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REMOVAL OF TRICHLORETHYLENE CONTAMINATION FROM DRINKING WATER AT A USAF INSTALLATION

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Trichloroethylene (TCE), a solvent previously used by numerous USAF industrial activities as a degreasing agent, was discovered in relatively high concentrations in the drinking water distribution system at one USAF installation. Various USAF agencies and the U.S. Environmental Protection Agency cooperated in research work to determine the most economically feasible method to remove TCE from the water supply. This report documents the historical aspects of the problem and the results of this phase of the research .

FOREWORD

This report was prepared by Detachment 1 (CEEDO) ADTC, Tyndall AFB FL under Job Order Number CEEDDZØ3.

This report summarizes work done between 1 Aug 77 and 31 Jul 78. Capt Robert G. Perry was the project officer.

This report has been reviewed by the Information Office (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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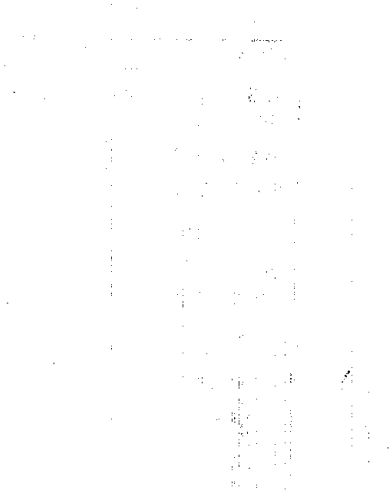

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INTRODUCTION

BACKGROUND

The Headquarters Strategic Air Command Directorate of Engineering (HQ SAC/DE) requested Det 1 ADTC investigate methods to remove trichloroethylene (TCE) from the Pease AFB NH drinking water supply. This work was accomplished in conjunction with ongoing research being conducted by the US Environmental Protection Agency (EPA) and with assistance from the USAF Occupational and Environmental Health Laboratory (OEHL), 509th Combat Support Group Base Civil Engineering personnel and the USAF Hospital, Pease, Environmental Health personnel.

OBJECTIVE

The objective of this report is to provide interim information on the discovery and nature of the TCE contaminated drinking water problem at Pease AFB NH and the research involved in finding a tentative solution to that problem. A final report shall be rendered upon completion of ongoing research by EPA.

SCOPE

This report details the history of this effort from discovery of the TCE contamination problem through the termination of bench scale field studies conducted at Pease AFB. Also discussed are ongoing efforts by the EPA to determine the most cost effective method to remove TCE from drinking water supplies.

SECTION II

HISTORICAL REVIEW OF THE PROBLEM

INTRODUCTION

This section provides a chronological review of the major events associated with this effort.

THE PROBLEM

During early 1977 Pease AFB residents complained of taste and odor problems with the base drinking water. In March 1977 the Base Bioenvironmental Engineer responded by passing a quantity of the base's drinking water through an activated charcoal cannister and forwarding the cannister to the USAF OEHL for analysis. The analysis revealed a significant concentration of TCE present in the sample. Further analysis during 24 May through 20 Jun 77 of Pease AFB drinking water by the EPA and a commercial laboratory verified the presence of TCE. Those analysis revealed the following TCE concentrations:

SAMPLE LOCATION	TCE CONCENTRATION IN PARTS PER BILLION (ppb)
Haven Well	69-390
Harrison Well	1.3-31
Smith Well	None detected

This information is particularly significant because the Haven Well provided 80 percent of the Pease AFB water supply with the Harrison and Smith Wells each contributing equal shares to the remaining demand.

PROBLEM SOLUTION INITIATIVES

Personnel from the OEHL conducted a staff assistance visit to Pease AFB during Jul-Aug 77 to gather background data on the base water supply and distribution system from which a continuing monitoring program was established. During their visit, OEHL personnel examined two, 1200 gallon underground waste TCE holding tanks. One tank contained approximately 1000 gallons of a liquid containing 79 percent TCE by volume while the balance was a silicone fluid similar to OS-45 Type II lubricating oil for aircraft weapons. The remaining tank contained water with traces of TCE in the 10 ppm range. OEHL also provided liaison assistance to the US Geological Survey (USGS) in support of a USGS team also addressing the TCE problem at Pease AFB.

At the request of HQ USAF/PRE, the USGS initiated a well sampling program at Pease AFB in July 1977. The purpose of this program was to:

(1) Identify the hydrocarbon compounds present in the sand and gravel aquifer underlying Pease AFB through USGS sample analysis.

(2) Determine the horizontal and vertical extent of the contamination. This was to be accomplished by drilling test wells.

(3) To identify the source and direction of movement of TCE contamination.

(4) Identify alternative action for providing clean water needed to meet base demands.

The Pease AFB water distribution system was constructed to permit segregation of the base industrial area from the residental/office areas. Commencing on 21 Jul 77, flow to these areas was segregated. Water from the Haven Well was supplied to the industrial area while water from the Smith Well and water purchased from the local community was supplied to the residential/office areas through the end of July 1978.

During August 77, The Headquarters Strategic Air Command Directorate of Engineering (HQ SAC/DE) requested Det 1 ADTC investigate methods to remove TCE from Pease AFB drinking water and provide HQ SAC/DE with the best practicable method to accomplish removal.

A literature search was conducted to determine methods to remove TCE from drinking water. The results of the literature research revealed that background information on TCE removal was extremely limited. Officials at the EPA's laboratoy in Cincinnati, Ohio were contacted to determine if research was currently being conducted on this problem. EPA personnel reported that bench scale TCE removal tests were currently being conducted in Plainville, Connecticut and Newport, Rhode Island. EPA officials were aware of the Pease AFB problem and agreed to meet with USAF personnel to discuss the problem.

The EPA-USAF meeting was held on 27 Oct 77. Representatives from the EPA, the HQ SAC Surgeon's Office, the HQ SAC Directorate of Engineering, the OEHL, the Pease AFB Civil Engineer's Office and Det 1 ADTC were in attendance. From this meeting, it was determined that:

(1) The EPA would fabricate and install at Pease AFB, a bench scale TCE removal apparatus similar to the two already in use in New England.

(2) Pease AFB personnel would be responsible for operation of the TCE removal apparatus and sample collection.

(3) OEHL and EPA would analyze the samples.

(4) Det 1 ADTC would:

(a) Act as a data repository.

(b) Monitor the EPA's findings at their other New England test sites.

(c) Reduce all data and recommend a treatment system for the Pease AFB drinking water supply.

e. The USGS role, which was independent of this USAF-EPA effort, was not discussed.

The EPA fabricated and installed two bench scale water treatment columns at Pease AFB during Nov 77. The physical features and operating characteristics are described in Section III. The beds were operated successfully for 17 weeks. During week 18 the beds became plugged, which required disassembly and cleaning. The results obtained after the 18th week are not considered valid. This will be discussed in Section IV.

A meeting to discuss and evaluate the results of the Pease AFB study was held on 7 Jun 78 at the EPA Laboratory, Cincinnati, Ohio. This will be discussed in Section V. In addition, follow-on work at Pease or Wurtsmith AFB (which is also experiencing a TCE problem) by the EPA was discussed. In lieu of work at either of these bases, Det 1 ADTC will monitor a large scale TCE removal study to be conducted on Long Island by EPA. The study will commence during Oct 78 and be completed during mid-summer 79. The effort will involve further research on TCE removal from water supplies.

SECTION III

BENCH SCALE COLUMN CHARACTERISTICS AND OPERATING PARAMETERS

CHARACTERISTICS

LENGTH

Activated Carbon (Calgon Filtrasorb 400)	32 inches (81.3 cm)
Ambersorb XE-340 (Rohm & Haas)	29 inches (73.7 cm)

DIAMETER

Both Columns	1½ inches (3.8 cm)
Bed Surface Area	1.77 sq in (11.34 sq cm)

BED VOLUME

Activated Carbon	56.5 cu in (921.6 cu cm)
Ambersorb XE-340	51.2 cu in (835.4 cu cm)

OPERATING PARAMETERS

Hydraulic Loading Rate: 100 ML/min

Operational Mode: Packed bed, continuous down flow

Temperature: Raw water - approximately 11°C
Ambient - approximately 16°C

Empty Bed Contact Time: approximately 9 minutes

Column influent is taken from the system side of the check value prior to chemical addition. The column plumbing schematic is shown in Figure 1.

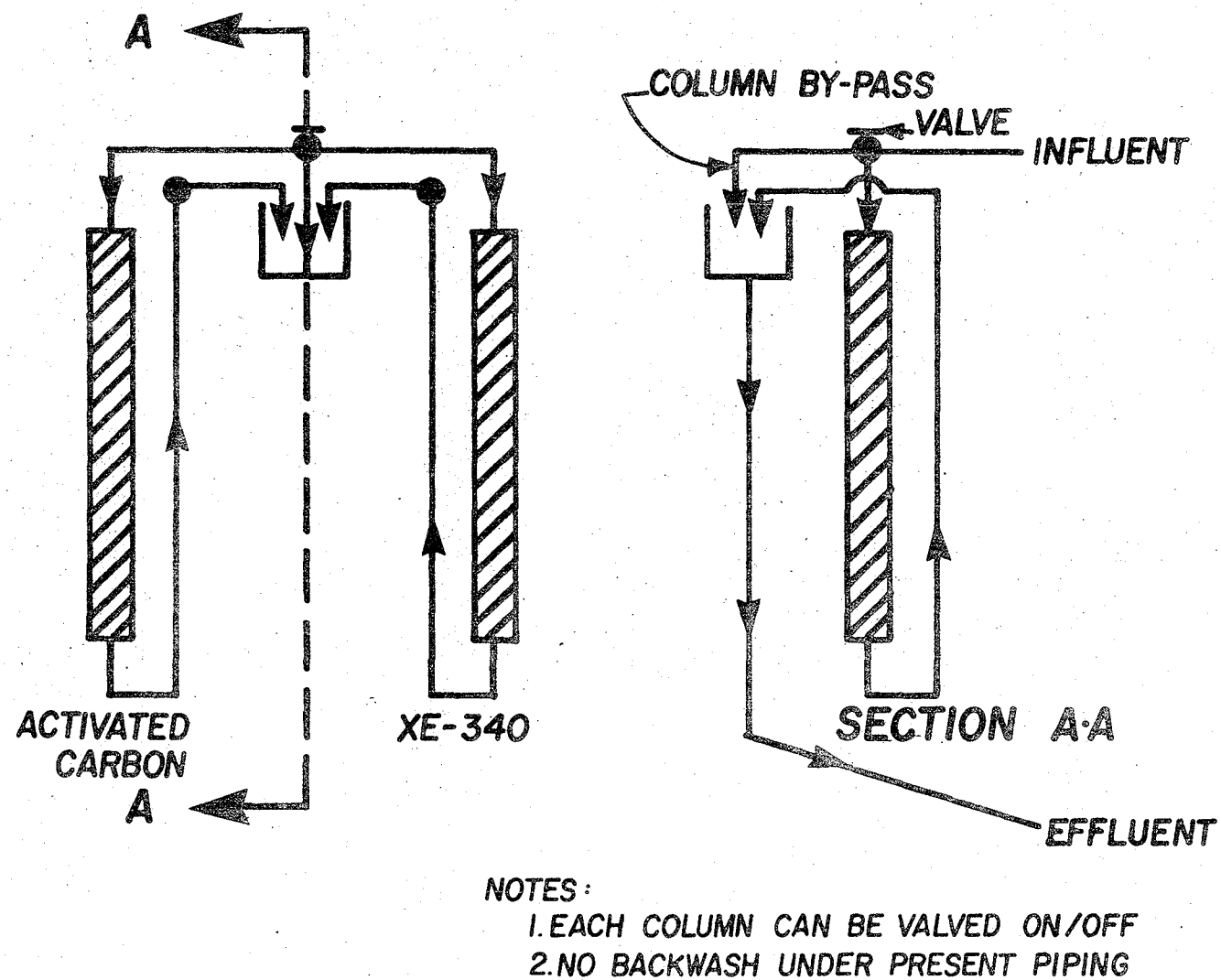

Figure 1. Test Apparatus Plumbing Scheme

SECTION IV

RESULTS OF THE PEASE AFB STUDY

The data gathered during this study is presented in tabular form in Table 1 and displayed graphically in Figures 2 and 3.

During week 18 both columns became plugged at the influent/adsorbent interface. Backwashing did not remove the material responsible for plugging the columns. The columns were dismantled by Pease AFB personnel and the material physically removed. Samples of the plugging material were not obtained. During reassembly of the test apparatus, Pease AFB personnel attempted to return the adsorbent to its original position in the column. This procedure was unsuccessful as indicated by column effluent data from weeks 19 to 23. The data shows TCE concentrations were as much as 850 times the effluent TCE concentration prior to column plugging and subsequent disassembly. Because TCE is removed by adsorption, it was theorized that disassembly of the columns disturbed the original organic front and consequently seriously degraded the columns' capability to remove TCE and organics. Therefore, column effluent data collected from weeks 19 to 23 is considered unreliable.

Both the F-400 and the XE-340 were highly effective in their removal of TCE from the Pease AFB drinking water supply. From the data (Table 1) it appears that breakthrough of Cis-1,2-Dichloroethylene in the activated carbon column occurred during week 14. The activated carbon performance decreased to the point where desorption apparently occurred during weeks 16 and 17. Unfortunately, due to the column plugging problem, the Pease AFB test could not be carried to adsorbent exhaustion. However, ongoing testing by the EPA at the Rhode Island and Connecticut test sites should produce conclusive data on TCE breakthrough of both adsorbents.

In addition to the New England testing, the EPA is to begin a TCE removal study in Long Island, New York, during early FY79. These studies will use larger diameter columns and will include variations of: hydraulic loading rates, influent contaminant concentration levels and column detention time. Also included in the study is determination of efficient adsorbent regeneration methods and the efficiency of the regenerated adsorbents to remove TCE and other materials.

TABLE 1. ADSORPTION OF TRACE ORGANICS AT PEASE AIR FORCE BASE (HAVEN WELL)
PORTSMOUTH, NEW HAMPSHIRE
(Nov 1977 - May 1978)
All Concentrations in µg/ℓ (ppb)

Time in Service, Weeks		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Contaminant	Packing Mat'ls																								
Trichloroethylene		195.8	239.0	164.3	250.5	276.2	(a)	132.9	(b)	125.5	132.4	(a)	119.9	(b)	(a)	166.5	226.0	124.0	158.8	(a)	142.0	223.7	193.2	192.0	193.6
($CHCl = CCl_2$)	F-400	<0.1	0.1	<0.1	0.3	<0.1		NF	NF	NF	NF		<0.1	<0.1		<0.1	<0.1	<0.1	<0.1		70.0	56.5	85.6	90.4	91.0
	XE-340	NF	NF	<0.1	NF	NF		NF	NF	<0.1	<0.1		<0.1	<0.1		<0.1	<0.1	NF	(b)		2.3	1.7	3.0	3.4	11.8
Cis-1,2-Dichloroethylene		5.3	8.1	5.3	6.0	9.3		4.6	(b)	4.5	4.6		4.5	(b)		9.6	3.0	3.8	5.6		4.4	9.8	6.2	6.0	6.4
(CHCl = CHCL)	F-400	NF	NF	<0.1	NF	NF		NF	NF	NF	NF		<0.1	0.6		3.6	1.4	5.6	7.3		16.1	17.2	18.2	15.5	8.9
	XE-340	NF	NF	<0.1	NF	NF		NF	NF	NF	NF		<0.1	<0.1		<0.1	NF	<0.1	(b)		0.3	0.3	0.5	0.5	NF
Tetrachloroethylene		1.9	1.6	1.3	4.5	3.3		1.3	(b)	1.2	1.3		1.3	(b)		1.4	1.2	0.8	0.2		<0.1	<0.3	<0.1	0.4	<0.1
($Cl_2C = CCl_2$)	F-400	0.2	NF	NF	NF	0.4		<0.1	NF	NF	NF		NF	<0.1		<0.1	<0.1	NF	NF		NF	0.1	NF	NF	NF
	XE-340	NF	NF	NF	NF	NF		NF	NF	<0.1	<0.1		NF	<0.1		<0.1	NF	NF	(b)		NF	NF	NF	NF	NF
1,1-Dichloroethane		<0.1	<0.1	<0.1	NF	0.2		<0.1	(b)	<0.1	<0.1		<0.1	(b)		0.1	0.1	NF	<0.1		NF	<0.1	NF	NF	<0.1
(CH_3CHCl_2)	F-400	NF	NF	<0.1	NF	NF		NF	NF	<0.1	NF		<0.1	0.1		0.2	0.1	0.1	0.1		<0.1	<0.1	<0.1	NF	NF
	XE-340	NF	NF	<0.1	NF	NF		NF	NF	NF	NF		<0.1	NF		<0.1	<0.1	NF	(b)		NF	NF	NF	NF	NF
1,1,1-Trichloroethane		0.3	0.7	<0.1	2.4	1.3		0.2	(b)	0.2	0.2		0.3	(b)		0.9	0.9	0.2	0.4		1.4	1.5	0.2	0.6	0.6
($C_1H_3Cl_3$)	F-400	NF	<0.1	<0.1	0.1	NF		NF	NF	NF	NF		<0.1	<0.1		0.3	0.3	0.4	0.1		1.4	1.6	1.4	1.2	1.1
	XE-340	NF	NF	<0.1	NF	NF		NF	NF	NF	NF		NF	<0.1		<0.1	NF	<0.1	(b)		NF	NF	<0.1	<0.1	NF

a = No Samples Received

b = Samples Broken in Shipment

NF = None Found

Columns disassembled and cleaned during 18th week.

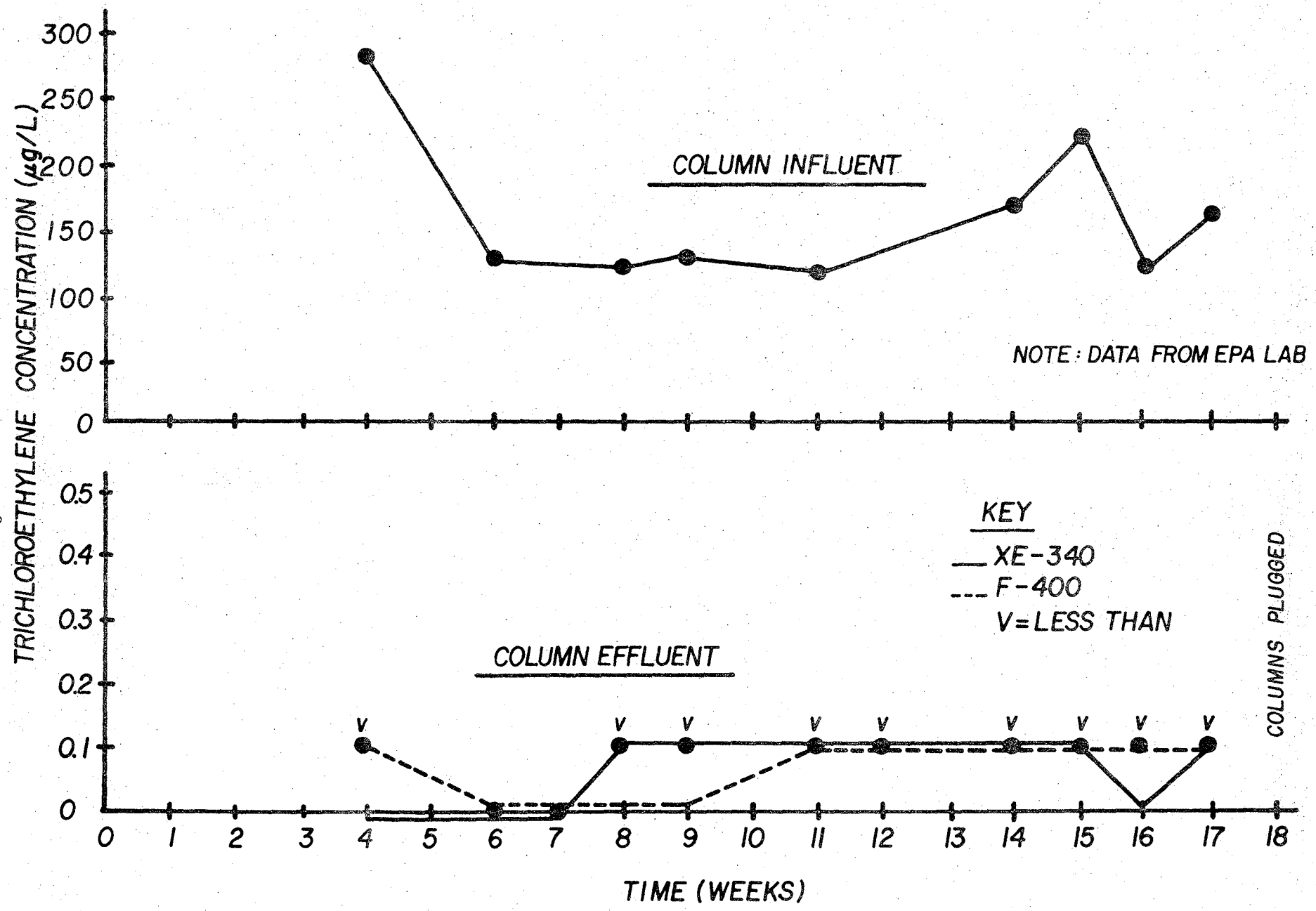

Figure 2. Trichloroethylene Influent/Effluent Data: Weeks 1-18

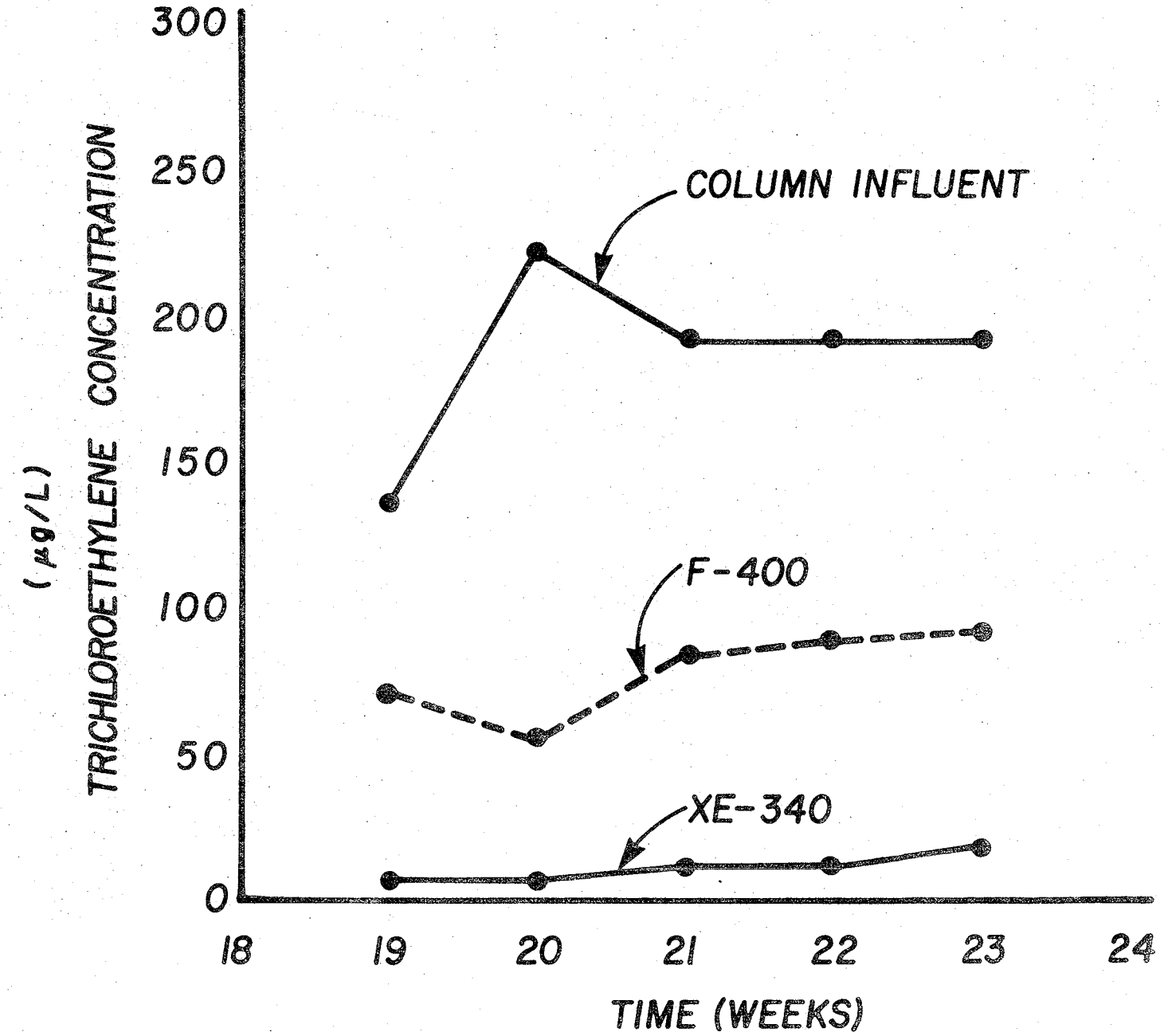

Figure 3. Trichloroethylene Influent/Effluent Data: Weeks 19-23

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

Based on this abbreviated study both adsorbents, the activated carbon and the Rohm and Haas resin, are suitable for use in a packed bed system to remove TCE from a drinking water supply. However, the relative efficiencies of the materials have not yet been determined.

The EPA's proposed Long Island NY study will determine the most economically efficient adsorbent to remove TCE from drinking water and the most efficient methods to regenerate the adsorbents.

Det 1 AFESC/ECW will monitor the entire EPA Long Island NY study, analyze the data from an Air Force requirements standpoint and determine if additional research is required to solve possible Air Force unique problems.

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