within the limits set by the Consent Decree and the RAP (G&M, 1990d). As discussed in section 4.3.3, routine operations and maintenance of the system has occurred since operation began in January 1991. Additional operation and maintenance problems have been address as they occurred.

A VES system was installed at the site in 1998 and a pilot test is currently being conducted to evaluate the applicability of using a VES to improve the existing remedial action of groundwater extraction/treatment.

7.2 Are the assumptions used at the time of the remedy selection still valid?

The Safe Drinking Water Act and the NMWQCC Regulations were reviewed to determine if any changes had been made in the standards since the ROD (USEPA, 1988c) was completed. Two changes were identified. The cleanup goal as stated in the ROD (USEPA, 1988c) for trans-1,2-dichloroethene is 70 ppb. According to the National Primary Drinking Water Regulations, the MCL for trans-1,2-dichloroethene is 100 ppb. This change has not made the standard more stringent. The cleanup goal as stated in the ROD (USEPA, 1988c) for PCE is 20 ppb. According to the National Primary Drinking Water Regulations, the MCL for PCE is 5 ppb. This change does make the standard more stringent.

There have not been any changes in exposure pathways and no changes in toxicity or other factors for constituents of concern.

7.3 Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come to light that could call into question the protectiveness of the remedy.

8.0 DEFICIENCIES

No deficiencies were discovered during this second five-year review.

9.0 RECOMMENDATIONS AND FOLLOW-UP ACTIVITIES

The following are the recommendations or follow-up activities suggested at this time:

- An additional groundwater monitoring well should be installed between monitoring wells GM-20 and GM-12R to ensure that the southern most component of the plume is being captured.

- The vapor extraction system should be expanded to incorporate the area defined by monitoring wells GM-01 and GM-22R to the north, GM-12R to the south, and I-25 to the east.

10.0 PROTECTIVENESS STATEMENT

The remedial system at the site is protective of human health and the environment. The ELCR associated with the operation of the treatment unit during the ninth year of operation (June 1998 to June 1999) was 1.2×10^{-9} with a cumulative risk of 2.5×10^{-7} for the first nine years of operation (June 1990 to June 1999). These risks are well below the USEPA guidance of an ELCR of 1.0×10^{-6}, the maximum air discharge requirements specified by the RAP (G&M, 1990d). Additionally, the plume has been captured by the recovery wells and has not migrated further downgradient. The installation of the expanded VES is expected to improve the effectiveness of the existing remedial system and more quickly reduce dissolved constituent concentrations to the maximum degree practical.

11.0 NEXT REVIEW

The next five-year review will be conducted in 2005 in accordance with policy.

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FIGURES

TABLES

APPENDIX A

Chronology of Remedial Activities

at the Van Waters & Rogers Inc.

3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX B

Time Trends in Concentrations of 1,1,1-Trichloroethane; 1,1-Dichloroethene; Trichloroethene; and Tetrachloroethene in the Treatment Unit Influent and Effluent, Recovery and Monitoring Wells through January 2000 at the Van Waters & Rogers Inc. 3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX C

Groundwater Elevations through January 2000

at the Van Waters & Rogers Inc.

3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX D

Groundwater Elevations Over Time through January 2000
at the Van Waters & Rogers Inc.
3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX E

Configuration of the Water-Table Surface
on March 13, 1991; April 3, 1995; March 25, 1996; April 7, 1997;
March 31, 1998; and April 12, 1999 at the Van Waters & Rogers Inc.
3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX F

Distribution of 1,1-Dichlorethene in the Shallow Aquifer for August 1989, April 1992, April 1994, April 1995, March and April 1996, April 1997, March and April 1998, and April 1999 at the Van Waters & Rogers Inc. 3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX G

Distribution of 1,1,1-Trichloroethane in the Shallow Aquifer for August 1989, April 1992, April 1994, April 1995, March and April 1996, April 1997, March and April 1998, and April 1999 at the Van Waters & Rogers Inc. 3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX H

Distribution of Trichlorethene in the Shallow Aquifer for August 1989, April 1992, April 1994, April 1995, March and April 1996, April 1997, March and April 1998 and April 1999 at the Van Waters & Rogers Inc. 3301 Edmunds Street Site, Albuquerque, New Mexico

APPENDIX I

Distribution of Tetrachloroethene in the Shallow Aquifer for August 1989, April 1992, April 1994, April 1995, March and April 1996, April 1997 March and April 1998, and April 1999 at the Van Waters & Rogers Inc. 3301 Edmunds Street Site, Albuquerque, New Mexico