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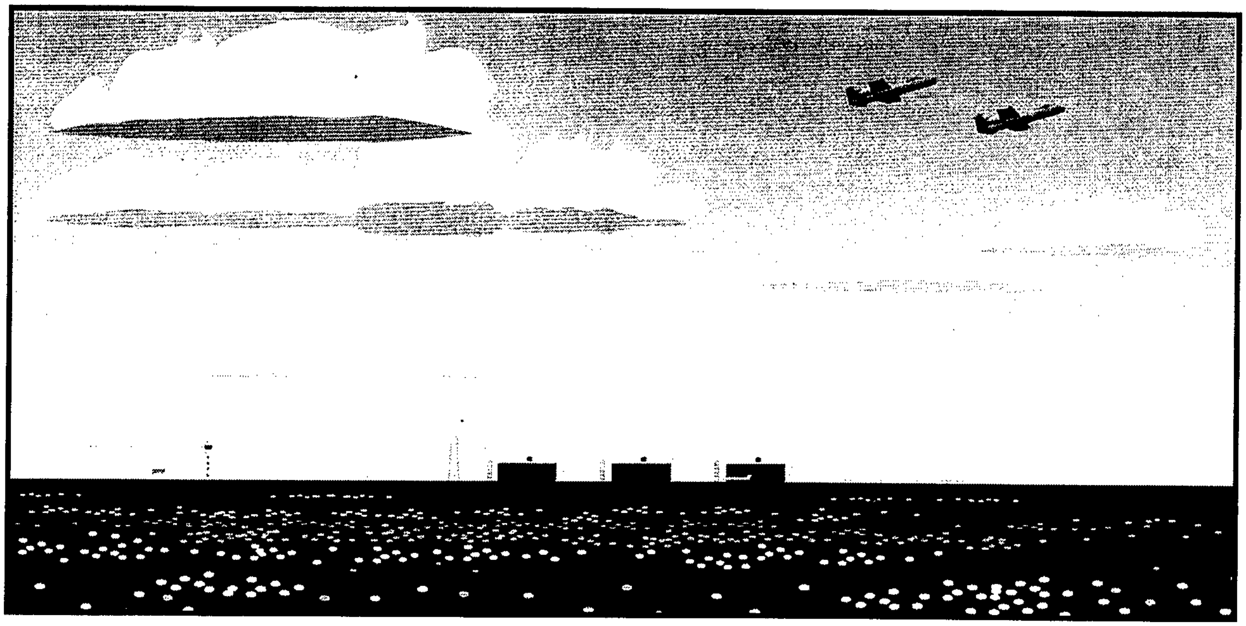
McClellan Air Force Base

# Evaluation of Elastomeric Polymer Filter Media



Technology Demonstration
Technical Memorandum

FINAL
Volume I: Text

**DECEMBER 1995**

AQ M01-03-0725

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2. If you have any questions or concerns, please contact Mr. Tim Chapman at (916) 643-2960 or Mr. Robert Shirley (916) 643-0830 ext. 151.

KIRK L. SCHMALZ, P.E.
Remedial Program Manager
Environmental Restoration Division
Environmental Management Directorate

Attachment:
Final TDTM

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# PREFACE

Radian Corporation is a contractor for the RI/FS Program at McClellan Air Force Base, California. This work was performed for the Sacramento-Air Logistics Center / Environmental Management Restoration (SM-ALC/EMR) under Air Force Contract No. F04699-93-D-0018, Delivery Order No. 8025.

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This document summarizes the results of the evaluation of an elastomeric polymer filter media (PetroLOK™ PL22) for the treatment of volatile organic compounds in offgas. The evaluation included conducting a treatability study at the soil vapor extraction and offgas treatment system in Operable Unit C1 at McClellan Air Force Base. This work was accomplished as part of the Environmental Process Improvement Center partnership between Cal/EPA, U.S. EPA, and McClellan Air Force Base, and was also conducted in cooperation with the Public Private Partnership, Clean Sites, and the U.S. EPA Technology Innovation Office and Superfund Innovative Technology Evaluation Program.

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# EVALUATION OF ELASTOMERIC POLYMER FILTER MEDIA TECHNOLOGY DEMONSTRATION TECHNICAL MEMORANDUM

VOLUME I

**FINAL**

PREPARED FOR:

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12 December 1995

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **AFB** | Air Force Base |
| **AWS** | Advanced Water Systems |
| **Cal/EPA** | California Environmental Protection Agency |
| **cat-ox** | Catalytic Oxidation |
| **cis-1,2-DCE** | cis-1,2-Dichloroethene |
| **DCA** | Dichloroethane |
| **DCE** | Dichloroethene |
| **DOT** | Department of Transportation |
| **EMR** | Environmental Management Restoration |
| **EPIC** | Environmental Process Improvement Center |
| **ER&D** | Environmental Resources and Disposal |
| **GAC** | Granular Activated Carbon |
| **Hg** | Mercury |
| **HASP** | Site Health and Safety Plan |
| **IC** | Investigation Cluster |
| **IRP** | U.S. Air Force Installation Restoration Program |
| **IWTP** | Industrial Waste Treatment Plant |
| **OSHA** | Occupational Safety and Health Administration |
| **OU** | Operable Unit |
| **ppbv** | Parts per billion by volume |
| **ppmv** | Parts per million by volume |
| **PRL** | Potential Release Location |
| **QAPP** | Quality Assurance Project Plan |
| **QA/QC** | Quality Assurance/Quality Control |
| **QCDA** | Quality Control Data Assessment |
| **RCRA** | Resource Conservation Recovery Act |
| **RI/FS** | Remedial Investigation / Feasibility Study |
| **scfm** | standard cubic feet per minute |
| **SMAQMD** | Sacramento Metropolitan Air Quality Management District |
| **SVE** | Soil Vapor Extraction |
| **TCE** | Trichloroethene |
| **TCLP** | Toxicity Characteristic Leaching Procedure |
| **TSD** | Transportation, Storage, and Disposal |
| **TDTM** | Technology Demonstration Technical Memorandum |
| **USAF** | United States Air Force |
| **U.S. EPA** | United States Environmental Protection Agency |
| **VOCs** | Volatile Organic Compounds |
| **WIP** | Work Implementation Plan |
| **°F** | Degrees Fahrenheit |

## EXECUTIVE SUMMARY

This technical memorandum summarizes the results of the evaluation of the PetroLOK™ PL22 elastomeric polymer filter media (polymer), an innovative technology, as applied to the treatment of vapor streams contaminated with chlorinated volatile organic compounds (VOCs). The evaluation included a pilot-scale treatability study, which was conducted from 12 September to 10 October 1995 at the Operable Unit (OU) C1 soil vapor extraction (SVE) system, McClellan Air Force Base (AFB), California.

PetroLOK™ PL22 is a proprietary blend of molecular-bonding, cross-linked polymer and activated carbon that is manufactured by Advanced Water Systems (AWS). The PetroLOK™ PL22 media is used to filter out contaminants from the waste stream in the same way conventional carbon adsorption systems are used. Waste streams are routed through the filter media canisters, contaminants are absorbed by the polymer/carbon mixture, and the treated effluent is discharged. PetroLOK™ PL22 is an "absorptive" technology, which not only "adsorbs" contaminants, but is also reported to chemically bond contaminants.

During the treatability study, tests were conducted on three separate canisters. Two canisters contained PetroLOK™ PL22, and the third contained only polymer without the carbon.

### TEST OBJECTIVES

The objectives for this evaluation were to determine:

- Contaminant removal efficiencies for the contaminants found in the OU C1 soil gas;
- Effectiveness of polymer in removing contaminants in offgas to meet Sacramento Metropolitan Air Quality Management District (SMAQMD) requirements;
- A range of conditions (e.g., contaminant concentrations) for which the technology is applicable and how these conditions compare to those for granular activated carbon (GAC) and catalytic oxidation (cat-ox);
- Cost-effective method(s) of disposal of spent media (with recycling as preferred method); and
- Feasibility and cost of installing and operating a full-scale system.

### RESULTS

- The maximum absorption capacity of the PetroLOK™ PL22 media observed during the treatability test was between 10% and 15%. However, test results from only the polymer indicate 0% absorption capacity, thus suggesting that the absorption capacities observed may be attributed mainly to the carbon contained in PetroLOK™ PL22.
- Results from tests on all three canisters demonstrated no solventizing (i.e., chemical breakdown) of the media.
- No significant changes in pressure drop across the treatment canisters occurred during each of the three tests.
- No significant temperature changes through the treatment canisters were observed during the tests.

- PetroLOK™ PL22 does have the ability to remove contaminants from the waste stream; however, significant amounts may be needed to remove contaminants to SMAQMD standards prior to discharge to the atmosphere (especially for highly-contaminated waste streams).
- Test results indicate that the applicable range of the PetroLOK™ PL22 technology resembles that of GAC more than of cat-ox due to similar contaminant removal efficiencies. Therefore, only comparisons of the PetroLOK™ PL22 to GAC are warranted.
- Research of available disposal options indicate that the spent polymer can be disposed as a Resource Conservation Recovery Act (RCRA) hazardous waste (incinerated, then landfilled) similar to GAC, or can be recycled as a supplemental fuel as long as hazardous contaminants are destroyed to acceptable regulatory limits in the process.
- The technology is simple to implement and operate, with procedures identical to those of carbon. No difficulties were encountered during system installation, operation, dismantling, or polymer disposal.

## CONCLUSIONS AND RECOMMENDATIONS

- It appears that the polymer alone was not effective in absorbing contaminants and the observed removal of contaminants was occurring through the carbon contained in PetroLOK™ PL22.
- A GAC system would be more cost-effective to implement than a PetroLOK™ PL22 system for treating contaminants in the vapor phase.
- Implementing PetroLOK™ PL22 over GAC for vapor-phase applications has no apparent benefit because of the media's lower absorption capacity and higher cost.
- Further testing or evaluation of the PetroLOK™ PL22 elastomeric polymer filter media for vapor-phase applications is not recommended at this time.
- More data exist that support the successful use of the PetroLOK™ PL22 for the removal of contaminants in liquid-phase applications. Further testing of the product for liquid-phase applications may prove beneficial to the Air Force.

## 1.0 PROJECT DESCRIPTION

- This report summarizes the results of the evaluation of the PetroLOK™ PL22 elastomeric polymer filter media, an innovative technology, as applied to the treatment of vapor streams contaminated with chlorinated VOCs. The evaluation was conducted at the OU C1 SVE system from 12 September to 10 October 1995 to provide information on the applicability of this technology as a cost-effective means of treating SVE offgas from contaminated sites at McClellan AFB, California.
- This demonstration was accomplished as part of the Environmental Process Improvement Center (EPIC) partnership between California Environmental Protection Agency (Cal/EPA), the United States Environmental Protection Agency (U.S. EPA), and McClellan AFB. This "proof-of-concept" evaluation was also performed in cooperation with the Public-Private Partnership formed to evaluate innovative technologies for environmental remediation of hazardous waste sites such as McClellan AFB. The Public-Private Partnership includes the United States Air Force (USAF), Clean Sites, the U.S. EPA Technology Innovation Office and Superfund Innovative Technology Evaluation Program, Radian Corporation, Dow Chemical Company, Beazer East, Inc., Southern California Edison, Xerox

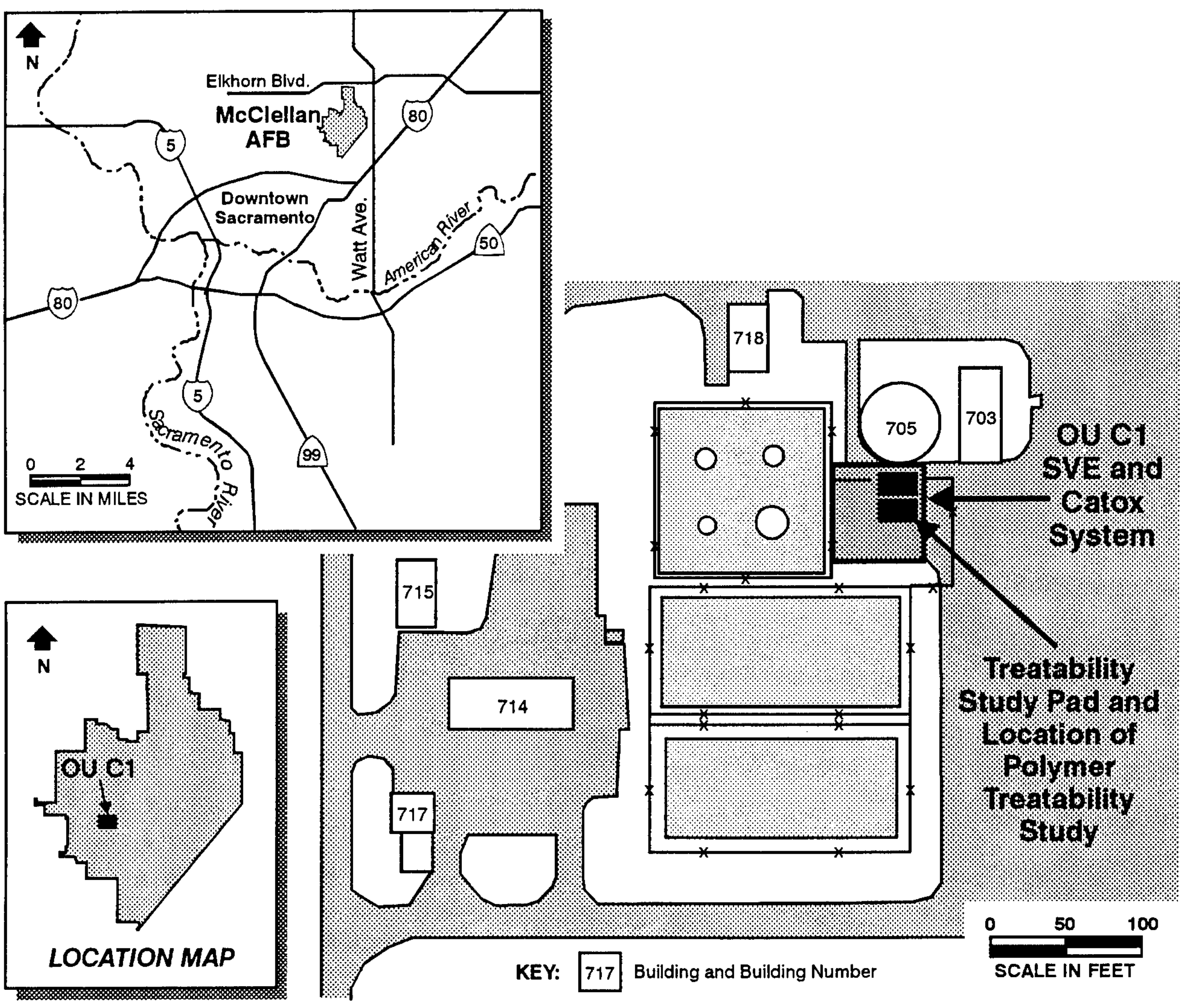
Corporation, American Telephone and Telegraph Company, Monsanto Chemical Company, and DuPont Chemicals.

- All treatability study activities were conducted in accordance with the Air Force- and regulatory agency-approved *Final Evaluation of Elastomeric Polymer Filter Media Work Implementation Plan and Site Health and Safety Plan* (Radian, 1995).

## Site Background

- OU C1 covers approximately 23 acres in the southwest portion of McClellan AFB as shown in Figure 1-1. The OU is comprised of three confirmed sites (Sites 22, 42, and 69) and two Potential Release Locations (PRLs 41 and 68). The area was used from the mid-1940s to 1970 for open bulk storage and burning of liquid and solid wastes. Specific activities conducted in the area and area uses included waste oil and solvent storage, burn pits, a refuse incinerator, and construction debris storage and burial (URS, 1994).

**Figure 1-1.**
**Site Location Map**



- Site 42 originally consisted of pits that reportedly held waste solvents and oil burning sludge. The northern portion of the site may also have been used as a fire training area. The existing Industrial Waste Treatment Plant (IWTP) was later constructed over this site and included an aeration basin that was retired from service in 1987, but remains in place. PRL 68 lies immediately west of Site 42 and covers four small areas corresponding to former locations of pits reportedly used for storage of waste oil (URS, 1994).

- Several investigations have been conducted at OU C1 since 1986 to determine the nature and extent of contamination. VOCs have been detected in the soil and groundwater at the OU. The main contaminant of concern at the site is trichloroethene (TCE). Other contaminants of concern include cis-1,2,dichloroethene (cis-1,2-DCE), benzene, and vinyl chloride.

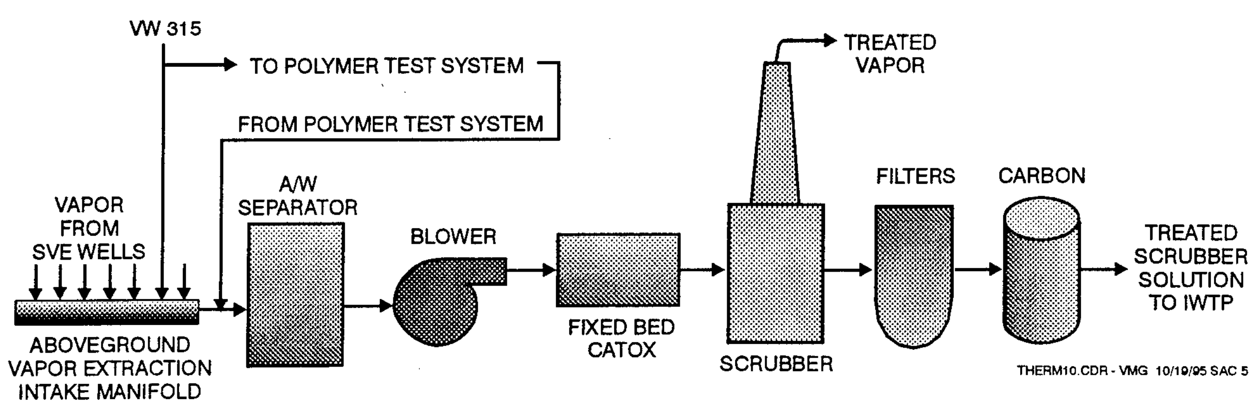
## OU C1 SVE System

- A SVE system consisting of seven extraction wells is located in OU C1 to extract contaminated soil vapor from Site 42 and PRL 68. Offgas from the wells is treated first by cat-ox, then by an acid scrubber. A schematic of the system is shown in Figure 1-2. The SVE and cat-ox systems are designed to extract and treat 1,000 standard cubic feet per minute (scfm) of contaminated vapor. Vapor was extracted from one of the existing vapor wells, VW-315, and routed through the polymer test system to conduct this study.

- Soil vapor from the seven vapor extraction wells is collected at a main manifold before entering the cat-ox unit as a single stream. For the purposes of this evaluation, the valve at VW-315 was closed at the main manifold, and piping was installed to route the vapor to the treatability study pad and polymer test system.

- Extraction well VW-315 is screened from 60 to 90 feet below ground surface in the deep zone of the contaminant plume. The TCE concentrations in soil gas samples collected from this well during installation ranged from non-detect to 1,700 parts per million by volume (ppmv).

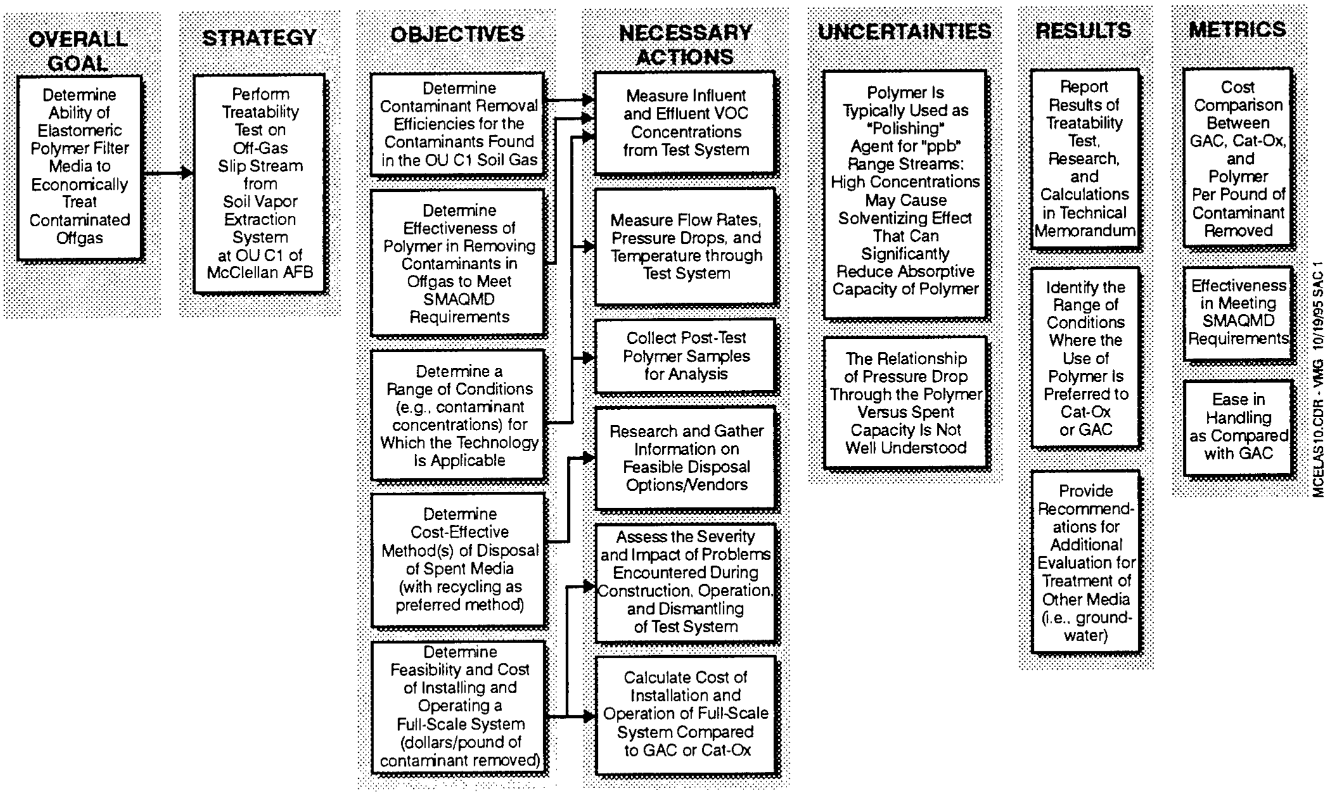
**Figure 1-2.**
**SVE Test System Schematic**



## Test Objectives

The goals, strategies, and metrics established for the test are summarized on Figure 1-3.

**Figure 1-3.**
**Evaluation of Elastomeric Polymer Filter Media Goals to Metrics**



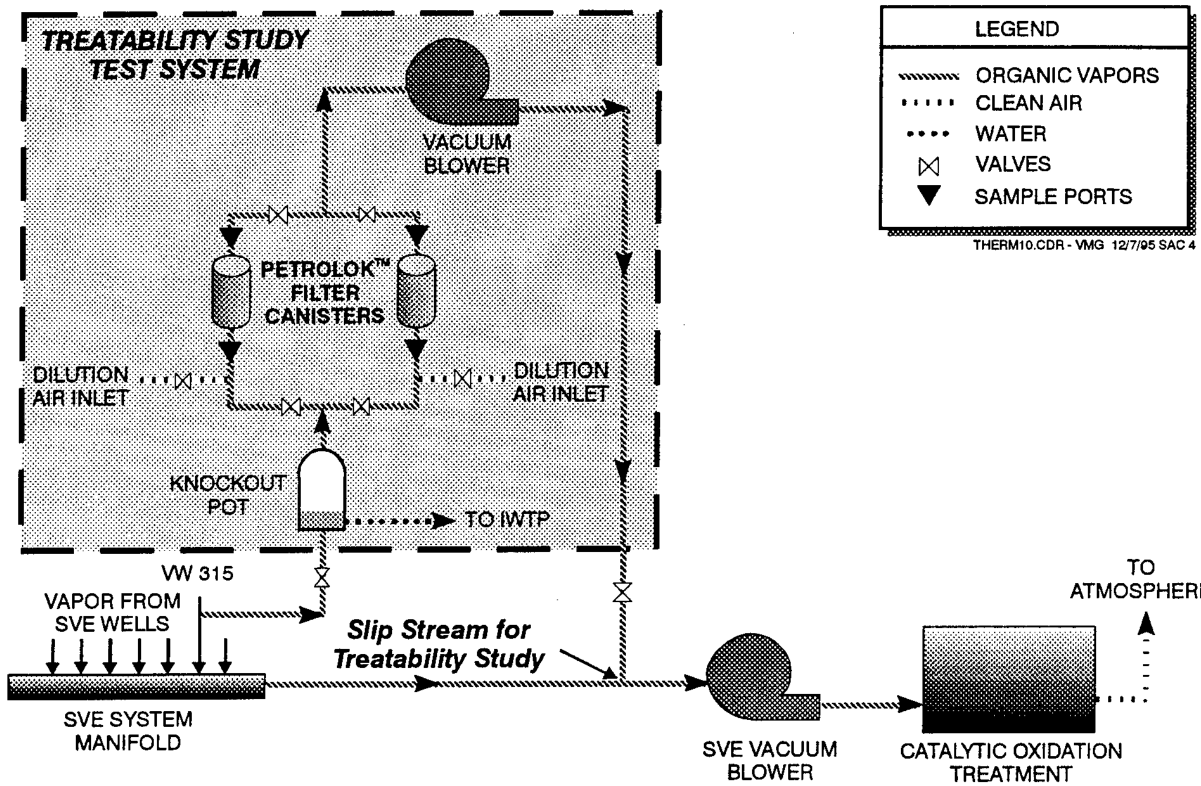

## 2.0 EXPERIMENTAL DESIGN

### Polymer Test System Description and Schematic

A schematic diagram of the polymer test system is shown on Figure 2-1.

- PetroLOK™ PL22 is a proprietary blend of molecular-bonding, cross-linked polymer and activated carbon that is manufactured by AWS.
- PetroLOK™ PL22 is an "absorptive" technology, which not only "adsorbs" contaminants, but is also reported to chemically bond contaminants.

**Figure 2-1.
Schematic Diagram of the Polymer Test System**




- The polymer media is used to filter out contaminants from the waste stream in the same way conventional carbon adsorption systems are used. Waste streams are routed through the filter media canisters, contaminants are absorbed by the polymer/carbon mixture, and the treated effluent is discharged.

- This treatability study was focused on determining the ability of PetroLOK™ PL22 to remove contaminants from vapor. During this evaluation, contaminated vapors were drawn from vapor well VW-315 and through the filter media using a vacuum blower. Effluent vapor was then routed back through the existing cat-ox treatment unit at OU C1 as a precaution to ensure no contaminants were released into the atmosphere.

- Three separate tests (one on each of three different canisters, Canisters A, B, and C) were conducted during the treatability study. The objectives of the tests on Canisters A and B were to determine an applicable operational range (of contaminant concentrations) for the PetroLOK™ PL22 and to determine if the absorption capacity of the media varies with influent concentration. The objective of the test on Canister C was to determine the absorption capacity of the polymer alone, without the carbon. The duration and operating parameters for each test are summarized in Table 2-1.

- The treatability study was conducted using an "observational" approach in which adjustments were made to the operating parameters and sampling and analysis plan based on the analytical results of the samples collected during the test and the measured system parameters. Tables 2-2 and 2-3 summarize the frequency of sampling, sampling rationale, analytical methods, and quality assurance/quality control (QA/QC) procedures followed during the tests for chemical and system parameters, respectively.

**Table 2-1.**
**Elastomeric Polymer Filter Media Treatability Study Operating Parameters**

| Canister ID | Contents | Test Duration | Flow Rate | Vacuum | Total Approximate Influent VOC Contaminant Concentration (ppbv)[a] |
|---|---|---|---|---|---|
| A | PetroLOK™ PL22 (polymer and carbon mix, off-the-shelf product) | 12 Sept- 22 Sept 1995 | 32-40 scfm | 6 inches of mercury (" Hg) | Full-Strength Stream (no dilution) 648,200 - 807,000 |
| B | PetroLOK™ PL22 | 22 Sept- 29 Sept 1995 | 10-12 scfm | 2" Hg | Diluted Stream 234,010 - 414,500 |
| C | Polymer only (no carbon) | 29 Sept - 10 Oct 1995 | 12-13 scfm | 2" Hg | Full-Strength Stream (no dilution) 685,300 - 773,100 |

ppbv = Parts per billion by volume.
[a] See Appendix A for Analytical Data Sheets.

**Table 2-2.**
**Summary of Sampling and Analysis Procedures for Chemical Parameters**

| Sample Location | Sample Rationale / Data Use | Analyte(s) Analytical Method | Sample[a] Frequency | QA/QC Samples |
|---|---|---|---|---|
| Before Canister A | Measure influent VOC concentrations. Calculate contaminant removal efficiencies. | VOCs, Method TO-14 and Modified Method 18 (vinyl chloride prefractionator). | Week 1: Daily. Week 2: Every other day until breakthrough occurred. | 10% field or lab duplicates. |
| After Canister A | Measure effluent VOC concentrations. Calculate contaminant removal efficiencies. Determine air emissions. | VOCs, Method TO-14 and Modified Method 18. | Week 1: Daily. Week 2: Every other day until breakthrough occurred. | 10% field or lab duplicates. |
| Canister A | Determine feasible disposal options. | Leachable VOCs, SW1331 (TCLP) / SW8260 | Once at conclusion of treatability study. | 1 lab duplicate. |
| Before Canisters B and C | Measure influent VOC concentrations. Calculate contaminant removal efficiencies. | VOCs, Method TO-14 and Modified Method 18. | Weeks 1 and 2: Every other day until break-through occurred. | 10% field or lab duplicates. |
| After Canisters B and C | Measure effluent VOC concentrations. Calculate contaminant removal efficiencies. | VOCs, Method TO-14 and Modified Method 18. | Weeks 1 and 2: Every other day until break-through occurred. | 10% field or lab duplicates. |

[a] The sampling frequency shown in this table represents the number of samples collected during the test. This number was determined by analytical data and system parameters measured during the study.
TCLP = Toxicity Characteristic Leaching Procedure.

**Table 2-3.**
**Summary of Sampling and Analysis Procedures for System Parameters**

| Sample Location | Sample Rationale/Data Use | System Parameter | Sample Method | Sample Frequency |
|---|---|---|---|---|
| Before and after each Canister | Determine pressure drop through test system. | Pressure/Vacuum | Pressure/Vacuum Gauges | Daily or whenever sampling events occurred. |
| | Determine if chemical reaction (between contaminants and polymer) causes significant temperature change.<br><br>Ensure system does not operate above melting temperature of polymer (140°F). | Temperature | Temperature Gauges | Daily or whenever sampling events occurred. |
| Before each Canister | Calculate contaminant removal efficiencies. | Flow Rate | Rotameters | Daily or whenever sampling events occurred. |

## 3.0 RESULTS AND INTERPRETATION

The following results were based on analytical data and system readings collected during the treatability study. Analytical data sheets containing laboratory data are included in Appendix A. Field data sheets containing system measurements as they were recorded in the field are included in Appendix B.

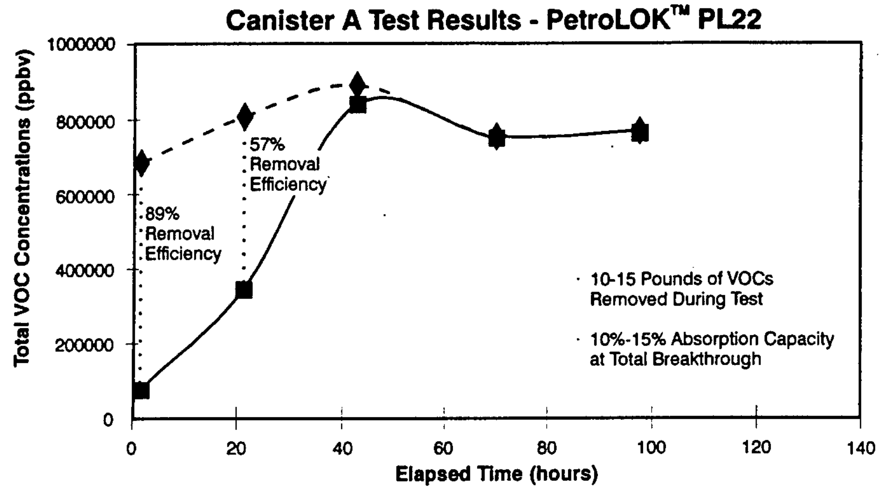
### Test Results

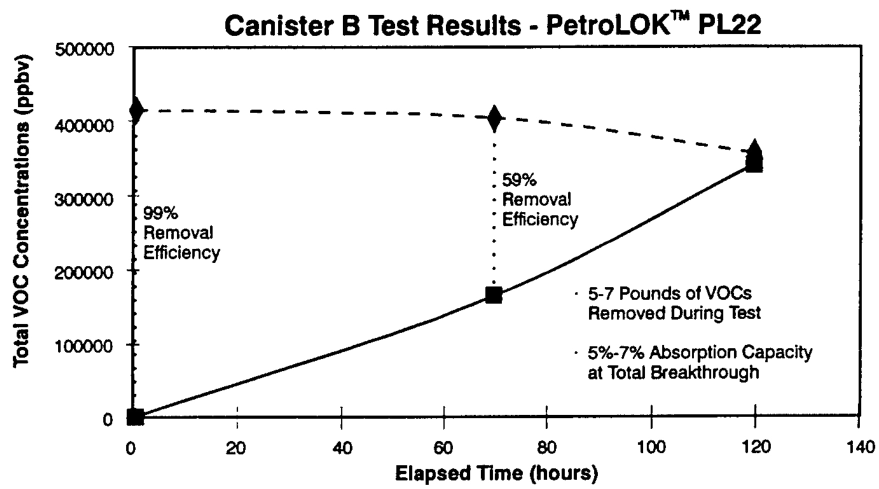
The results of the tests are summarized in Figure 3-1 and on Table 3-1.

Total contaminant breakthrough occurred on Canister A at approximately 43 hours into the test. At this time, only 10 to 15 pounds of VOCs had been removed; much less than claimed by the vendor. AWS was contacted to see if they had any suggestions or answers as to why the media was not performing as they indicated. They suggested reducing the influent flow rate through the media to 10-12 scfm. They also suggested that the media be examined for solventizing or anything out of the ordinary. (Solventizing is the chemical breakdown of the polymer caused by exposure to a highly-contaminated waste stream, which causes significant loss of absorptive capacity of the media.) The media was examined, but no sign of solventizing or anything unusual was detected. The test was then continued at a lower flow rate (12 scfm); however, complete breakthrough of the contaminants continued.

Considering the test results from Canister A, the test procedures for the Canister B test were modified. The influent flow rate was decreased to approximately 10-12 scfm and the influent vapor concentration diluted by about 50% to determine if the absorption capacity of the media would increase with a higher residence time and lower influent concentration. Preliminary results from samples collected from Canister B indicated that significant breakthrough still occurred after the third day of testing. In that time,

## Figure 3-1. Summary of Treatability Study Results



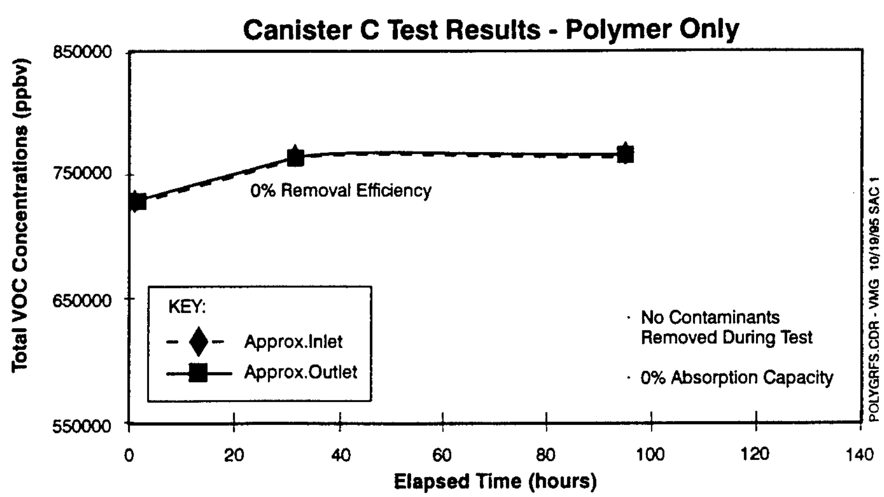



**Table 3-1.**
**Evaluation of PetroLOK™ PL22 Elastomeric Polymer Filter Media Test Results**

| Content | Test Duration | Flow Rate (scfm) | Samples Collected | Elapsed Test Time (hours) | Total Influent VOC Concentration (ppbv) | Total Effluent VOC Concentration (ppbv) | Removal Efficiencies (%) | Absorption Capacity (%) | Total lbs. of VOCs Removed |
|---|---|---|---|---|---|---|---|---|---|
| **CANISTER A** | | | | | | | | | |
| PetroLOK™ PL22 | 12 - 22 Sept 1995 | 32-40 scfm | AIN-002 AEN-003 | 1.6 | 648,200 | 76,860 | 89% | 10-15% | 10-15 lbs. |
| | | | AIN-004 AEN-005 | 21 | 807,000 | 348,300 | 57% | | |
| | | | AEN-007 | 43 | | 915,500 | 0% | | |
| | | | AEN-008 | 70 | | 701,800 | 0% | | |
| | | | AIN-009 AEN-010 | 98 | 768,200 | 689,600 | 0% | | |
| **CANISTER B** | | | | | | | | | |
| PetroLOK™ PL22 | 22-29 Sept 1995 | 10-12 scfm (diluted) | BIN-016 BEN-017 | 0.5 | 414,500 | 1,234 | 99% | 5-7% | 5-7 lbs. |
| | | | BIN-018 BEN-019 | 70 | 403,100 | 164,950 | 59% | | |
| | | | BIN-020 BEN-021 | 120 | 234,010 | 523,800 | 0% | | |
| **CANISTER C** | | | | | | | | | |
| Polymer only (no carbon) | 29 Sept-10 Oct 1995 | 12-13 scfm | CIN-024 CEN-025 | 1 | 685,300 | 728,700 | 0% | 0% | No contaminants removed |
| | | | CIN-026 CEN-027 | 31.5 | 773,100 | 763,800 | 0% | | |
| | | | CIN-028 CEN-029 | 95.5 | 710,500 | 766,400 | 0% | | |

not more than 5 pounds of contaminant had been removed by the media in Canister B. AWS was again contacted and they suspected that the binding agent used to keep the polymer and carbon mixture evenly distributed in the filter canisters during shipping may have something to do with the lack of absorption capacity. AWS suggested testing a canister filled with just the polymer without the binding agent or carbon. AWS also suggested that the direction of flow through the canisters be changed from top to bottom flow to an up-flow (bottom to top) configuration so that the polymer stays separated and uncompacted.

The Canister C test was initiated using only the polymer in the up-flow configuration. In this test a 12-13 scfm, undiluted contaminant stream was routed through the canister. Results from three sets of samples collected from the Canister C influent and effluent vapor streams indicated no absorption of contaminants occurred. Therefore, it was concluded that the binding agent initially suspected of affecting absorption capacity had nothing to do with the problem encountered, and the majority of contaminants removed from the influent waste stream in the Canister A and B tests were most likely removed by the carbon, which was mixed with the polymer in those canisters.

Result highlights are summarized below.

- The maximum absorption capacity of the media observed during the treatability test was between 10% and 15%, which was observed during the Canister A test. Absorption capacity varied between tests from 0% to 15% and appeared to decrease with decreasing flow rate.

- Test results from Canister C, which contained only polymer, indicated 0% absorption capacity. Thus suggesting that the absorption capacities observed in the Canister A and B tests may be attributed mainly to the carbon contained in PetroLOK™ PL22, and the polymer alone was not effective at absorbing VOCs in the vapor phase. If this is the case, a PetroLOK™ PL22 system may only be as efficient as the amount of carbon contained in the filter media.

- Results from tests on all canisters demonstrated no solventizing; these results are consistent with pre-test estimates by AWS that solventizing would not occur below influent concentrations of 900,000 ppbv.

- No significant changes in pressure drop through the treatment canisters occurred during each of the three tests. During the study, pressure drop through the polymer system was measured to determine a relationship to spent capacity. Pressure drop through the polymer filter canisters remained essentially constant from the time each test started to full contaminant breakthrough (i.e., the point at which the media was considered fully spent). During the Canister A test, the pressure drop was approximately 6 inches of water; during the Canister B and C tests, the pressure drop was approximately 1 to 2 inches of water. This amount of pressure drop would be considered insignificant in a full-scale system operation.

- No significant temperature changes through the treatment canisters were observed during the tests. Temperature was measured to determine if chemical reactions (between the contaminants and the filter media) would cause significant temperature changes, and to ensure that the system was not operating above the melting temperature of the polymer (140°F). Temperature measurements indicate that the system was operating within a feasible temperature range.

- The observed PetroLOK™ PL22 absorption capacity for the contaminants of concern are summarized on Table 3-2. These results indicate that PetroLOK™ PL22 does have the ability to remove contaminants from the waste stream; however, significant amounts may be needed to remove contaminants to SMAQMD standards prior to discharge to the atmosphere (especially for highly-contaminated waste streams). To protect public health, welfare, and the environment, the SMAQMD has established rules which limit the amount of hazardous constituents emitted into the atmosphere by treatment technologies implemented in the remediation of hazardous waste sites. Ideally, these technologies must have the ability to remove contaminants to levels that meet SMAQMD limits. The contaminants of concern at the site include TCE, vinyl chloride, benzene, and cis-1,2-DCE, which are considered to be carcinogens, hazardous constituents, and controlled substances.

- A comparison of the PetroLOK™ PL22 absorption capacities with the expected carbon absorption capacities indicates that more PetroLOK™ PL22 than GAC would be needed to remove contaminants to the same levels, because PetroLOK™ PL22 is a blend of polymer and carbon.

- Test results indicate that the applicable range for the PetroLOK™ PL22 technology resembles that of GAC more than of cat-ox since the contaminant removal efficiencies observed during the Canisters A and B tests are comparable. Therefore, only comparisons of the PetroLOK™ PL22 to GAC are warranted. However, the PetroLOK™ PL22 absorption capacities are lower than GAC.

**Table 3-2.**
**Absorption/Adsorption Capacities for Contaminants of Concern**

| Contaminant of Concern | PetroLOK™ PL22 Absorption Capacity by Weight[a] | Carbon Adsorption Capacity by Weight[b] |
|---|---|---|
| TCE | 5 - 14% | 20 - 30% |
| Vinyl Chloride | 0.003 - 0.01% | 0 - 1% |
| Benzene | 0.01 - 0.04% | 20 - 30% |
| cis 1,2-DCE | 0.03 - 0.07% | 7 - 10% |

[a] Based on results from Canister A and B tests. Actual results may vary.
[b] Based on isotherm data obtained from Barnebey & Sutcliffe Corporation and Westates Carbon.

## Quality Assurance/Quality Control

- Results of a quality control data assessment (QCDA) indicate that the data are valid and can be used to evaluate the performance of the media (Appendix C). All data were collected in accordance with the McClellan AFB Basewide RI/FS Quality Assurance Project Plan (QAPP) (Radian, 1994).

## Residuals Management

- Spent polymer media (approximately 200 pounds) was the only residual waste generated using this treatment technology.

- A sample of the spent polymer from Canister A was analyzed by the toxicity characteristic leaching procedure (TCLP) Method SW1331 and Method SW8260 (for VOCs) to determine feasible disposal options. Data indicated that TCE, 1,2-DCA, and benzene leached from the spent media. Concentrations of TCE and 1,2-DCA were above land ban disposal limits as shown in Table 3-3. Therefore, the polymer is considered a RCRA hazardous waste and must be handled accordingly.

**Table 3-3.**
**TCLP Results**

| Contaminant | Leachable Concentration[a] (μg/L) | EPA Land Ban Disposal Limit[b] (μg/L) |
|---|---|---|
| TCE | 14,900 - 15,600 | 6,000 |
| Benzene | 60 | 10,000 |
| 1,2-DCA | 5,830 - 6,550 | 6,000 |

[a] Determined using TCLP/SW8260 analyses.
[b] Obtained from Laidlaw Environmental.

- Research of available disposal options indicate that the spent polymer can be disposed as a RCRA hazardous waste (incinerated, then landfilled) similar to GAC, or can be recycled as a supplemental fuel as long as hazardous contaminants are destroyed in the process. The Air Force's preferred option is recycling.

- The polymer used during the treatability study was disposed in accordance with federal, state, and local regulations. Spent polymer was manifested, transported to the Environmental Resources & Disposal (ER&D), Inc. waste energy facility (Essex Waste Management Services) in Kingsville, Missouri, where it will be incinerated and recycled into electricity for the city. A certificate of recycling and destruction will be forwarded to McClellan AFB.

## 4.0 COST ANALYSIS

Table 4-1 provides a cost comparison between installing and maintaining PetroLOK™ PL22 and GAC systems. The comparison shows that the cost of implementing a PetroLOK™ PL22 system would be significantly higher than implementing a GAC system due to the polymer's higher unit cost than GAC, the greater frequency of replacement, and the higher cost of disposal/recycling. Comparison results are based upon estimates contained in the comments column of Table 4-1.

**Table 4-1.**
**Cost Analysis and Comparison PetroLOK™ PL22 vs. Vapor-Phase GAC**

| Cost Item Description | PetroLOK™ PL22[a] | Vapor-Phase GAC[b] | Comment |
|---|---|---|---|
| **CAPITAL COSTS** | | | |
| Treatment system design and installation | Same | Same | The same system can be used for both technologies. |
| Unit cost per pound | $36/Pound | $1/Pound | Unit costs may vary with quantity purchased. |
| **O&M COSTS** | | | |
| Replacement | Higher | Lower | Based on a comparison of the absorption capacity of the polymer (10-15%) to the adsorption capacity of GAC (20-30%), the polymer would have to be replaced twice as many times as carbon for a comparably sized GAC system. |
| Disposal/Recycling/ Regeneration | $4.50/Pound<br>Based on a quote from ER&D to recycle the polymer for $450/55-gallon drum containing 100 pounds of polymer. | $0.27/Pound<br>Based on quote from Calgon Carbon Corp. to regenerate 30,000 lbs. for $8,150. | Actual costs of disposal, recycling, or regeneration may vary based on quantity and frequency of disposal. |
| Labor | Higher | Lower | The same technique would be used to replace the polymer and the carbon. Therefore, for each changeout event, the cost would be the same. However, due to the number of changeout events, labor cost associated with the polymer would at least be twice as high. |

[a] Costs for the polymer system are based on observations made during the test and information from the vendor.

[b] Costs for the GAC system are based on a quote provided by Calgon Carbon Corporation to replace 30,000 pounds of spent carbon from two adsorbers at IC1 with 40,000 pounds of virgin Filtrasorb 300 carbon using the vacuum-assist method. This quote also provided a cost to return and reactivate the 30,000 pounds of carbon for $8,150.

## 5.0 LESSONS LEARNED

The technology is simple to implement and operate. The procedures for implementation and operation are the same as those for carbon. No difficulties were encountered during system installation, operation, and dismantling or polymer disposal.

Some significant vendor claims regarding PetroLOK™ PL22 could not be substantiated during the evaluation. Those not substantiated are summarized in Table 5-1.

**Table 5-1.**
**Unsubstantiated PetroLOK™ PL22 Features and Benefits[a]**

- Removes up to 400% of its weight in hydrocarbons with minimal volumetric increase. Maximum volumetric increase is estimated to be 20%.
- Up to 99.99% effective in removing VOC contamination.
- Non-toxic, non-corrosive, and environmentally safe.
- Bonded hydrocarbons will not leach from PetroLOK™ PL22 after they are removed from the waste stream.
- Less material used, more contaminants removed, fewer media changes, lower maintenance costs. Reduced amount of waste for disposal, and therefore lower total treatment cost.
- Spent media meets TCLP standards for waste disposal in landfills.
- Absorption capacity is 4 pounds of petroleum hydrocarbon per pound of PetroLOK™ PL22 and 2-3 pounds of chlorinated hydrocarbon per pound of PetroLOK™ PL22.

[a] Features and benefits listed above are those stated by AWS.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the evaluation, the following conclusions and recommendations have been reached:

- It appears that the polymer alone was not effective in absorbing contaminants and the observed removal of contaminants was occurring through the carbon contained in PetroLOK™ PL22.
- A GAC system would be more cost-effective to implement than a PetroLOK™ PL22 system for treating contaminants in the vapor phase.
- There appears to be no real benefit to implementing PetroLOK™ PL22 over GAC for vapor-phase applications because of the media's lower absorption capacity and higher cost.
- Further testing or evaluation of the PetroLOK™ PL22 elastomeric polymer filter media for vapor-phase applications is not recommended at this time.
- More data exist that support the successful use of the PetroLOK™ PL22 for the removal of contaminants in liquid-phase applications (see supporting vendor information included in Appendix D). Further testing of the product for liquid-phase applications may prove beneficial to the Air Force.

## 7.0 REFERENCES

Advanced Water Systems, Inc. Statement of Qualifications and Product Information. Woodinville, WA.

Radian Corporation, 1994. *Installation Restoration Program Basewide RI/FS Quality Assurance Project Plan*. Final. Prepared for United States Air Force, Air Force Center for Environmental Excellence, Environmental Services Office, Environmental Restoration Division (AFCEE/ESR), Brooks AFB/EM, Texas. November.

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