NOSE DOCK 8 (SS-016)
WORK PLAN

Plattsburgh Air Force Base Installation Restoration Program

DEPARTMENT OF THE AIR FORCE · UNITED STATES OF AMERICA · MCMXLVII

prepared for:

United States Department of The Air Force
Plattsburgh Air Force Base
Plattsburgh, New York

Final Report
October 1996

G2353

15 (12/75)

New York State Department of Environmental Conservation

MEMORANDUM

TO: Daniel Steenberge, RHWRE, Region 5 - Ray Brook
FROM: Marsden Chen, Bureau of Eastern Remedial Action
SUBJECT: Plattsburgh Air Force Base ID No. 510003

DATE: October 31, 1996

Attached is a copy of the final work plan for Nose Dock 8 (SS-016) at the Plattsburgh Air Force Base site.

Please have staff review this document to ensure that all comments have been addressed and, if not, please send your comments to Jim Lister, of my staff, by November 15, 1996.

If you have any questions, please contact him at (518) 457-3976.

Attachment

Marsden Chen

ENVIRONMENTAL CONSERVATION DEPT.
RECEIVED
NOV 4 1996
REGIONAL ENGINEER, REGION 5
RAY BROOK, NY 12977

NOSE DOCK 8 (SS-016)
WORK PLAN

PLATTSBURGH AIR FORCE BASE
INSTALLATION RESTORATION PROGRAM

PLATTSBURGH, NEW YORK

FINAL REPORT

OCTOBER 1996

PREPARED BY:

URS CONSULTANTS, INC.

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EXECUTIVE SUMMARY

This Work Plan describes the proposed plan for implementation of a treatability study at the Nose Dock 8 (SS-016) site at Plattsburgh Air Force Base. The study will include installation of a full-scale treatment system, including components to "pump and treat" groundwater and treat contaminated soil by soil vapor extraction.

The objective of the treatability study will be to evaluate the effectiveness of the treatment system, which originally was proposed in the *Draft Engineering Evaluation/Cost Analysis (EE/CA)* report (URS 1995a).

The scheduled duration of the treatability study is 9 months. At the end of this period, data collected during the operation of the system will be compiled and evaluated. A treatability study report subsequently will be submitted to the United States Environmental Protection Agency and the New York State Department of Environmental Conservation for review. The report will be used to evaluate potential future actions and will serve as a basis for revisions to the EE/CA and preparation of decision documents.

1.0 INTRODUCTION

1.1 Scope

This Treatability Study Work Plan is being prepared as part of the United States Air Force (USAF) Installation Restoration Program (IRP) at the Plattsburgh Air Force Base (PAFB). The IRP is administered by the Air Force Base Conversion Agency (AFBCA) in accordance with the interagency Federal Facilities Agreement (Docket No: II-CERCLA-FFA-10201) among the USAF, the United States Environmental Protection Agency (USEPA), and the New York State Department of Environmental Conservation (NYSDEC). The purpose of this Work Plan is to present a description of the approach to construction and operation of a treatability study at the Nose Dock 8 (SS-016) site (Figure 1-1).

The primary objective of the treatability study will be to evaluate the effectiveness of the removal action recommended in the *Draft Engineering Evaluation/Cost Analysis (EE/CA)* report (URS 1995a) to accomplish groundwater remediation--in particular, to estimate the time required to meet the removal action objectives. The treatability study will employ a full-scale system during the period of operation. This full-scale system will serve to immediately begin the remediation process and will provide data from operation of the system that will be used to evaluate system effectiveness. The treatability study results will be used as the basis for subsequent revisions of the EE/CA and decision documents.

1.2 Background

Nose Dock 8 was used for aircraft painting and maintenance. The major source of contamination at the site was a former underground storage tank (UST) that ruptured in 1987. The principal constituents of concern from this spill were reported to be 2-butanone, methylene chloride, toluene, xylenes, ethylbenzene, and trichloroethene. The UST subsequently was filled with concrete. Other potential sources of contamination at the site are related to leaks in below-grade piping that connected the UST to a former aboveground storage tank and floor drains.

Based on the results of the *Draft Remedial Investigation* (RI) report, URS Consultants, Inc. (URS) identified an approach to remediation and a plan for implementation of a treatability study to evaluate that approach in an Initial Screening of Alternatives (ISOA) letter (URS 1994a; 1994b). The approach to remediation was further evaluated in the EE/CA report (URS 1995a). The basic components of the recommended approach include the following:

- Groundwater Collection - Installation of an extraction well and groundwater pump to extract contaminated groundwater.

- Groundwater Treatment - Installation of an air stripper and carbon adsorption system to remove organic compounds from groundwater.

- Soil Treatment - Installation of a soil vapor extraction (SVE) system to treat contaminated subsurface soil.

- Treated Water Discharge - Discharge of groundwater to either the existing storm sewer or an infiltration gallery after treatment.

Additional field work was performed in September and October of 1995, and a draft final RI report (URS 1995b) was issued. The additional field work more clearly defined the nature and extent of contamination at the site, and confirmed that the recommended approach to the treatability study was sound. On this basis, AFBCA has initiated implementation of the treatability study with this Work Plan.

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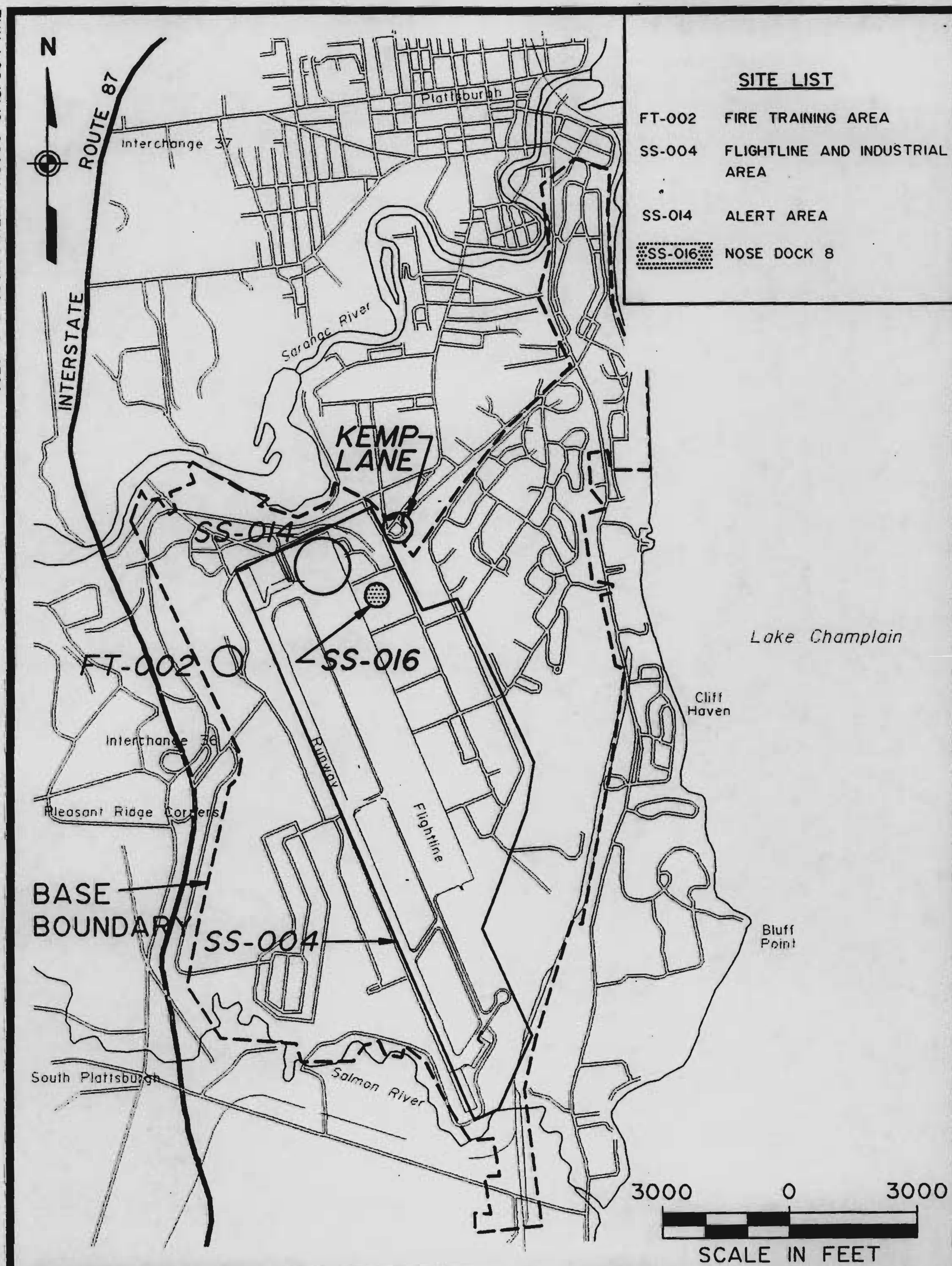

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SITE LOCATION MAP

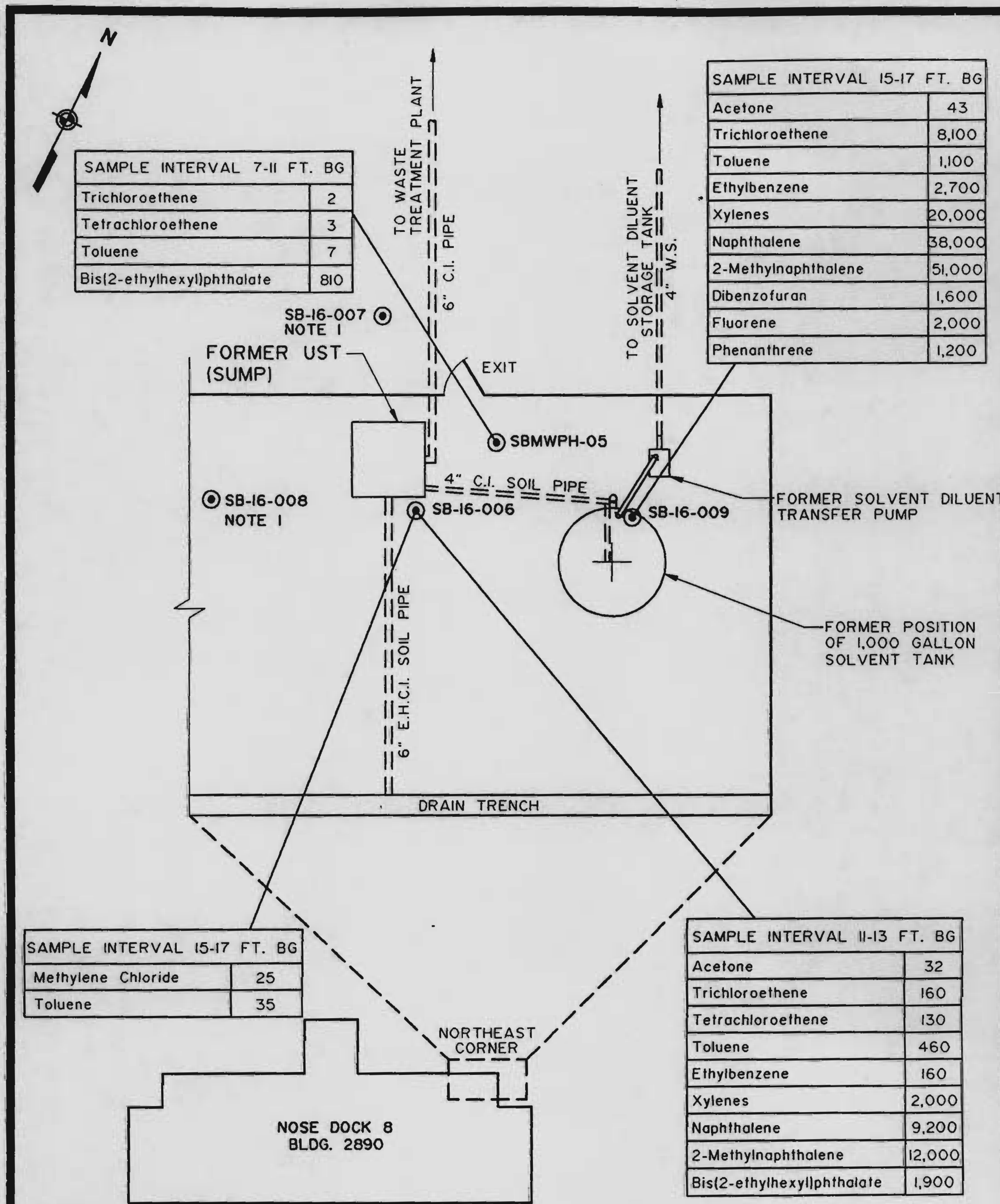
FIGURE 1-1

2.0 NATURE AND EXTENT OF CONTAMINATION

The overall objective of the treatability study is to evaluate the effectiveness of combined SVE and pump and treat systems in remediating contaminated soil and groundwater to acceptable levels. Remediation effectiveness is dependent on the nature and extent of groundwater contamination (i.e., dissolved chemicals) and soil contamination (both above and below the water table), which can impact groundwater quality.

The results of subsurface soil sampling in potential source areas are summarized in Figures 2-1 and 2-2. Soil contaminants were detected above the water table near the former UST and below the water table near the former UST and the former 1,000 gallon aboveground solvent tank. The most significant soil contamination above the water table, however, is directly adjacent to the former UST (SB-16-006) and below the water near the former solvent tank (SB-16-009). Based on the history of site operations and data from the RI report, (URS 1995b), it appears that potential sources of groundwater contamination are located above the water table in areas immediately east and south of the former UST and below the water table in the immediate vicinity of the former aboveground solvent tank.

Groundwater analytical results are summarized in Tables 2-1 and 2-2. Principal chemical groups detected in groundwater include: BTEX (benzene, toluene, ethylbenzene, xylene), chlorinated hydrocarbons, ketones, and napthalenes. The extent of groundwater contamination is represented by Figures 2-3 and 2-4 which show the horizontal and vertical extent of chlorinated hydrocarbons, respectively. Groundwater contamination appears to be centered approximately at MW-16-004 where the highest concentrations of contaminants were detected. The horizontal and vertical extent of contamination varies somewhat based on the type of chemical, but patterns of contamination for all groups are similar.



SAMPLE INTERVAL 7-11 FT. BG	
Trichloroethene	2
Tetrachloroethene	3
Toluene	7
Bis(2-ethylhexyl)phthalate	810

SAMPLE INTERVAL 15-17 FT. BG	
Acetone	43
Trichloroethene	8,100
Toluene	1,100
Ethylbenzene	2,700
Xylenes	20,000
Naphthalene	38,000
2-Methylnaphthalene	51,000
Dibenzofuran	1,600
Fluorene	2,000
Phenanthrene	1,200

SAMPLE INTERVAL 15-17 FT. BG	
Methylene Chloride	25
Toluene	35

SAMPLE INTERVAL 11-13 FT. BG	
Acetone	32
Trichloroethene	160
Tetrachloroethene	130
Toluene	460
Ethylbenzene	160
Xylenes	2,000
Naphthalene	9,200
2-Methylnaphthalene	12,000
Bis(2-ethylhexyl)phthalate	1,900

NOTES:

ALL CONCENTRATIONS REPORTED IN µg/kg (ppb)

1. SOIL NOT SAMPLED IN THESE LOCATIONS, HOWEVER; PID SCREENING INDICATES THESE BORINGS ARE NOT CONTAMINATED..

ABBREVIATIONS

BG - BELOWGROUND

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SUBSURFACE SOIL RESULTS SUMMARY

FIGURE 2-1

\35291.12\CAD\SS016\TREAT\ 1=10 6/27/96-3 ELB

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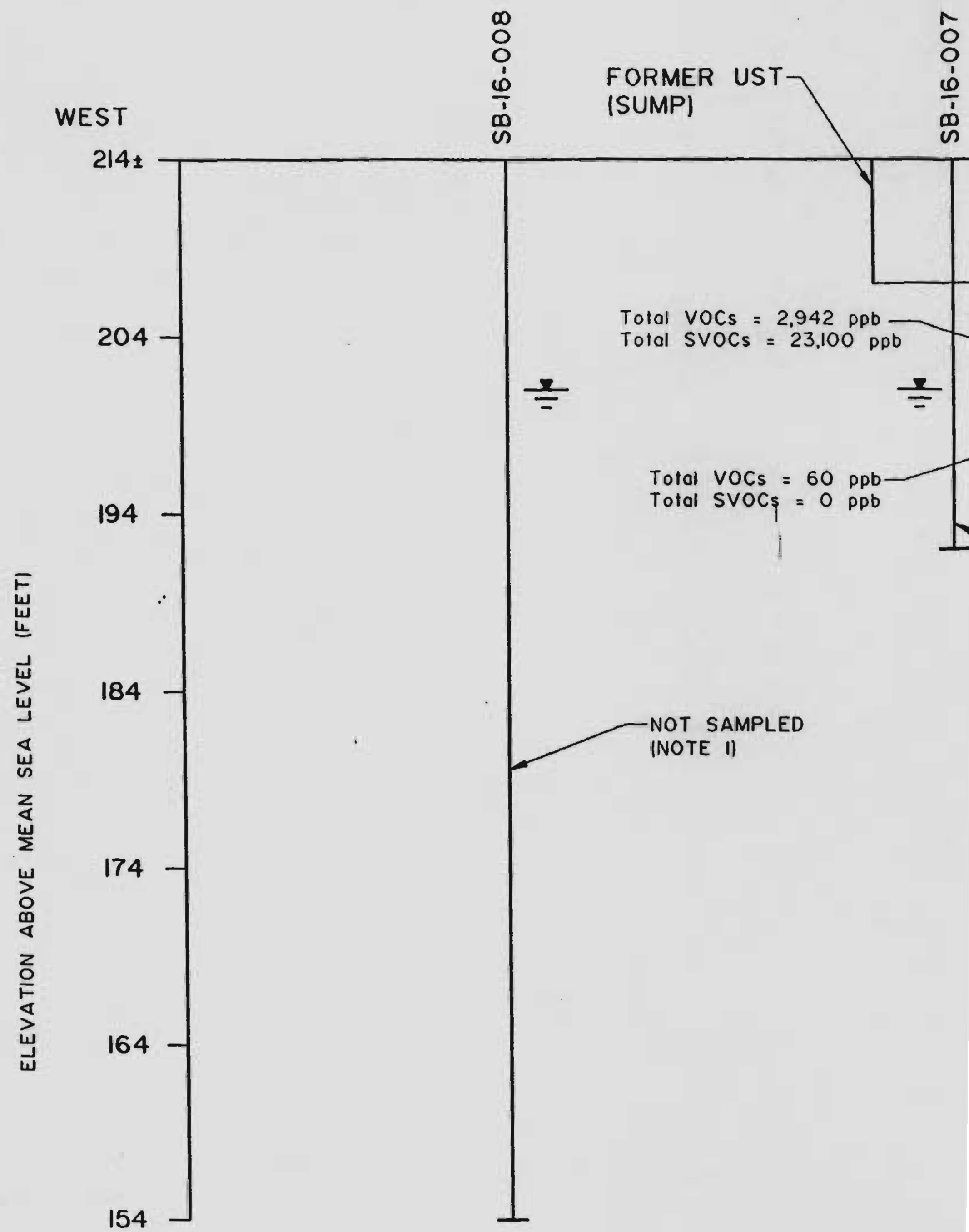
J:\0535291.12\CAD\SS016\TREAT\ 1=5 6/24/96-2 ETM



LEGEND

SB-16-005 ← SOIL BORING NUMBER

GROUNDWATER POTENTIOMETRIC SURFACE

SUBSURFACE SOIL SAMPLE

BOREHOLE TERMINATION

ABBREVIATIONS

VOC	VOLATILE ORGANIC COM
SVOCs	SEMI-VOLATILE ORGANIC

NOTES:

1. SOIL NOT SAMPLED IN THESE LO(INDICATES THESE BORINGS ARE N(
2. ELEVATIONS BASED ON NAVD 198(
3. WATER LEVELS BASED ON SOIL E IN SEPTEMBER 1995.

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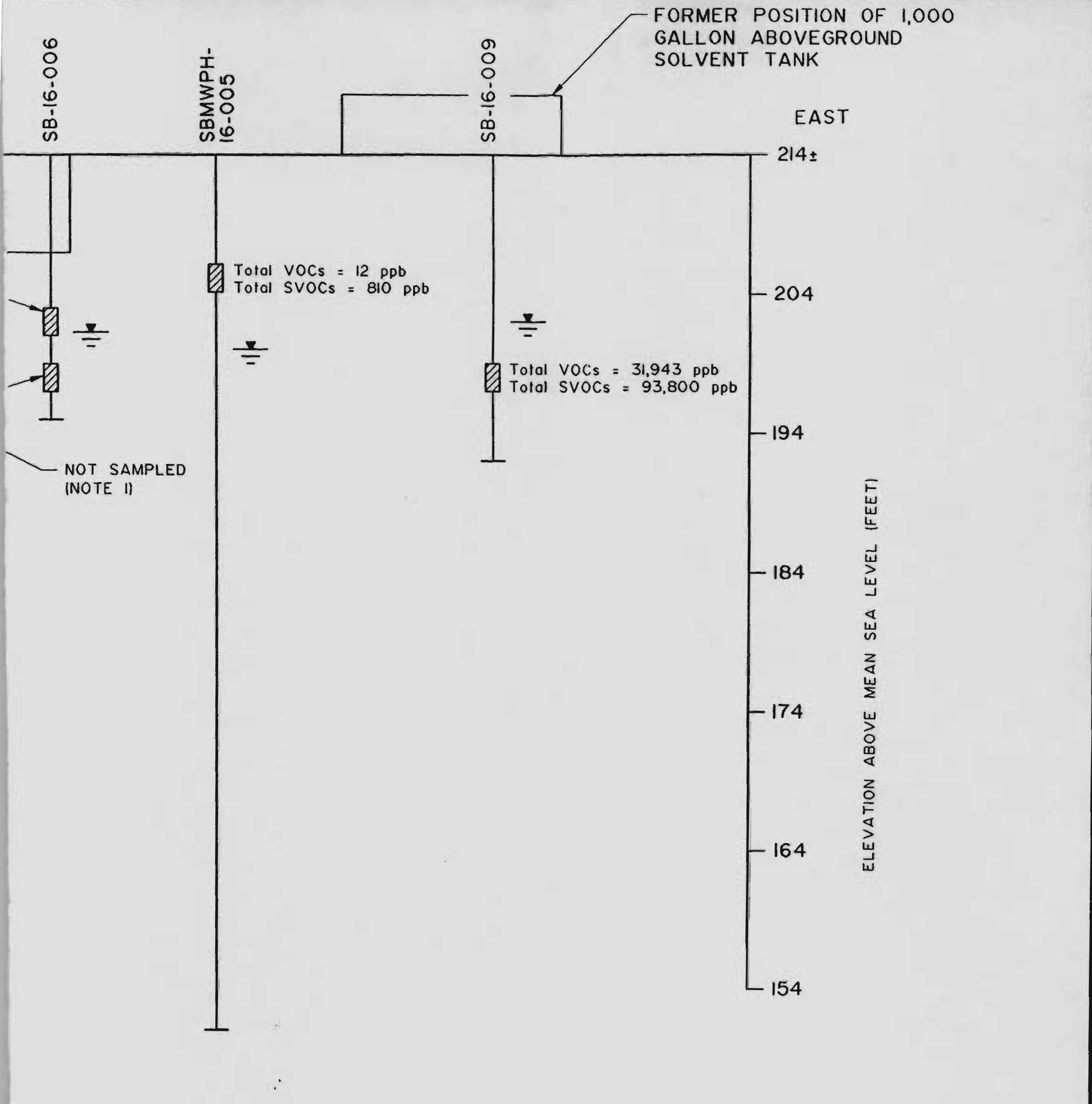

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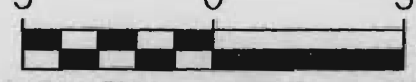

HORIZONTAL SCALE IN FEET

VERTICAL EXAGGERATION = 2X

TIONS; HOWEVER, PID SCREENING
CONTAMINATED.

RING LOGS. BORINGS INSTALLED

VERTICAL REPRESENTATION OF SUBSURFACE SOIL RESULTS

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FIGURE 2-2

TABLE 2-1

NOSE DOCK 8 (SS-016) - TREATABILITY STUDY WORK PLAN
GROUNDWATER RESULTS - ROUNDS 1 AND 2

ANALYTE	AVERAGE[1] LOCAL BACKGROUND CONCENTRATION	** ARAR VALUE	ROUND - 1 - January 1994					ROUND - 2 - February 1994				
			FREQUENCY OF DETECTION	DETECTED MINIMUM CONCENTRATION	DETECTED MAXIMUM CONCENTRATION	AVERAGE OF DETECTIONS	LOCATION OF MAXIMUM DETECTION	FREQUENCY OF DETECTION	DETECTED MINIMUM CONCENTRATION	DETECTED MAXIMUM CONCENTRATION	AVERAGE OF DETECTIONS	LOCATION OF MAXIMUM DETECTION
Acetone	ND	50	2/6	18	32	25	MW-16-004	2/6	9.2	13	11.1	MW16-007
Carbon Disulfide	ND	50	1/6	2	2	2	MW-16-003	1/6	1.1	1.1	1.1	MW16-007
1,1-Dichloroethane	ND	5	—	—	—	—	—	1/6	3	3	3	MW-16-004
1,2-Dichloroethene (total)	ND	5	1/6	42	42 *	42	MW-16-004	2/6	1	28	14.5	MW-16-004
Chloroform	ND	7	1/6	28	28	28	MW-16-007	—	—	—	—	—
1,2-Dichloroethane	ND	5	1/6	4	4	4	MW-16-005	1/6	1.1	1.1	1.1	MW16-005
2-Butanone	ND	50	1/6	16	16	16	MW-16-004	—	—	—	—	—
1,2-Dichloropropane	ND	5	1/6	10	10	10	MW-16-004	—	—	—	—	—
Trichloroethene	ND	5	2/6	1	110	55.5	MW-16-004	2/6	1.1	100	50.6	MW-16-004
Toluene	ND	5	1/6	88	88	88	MW-16-004	1/6	78	78	78	MW-16-004
Ethylbenzene	ND	5	1/6	38	38	38	MW-16-004	1/6	33	33	33	MW-16-004
Xylene (total)	ND	5	1/6	250	250 *	250	MW-16-004	1/6	220	220	220	MW-16-004
1,2-Dichlorobenzene	ND	4.7	1/6	2	2	2	MW-16-004	1/6	1	1	1	MW-16-004
2-Methylphenol	ND	1	—	—	—	—	—	1/6	3	3	3	MW-16-004
4-Methylphenol	ND	1	1/6	110	110	110	MW-16-004	1/6	79	79	79	MW-16-004
Naphthalene	ND	10	3/6	0.8	130	43.9	MW-16-004	2/6	1	170	85.5	MW-16-004
2-Methylnaphthalene	ND	50	2/6	8	43	25.5	MW-16-004	2/6	13	70 *	41.5	MW-16-004
Diethylphthalate	ND	50	—	—	—	—	—	1/6	5	5	5	MW-16-004
bis(2-Ethylhexyl)phthalate	ND	50	3/6	1	2	1.7	MW-16-005, MW-16-007	—	—	—	—	—
Arsenic (unfiltered)	20.1	25	2/6	1.9	26.3	13.35	MW-16-001	2/6	2.1	14.6	8.35	MW-16-004
Barium (unfiltered)	165	1,000	5/6	25.5	90.9	50.1	MW-16-004	5/6	20.2	231	71.88	MW-16-002
Chromium (unfiltered)	7.35	50	3/6	4.6	24.3	11.53	MW-16-004	1/6	5.3	5.3	5.3	MW-16-001
Lead (unfiltered)	17.75	15	3/6	1.4	27.6	11.4	MW-16-004	3/6	1.6	5.7	4.1	MW-16-004
Silver (unfiltered)	ND	50	—	—	—	—	—	1/6	6.5	6.5	6.5	MW-16-005
Arsenic (filtered)	ND	25	1/6	11.2	11.2	11.2	MW-16-004	2/6	2.5	11.3	6.9	MW-16-004
Barium (filtered)	77.25	1,000	5/6	29.6	94.6	54.58	MW-16-004	5/6	26.3	97.7	48.52	MW-16-004
Chromium (filtered)	ND	50	1/6	4.7	4.7	4.7	MW-16-004	—	—	—	—	—
Lead (filtered)	ND	15	—	—	—	—	—	2/6	1.7	2.3	2	MW-16-002

Results reported in µg/l.
1 - Average local background concentration from MW-16-001
ARAR - "Applicable or Relevant and Appropriate Requirements"
** - ARAR value from Table 4-1 of RI Report (URS 1995b)
Source: URS Consultants, Inc., 1194f

— - Indicates analyte was analyzed for but not detected.
* Maximum from duplicate sample.
(shaded) - Exceeds ARAR.
ND - Not Detected.

TABLE 2-2

NOSE DOCK 8 (SS-016) - TREATABILITY STUDY WORK PLAN
GROUNDWATER RESULTS - ROUND 3

ANALYTE	AVERAGE[1] LOCAL BACKGROUND CONCENTRATION	** ARAR VALUE	ROUND - 3[2] - September 1995				
			FREQUENCY OF DETECTION	DETECTED MINIMUM CONCENTRATION	DETECTED MAXIMUM CONCENTRATION	AVERAGE OF DETECTIONS	LOCATION OF MAXIMUM DETECTION
Acetone	ND	50	2/7	25	140	82.5	MW-16-004
1,2-Dichloroethene (total)	ND	5	3/7	3	11	8	MW-16-004DUP
1,2-Dichloropropane	ND	5	2/7	7	8	7.5	MW-16-004DUP
Trichloroethene	ND	5	3/7	1	72	42.67	MW-16-004DUP
Toluene	ND	5	2/7	38	51	44.5	MW-16-004DUP
Ethylbenzene	ND	5	2/7	8	14	11	MW-16-004DUP
Xylene (total)	ND	5	2/7	79	112	95.5	MW-16-004DUP

Results reported in µg/l.

1 - Average local background concentration from MW-16-001

2. Only wells MW-16-004, MW-16-005, MW-16-008, MW-16-009, PZ-2S, and PZ-2I were sampled during Round - 3.

[shaded] - Exceeds ARAR.

ARAR - "Applicable or Relevant and Appropriate Requirements"

** - ARAR value from Table 4-1 of RI Report (URS 1995b)

ND - Not Detected

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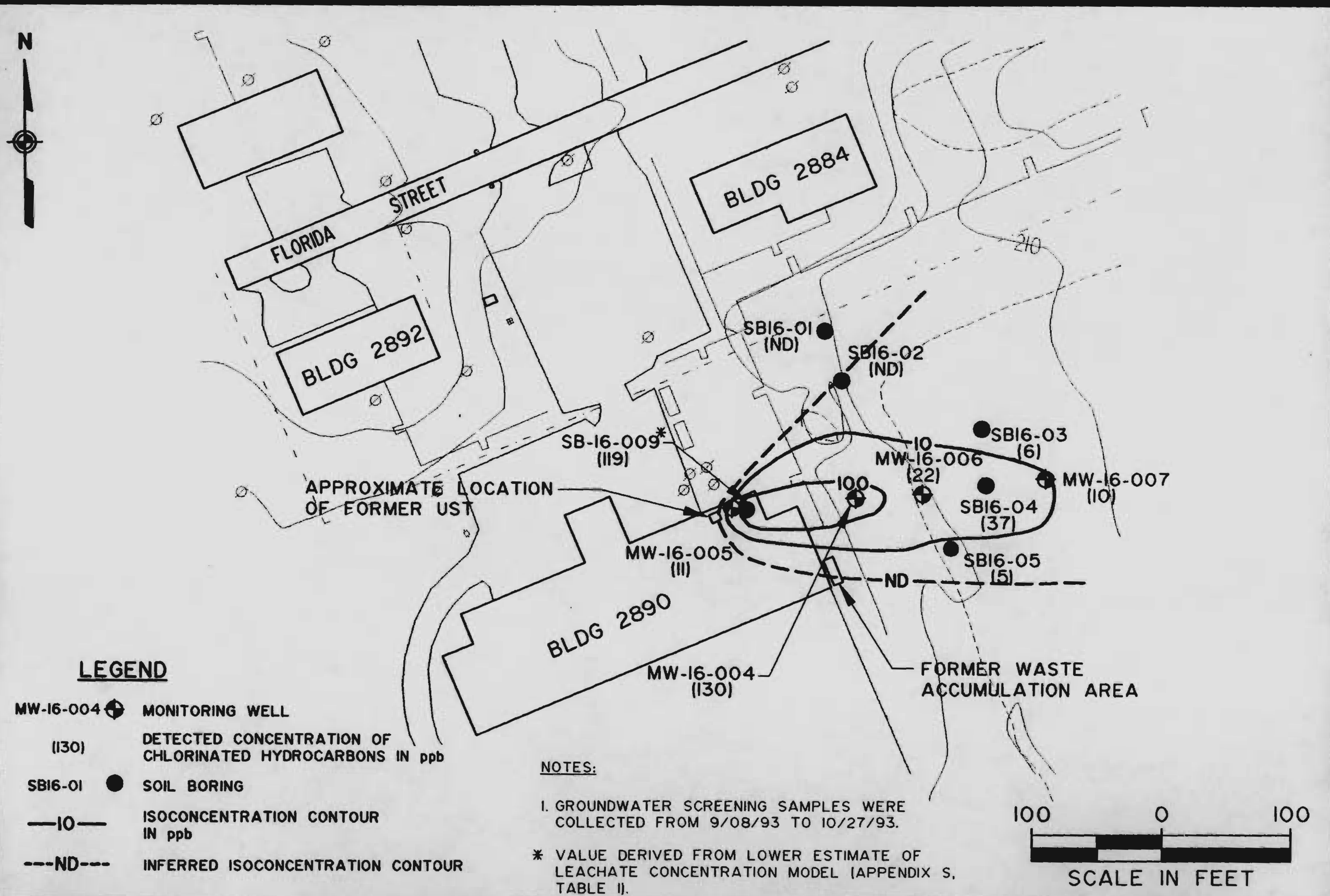

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HORIZONTAL EXTENT OF CHLORINATED HYDROCARBON CONTAMINATION

FIGURE 2-3

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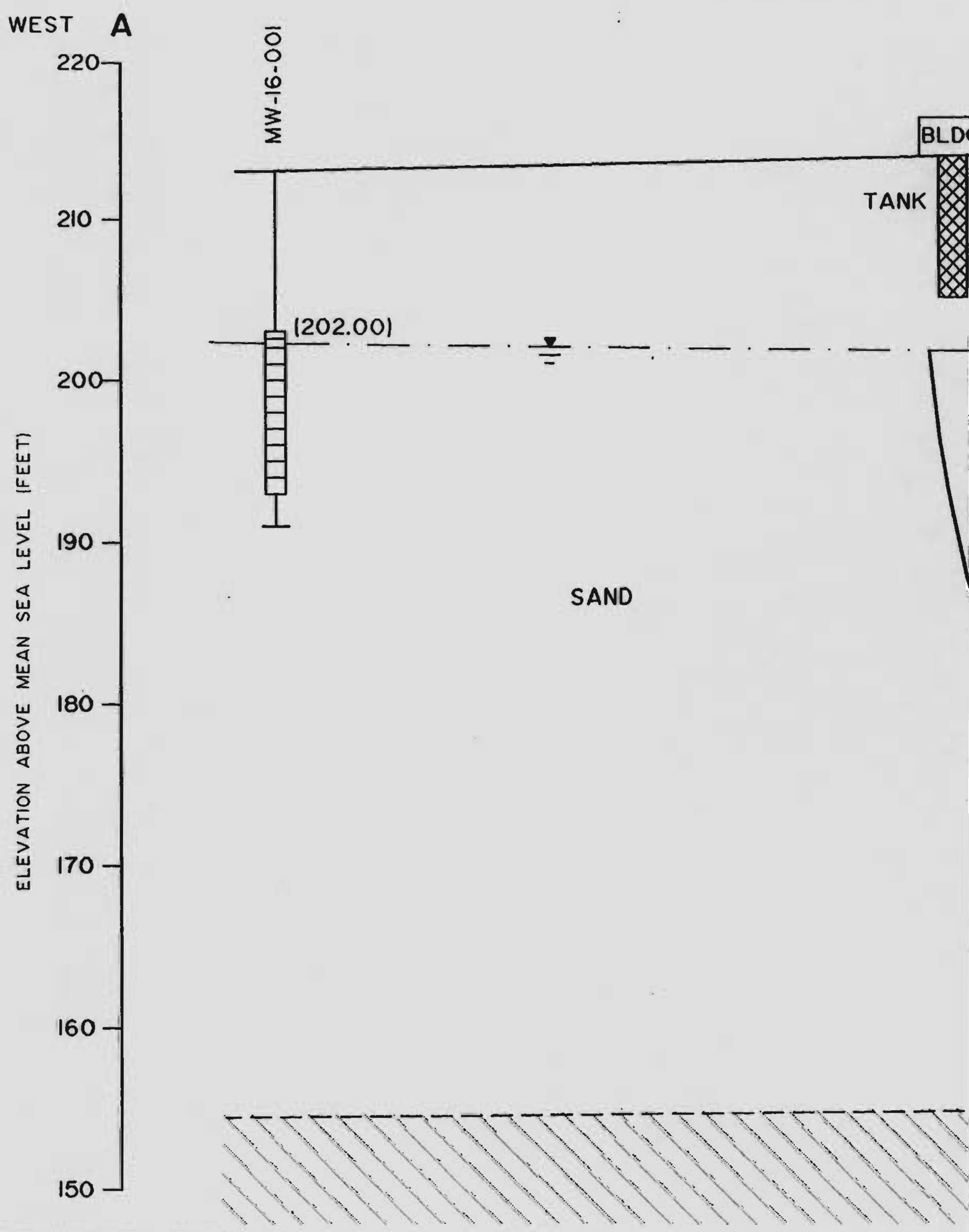

LEGEND

MW-16-005 ← MONITORING WELL NUMBER

(201.26) GROUNDWATER POTENTIOMETRIC SURFACE (GROUNDWATER ELEVATIONS FROM 12/2/93)

11 ← CONCENTRATION OF CHLORINATED HYDROCARBONS (ppb)

← SCREENED INTERVAL OF MONITORING WELL

← BOREHOLE TERMINATION

ND NON-DETECT

—— 100 —— ISOCONCENTRATION CONTOUR (ppb)

— — 10 - - - INFERRED ISOCONCENTRATION CONTOUR (ppb)

NOTES:

1. CONTAMINANT CONCENTRATIONS SHOWN AR SCREENING SAMPLES COLLECTED FROM B MONITORING WELL GROUNDWATER SAMPLES ARE INTERPRETIVE. ACTUAL CONDITIONS M

2. GEOLOGICAL CONDITIONS SHOWN ARE REPR ENCOUNTERED AT EACH BORING LOCATION EXTRAPOLATIONS BETWEEN BORINGS HAVE STANDARDLY ACCEPTED GEOLOGIC PRACTIC CONDITIONS MAY VARY BETWEEN BORINGS

3. ELEVATIONS BASED ON TRANSVERSE MERC NORTH AMERICAN DATUM 1983.

✱ VALUE DERIVED FROM LOWER ESTIMATE O

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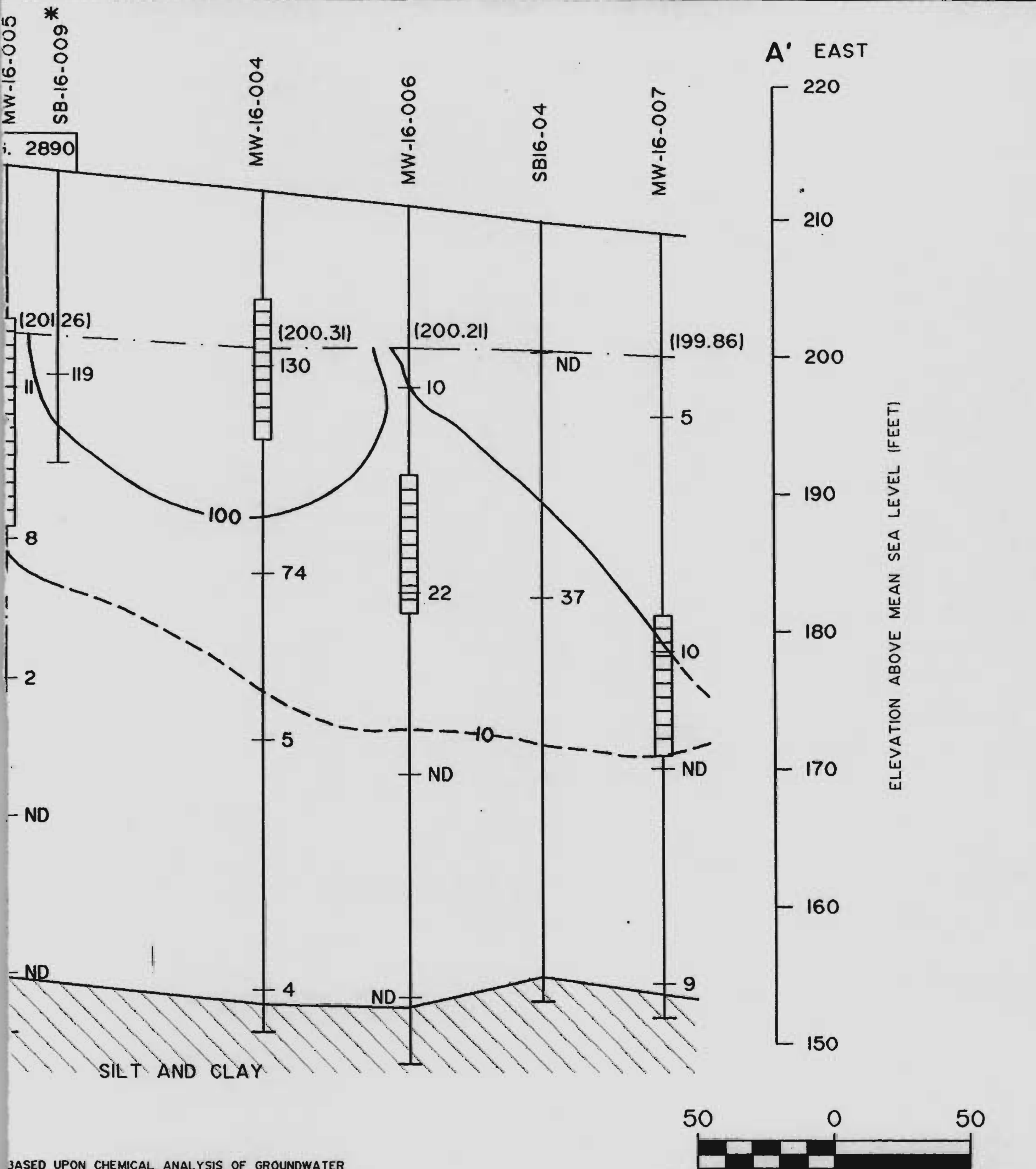

VERTICAL EXAGGERATION = 5X

BASED UPON CHEMICAL ANALYSIS OF GROUNDWATER
NGS BETWEEN 9/08/93 AND 10/27/93. DATA FROM
RE NOT SHOWN. EXTRAPOLATIONS BETWEEN BORINGS
VARY BETWEEN BORINGS FROM THOSE SHOWN.

NTATIVE OF THE CONDITIONS
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OR PROJECTION. EAST ZONE.

EACHATE CONCENTRATION MODEL (APPENDIX S. TABLE I).

VERTICAL EXTENT OF CHLORINATED HYDROCARBON CONTAMINATION

URS CONSULTANTS, INC.

FIGURE 2-4

3.0 SYSTEM DESIGN

The full-scale remediation system employed for the treatability study will include a "pump and treat" system for groundwater and an SVE system for remediation of contaminated subsurface soil which is a potential source of continuing groundwater contamination. The basis for treatability study system design is presented below.

3.1 Groundwater Collection

Design Objectives

The design objectives for the groundwater collection system are as follows:

- Lower the water table in the area of the former 1,000-gallon aboveground solvent storage tank so that soil contamination just below the water table is exposed to the atmosphere. This will permit remediation of the contaminated soil by SVE.

- Capture the majority of onsite contaminated groundwater.

Design Criteria

In order to meet the objectives for groundwater collection, the following design criteria have been established.

- Lower water table 5 feet at the point of extraction (i.e., near the former aboveground solvent tank).

- Pump groundwater at rate of 50 gallons per minute (gpm).

The depth of 5 feet at the point of groundwater extraction is based on RI data summarized in Section 2.0. The data shows that the soil below the water table in the area of the former 1,000-gallon solvent tank (sample SB-16-009-15) is contaminated to a depth of 15 feet (about 4 feet below the water

AC-9929

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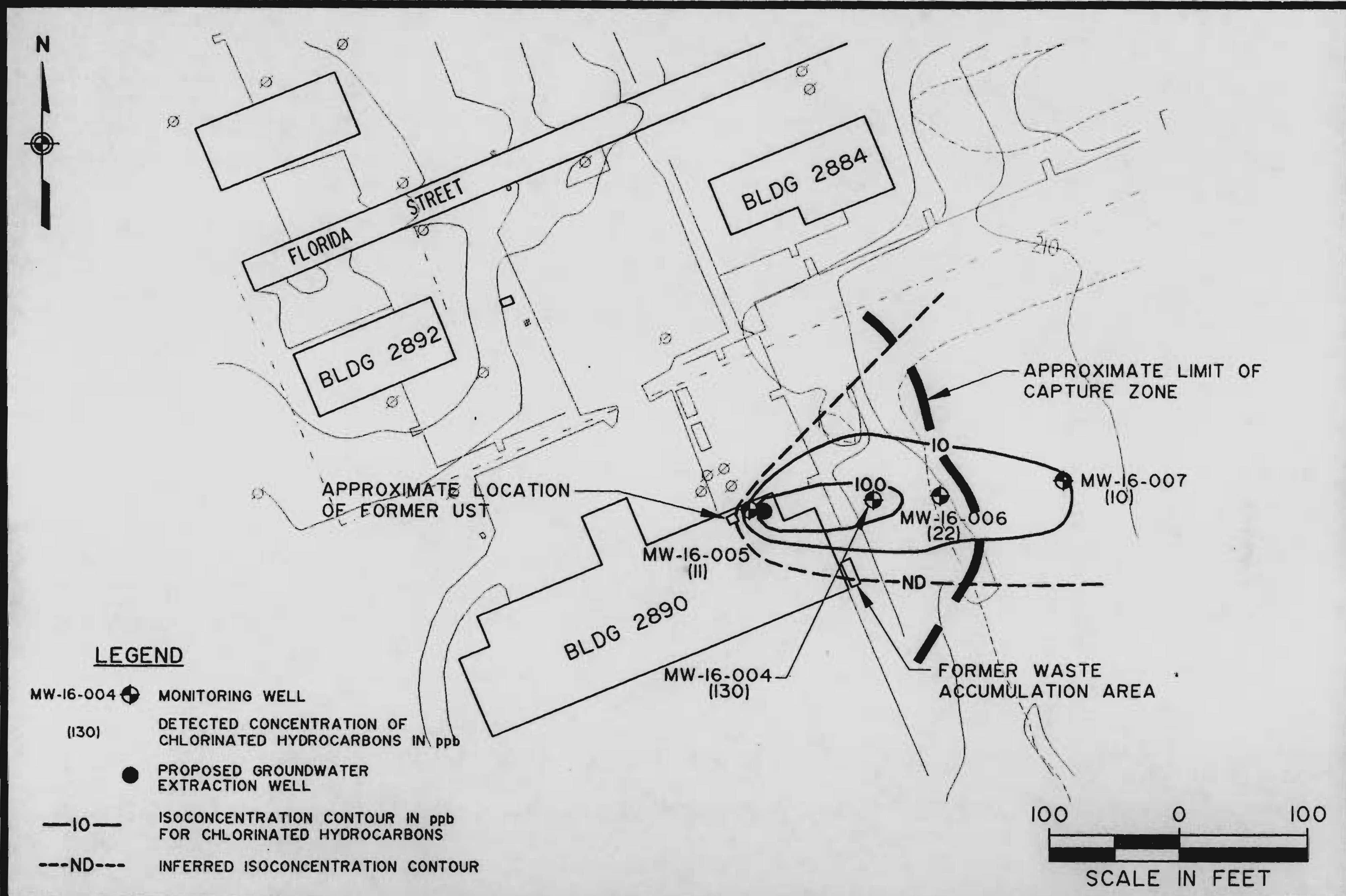

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ESTIMATED GROUNDWATER CAPTURE ZONE AT 50 GPM PUMPING RATE

FIGURE 3-1

\3529\SS016\TREAT\ 1=200 9/17/96-4 ETM

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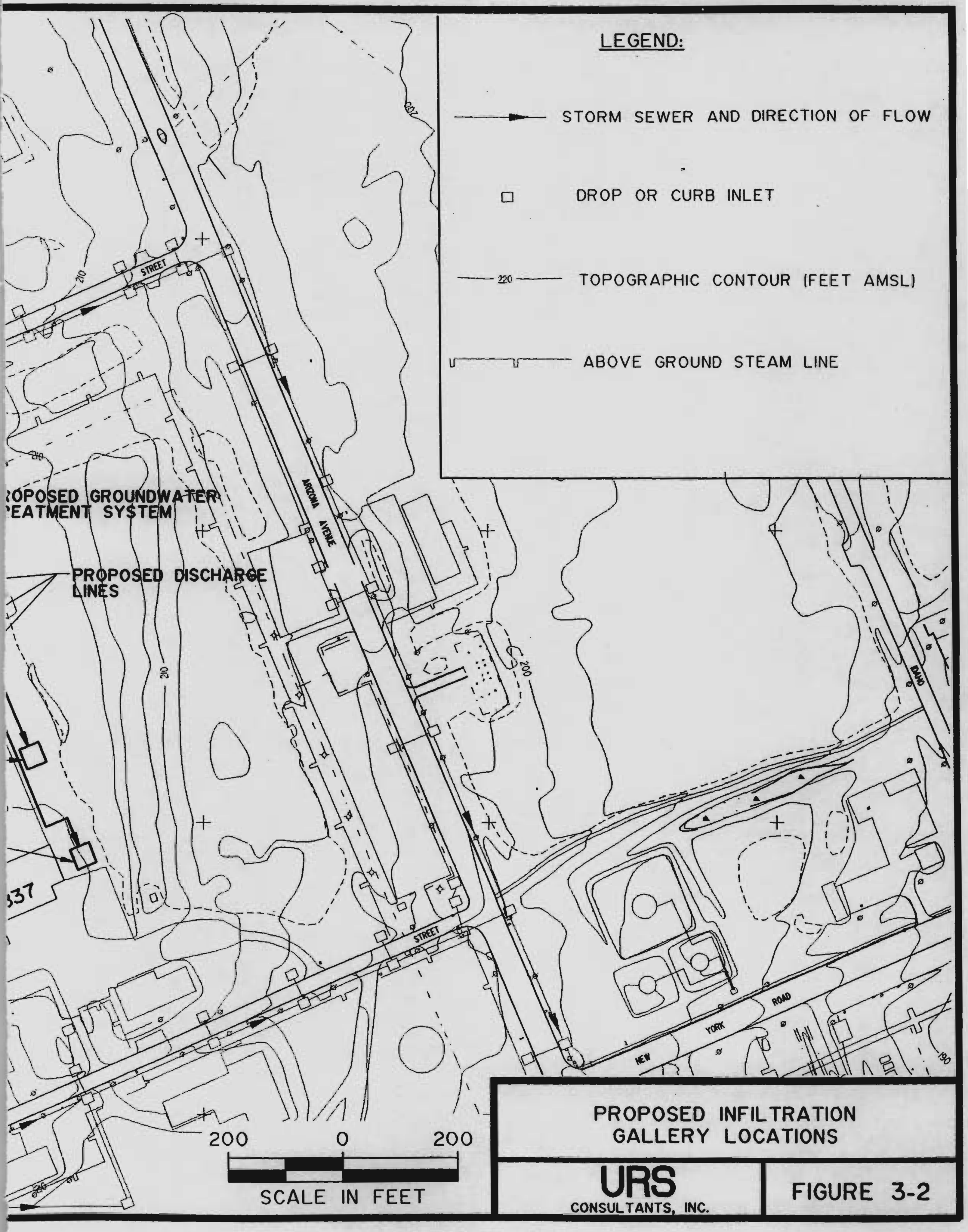

PROPOSED INFILTRATION GALLERY LOCATIONS

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FIGURE 3-2

TABLE 3-1
NOSE DOCK 8 (SS-016) - TREATABILITY STUDY WORK PLAN
GROUNDWATER TREATMENT SUMMARY

CHEMICAL	ESTIMATED INFLUENT CONCENTRATION (µg/L)	DISCHARGE LIMITATION (µg/L)	* PERCENT REMOVAL REQUIRED
Acetone	20.9	50.0	0
Carbon Disulfide	0.3	NS	NC
1,1-Dichloroethane	0.4	5.0	0
1,2-Dichloroethene (total)	5.5	5.0 *	10
Chloroform	4.2	7.0	0
1,2-Dichloroethane	0.6	5.0	0
2-Butanone	2.4	50.0	0
1,2-Dichloropropane	1.5	5.0	0
Trichloroethylene	21.6	10.0	54
Toluene	12.6	5.0	60
Ethylbenzene	5.5	5.0	9
1,2 Xylene	ND	5.0	NC
Xylene (sum of 1,3 and 1,4)	36.2	10.0	72
1,2-Dichlorobenzene	0.3	4.7	0
2-Methylphenol	0.5	10.0	0
4-Methylphenol	16.5	10.0	39
Naphthalene	24.6	10.0	59
2-Methylnaphthalene	10.1	NS	0
Diethylphthalate	0.8	NS	NC
bis(2-Ethylhexyl)phthalate	0.3	NS	NC

NC - Value not calculated. Insufficient data.
ND - Concentration not determined. No data available.
NS - Water quality criteria has not been established by NYSDEC for this chemical.
* - Discharge limitations are 5.0 µg/L for cis and 5.0 µg/L for trans 1,2-Dichloroethene

- There were only two detections of a metal analyte (lead and arsenic in Round 1 of sampling) that exceeded groundwater Applicable or Relevant and Appropriate Requirements (ARARs)

- Both arsenic and lead were detected well below the ARARs in Round 2 of sampling

- Background concentrations of metals are comparable to onsite concentrations, indicating metals are not contaminants

- Metal contamination is not expected based on past onsite activities or records

<u>Influent Concentrations</u>

Treatment system influent concentrations were estimated using RI data and an appropriate dilution factor developed from a hydrogeologic model. These estimated concentrations are presented in Table 3-1. Methodology used for development of influent concentration is presented in Appendix A-3.

<u>Equipment Specifications</u>

As shown in Table 3-1, treatment and removal of 1,2-dichloroethene (total), trichloroethylene, toluene, ethylbenzene, xylene (sum of 1,3 and 1,4), 4-methylphenol and naphthalene is required to meet the discharge limitations. The treatment system equipment specified for the treatability study to meet the design objectives is as follows:

- One shallow tray-type air stripper. (Reference Appendix A-4).

- Two 1,800-pound activated carbon units. Based on calculations, the air stripper will reduce the levels of all VOCs to concentrations well below the discharge limitations. Carbon will reduce 4-methylphenol and naphthalene to below the assumed discharge limitations.

3.5 Treated Water Discharge

Design Objective

The design objective for this component of remediation is to discharge treated water from the groundwater treatment system to three nearby infiltration galleries (Figure 3-2) so that treated water can be reinjected into the aquifer.

Design Objective

Provide sufficient area and depth for discharge of 50 gpm of treated water to the groundwater aquifer.

Equipment Specification

Three (3) 35' x 35' x 7' deep infiltration galleries (see Appendix A-7).

3.6 System Specifications

The treatability study system will be installed by Sevenson Environmental Services, Inc. - a subcontractor to URS. System installation shall be in accordance with the performance specification prepared by URS as presented in Appendix C.

4.0 SYSTEM OPERATION

The scheduled duration of the treatability study is 9 months. This period will include approximately 1 month for system start-up and an additional 8 months of system operation after completion of system start-up. URS will be responsible for system monitoring, and operation and maintenance (O&M) during this period. A description of the monitoring program and the approach to O&M is presented in the remainder of this section.

4.1 Monitoring

The treatment system will be monitored to evaluate system performance and to ensure compliance with water discharge requirements. The sampling and analytical schedule for this monitoring program is presented below.

Weeks 1 to 4 (System Start-up)

Two water samples will be collected weekly. Water samples will be collected from the groundwater treatment system influent (before the air stripper) and effluent (after the carbon adsorption unit). Water samples will be analyzed for target compound list (TCL) volatiles and semivolatiles.

Weeks 5 to 36 (System Operation)

Two water samples will be collected each week during the first twenty weeks of operation as required by the NYSDEC (see Appendix B-3). Two water samples will be collected each month during the remainder of the operating period. Sampling points and parameters shall be the same as Weeks 1-4.

Analytical methods utilized for monitoring are listed below:

VOCs (Water) - EPA Method 624
SVOCs (Water) - EPA Method 625

5.0 TREATABILITY STUDY REPORT

A treatability study report will be prepared after completion of the 9-month treatability study. The report will include analytical data, O & M information, and conclusions and recommendations. The treatability study report will be used as the basis for revisions of the EE/CA and decision documents, and will be used to evaluate future actions. Potential future actions include, but are not limited to, the following.

- No action; that is, the results of the treatability study indicate that groundwater has been remediated to acceptable levels during the treatability study
- Continued operation of the system utilized in the treatability study
- Continued operation of the treatability study system after modifying the system components or method of operation
- Installation and operation of another system to evaluate an alternate technology

REFERENCES

NYSDEC. 1993. *Ambient Water Quality Standards and Guidance Values, Technical and Operational Guidance Series (1.1.1)*, October. Albany: Division of Water.

URS. 1994a. *Draft Remedial Investigation Report*, August.

URS. 1994b. Initial Screening of Alternatives (ISOA) letter to the USAF, 14 October.

URS. 1995a. *Draft Engineering Evaluation/Cost Analysis*, February.

URS. 1995b. *Draft Final Remedial Investigation Report*, December.

LIST OF ACRONYMS

AFBCA	Air Force Base Conversion Agency
ARAR	Applicable or Relevant and Appropriate Requirement
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
EE/CA	Engineering Evaluation/Cost Analysis
gpm	gallons per minute
IRP	Installation Restoration Program
ISOA	Initial Screening of Alternatives
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and Maintenance
PAFB	Plattsburgh Air Force Base
PLC	Programmable Logic Controller
RI	Remedial Investigation
SS-016	Nose Dock 8
SVE	Soil Vapor Extraction
SVOC	Semi-volatile Organic Compound
URS	URS Consultants, Inc.
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VOC	Volatile Organic Compound

APPENDIX A
CALCULATIONS

APPENDIX A-1
DRAWDOWN AND CAPTURE ZONE CALCULATIONS

REF. PAGE

PURPOSE:

The purpose of this calculation is to assess drawdown at various distances around a proposed extraction well near the former solvent tank at SS-016 if pumped to steady state at various constant rates.

Assumptions:

In addition to the common Theis equation assumptions it is assumed that drawdown will stabilize to steady state levels approximately 90 days after the start of pumping at each rate. It is also assumed that the proposed well will be pumped at constant rates of 10, 20, 30 40 and 50 gpm.

CALCULATIONS:

The Jacob modification of the Theis equation, with the attached graph, will be used to calculate and illustrate the resulting drawdown.

in common USGS units

$$\Delta = \frac{264Q}{T} \log \frac{0.3Tt}{r^2S}$$

and

$$\Delta\Delta = \frac{528Q}{T}$$

where: Δ = drawdown (ft)
Q = discharge (gpm)
T = transmissivity (gpd/ft)
T = Kb
K = hydr. cond. (gpd/ft^2)
b = sat. thick (ft)
t = time (days)
r = radius of obs (ft)
S = Specific yield (–)
$\Delta\Delta$ = drawdown over one log cycle (ft)

PROJECT PAFB SS-016
SUBJECT Theoretical Drawdown Near Former Solvent Tank

REF. PAGE

the areal rate of drawdown is

$$\Delta A = \frac{528\,Q}{T}$$

which for 10 gpm is

$$\Delta A_{10} = \frac{528(10)}{14306}$$

$$\Delta A_{10} = 0.37 \text{ ft}$$

and similarly for 20 gpm

$$\Delta A_{20} = 0.74 \text{ ft}$$

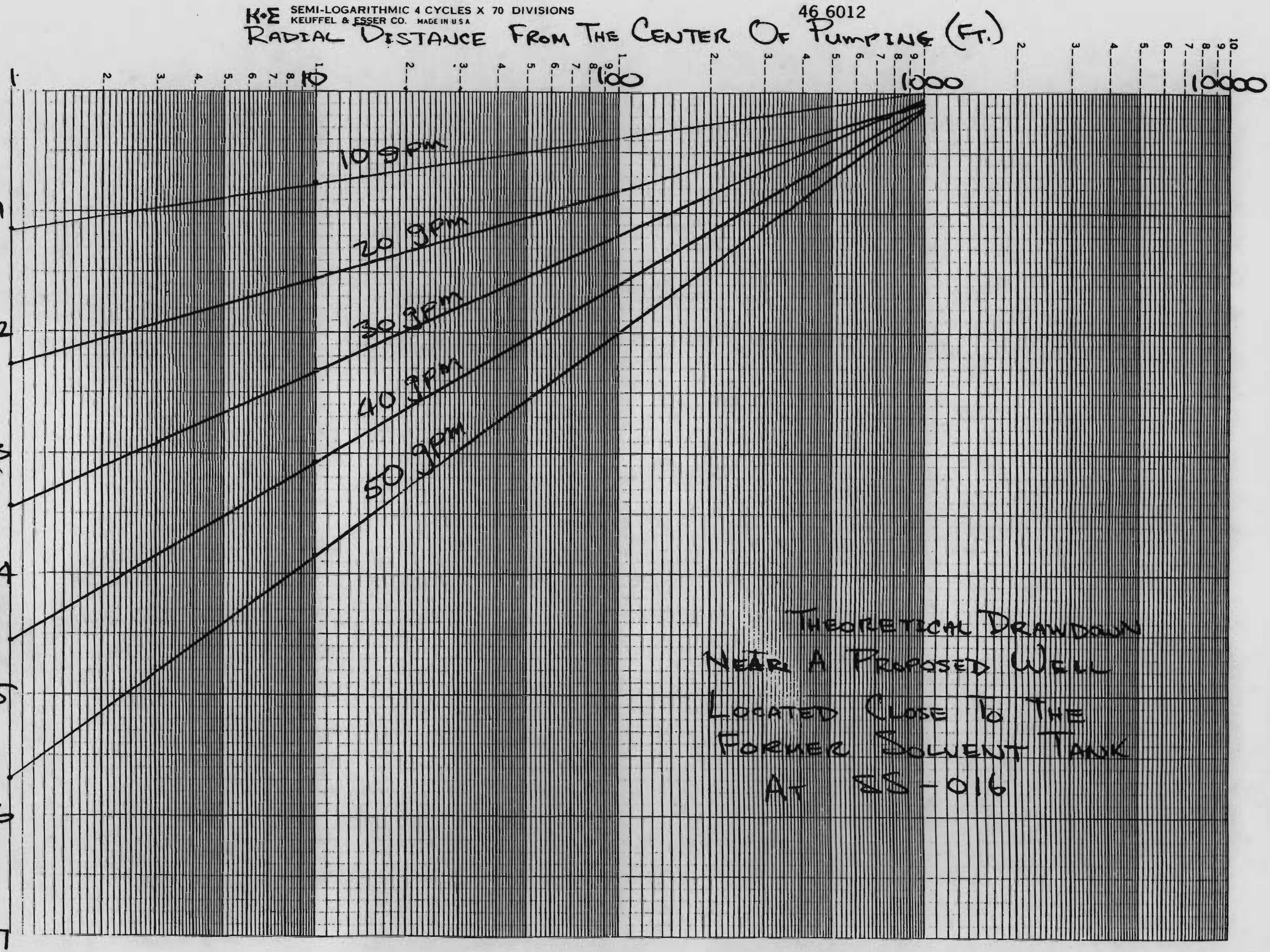
∴ at the other pumping rates

$$\Delta A_{30} = 1.11$$

$$\Delta A_{40} = 1.48$$

$$\Delta A_{50} = 1.85$$

This data results in the attached drawdown graph


K•E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U S A
46 6012
RADIAL DISTANCE FROM THE CENTER OF PUMPING (FT.)
1
10
100
1000
10000
10 gpm
20 gpm
30 gpm
40 gpm
50 gpm
1
2
4
THEORETICAL DRAWDOWN
NEAR A PROPOSED WELL
LOCATED CLOSE TO THE
FORMER SOLVENT TANK
AT SS-016

PROJECT PLATTSBURGH, SS-016
SUBJECT GW EXTRACTION/CAPTURE

REF. PAGE

1. OBJECTIVE

CHECK THE EXTENT OF CAPTURE ZONE AT SITE SS-016, AS CALCULATED USING A "QUICKFLOW" SOFTWARE. SEE ATTACHED DWG.

2. CALS

BASED ON THE DEC 1995 RI REPORT, ASSUME

$$K_{AVG} = K_{GEOM\ MEAN} \approx 1.5 \cdot 10^{-2}\ cm/s = 42\ ft/d$$

$$H_0 \approx 50\ ft$$

$$i \approx \frac{2}{350} \approx 0.006$$

FROM ~~ORI~~ "GROUNDWATER CONTAMINATION: OPTIMAL CAPTURE AND CONTAINMENT":

$$\frac{1}{2}W = \frac{1}{2}\frac{Q}{2Ti} = \frac{1}{2} \cdot \frac{Q}{2 \cdot H_0 \cdot K \cdot i}$$

$$S = \frac{Q}{2\pi Ti} = \frac{Q}{2 \cdot \pi \cdot H_0 \cdot K \cdot i}$$

EXTRACTION RATE - ASSUME 50 GPM. THIS IS FEASIBLE FROM A 50 FT THICK AQUIFER WITH $K = 1.5 \cdot 10^{-2}$ cm/s.

$$Q = 50\ gpm \approx 9{,}600\ ft^3/d$$

SO:

$$\frac{1}{2}W = \frac{1}{2} \cdot \frac{9{,}600}{2 \cdot 50 \cdot 42 \cdot 0.006} \cong 190\ ft$$

$$S = \frac{9{,}600}{2 \cdot \pi \cdot 50 \cdot 42 \cdot 0.006} \cong 120\ ft$$

THIS IS VERY SIMILAR TO VALUES OBTAINED FROM "QUICK FLOW" SIMULATION. OK

APPENDIX A-2
EXTRACTION WELL

PROJECT: Plattsburgh AFB, Site SS-016 MADE BY: M.O. DATE: 6/19/96
SUBJECT: Design of Extraction Well CHKD. BY: [signature] DATE: 6/25/96

1. PURPOSE

These calculations were performed with a purpose of designing the groundwater/soil vapor extraction well that will be installed as part of the remedial scenario at the SS-016 site. The design incudes:

* Filter pack
* Screen

Note that both the ground water and soil vapor will be extracted using the same well.

2. DESIGN OF THE FILTER PACK

A single well is used for the extraction of both the soil vapor and the groundwater. Because design criteria for water are more stringent than those for soil vapor, the methodology followed in this calculation is based on the design of water wells. Design of the filter pack will be performed using the procedures outlined in Ref 1, Chapter 13. Copies of the referenced material are included in this Appendix.

The extraction well will be screened in the overburden. The design will be based on grain size distribution curves from samples taken within the overburden unit, at locations in the vicinity of the proposed well. The grain size distribution curves can be found in Appendix H of Ref 2.

Note that the procedure outlined in Ref 1 is based on distribution curves expressed in terms of "percent retained", whereas the curves from Ref 2 show the "percent finer". The relationship between those two is as follows:

% retained = 100% - % finer

Based on the grain size distribution curves, it appears that the properties of the overburden unit change significantly as a function of depth from the ground surface. The summary of characteristic grain sizes for several depth intervals (presented below) illustrates that change. Note that the water table occurs roughly at depth of 10 ft, and the overburden grades into the underlying silt/clay unit at the depth of approximately 60 ft (see Ref 2, Figure 5-20).

PROJECT: Plattsburgh AFB, Site SS-016
SUBJECT: Design of Extraction Well

MADE BY: M.O. DATE: 6/19/96
CHKD. BY: [signature] DATE: 6/25/96

The table with data supporting the summary presented below is shown on page 7 of this calculation. It was based on several grain size distribution curves from Ref 2, Appendix H (not presented in this package).

SUMMARY OF CHARACTERISTIC GRAIN SIZES

Depth [ft]	70% Retained Size (or 30% Finer) [mm]	40% Retained Size (or 60% Finer) [mm]
10-20	0.2 - 0.3	0.3 - 0.45
20-30	0.15 - 0.3	0.3 - 0.45
30-40	0.09	0.2
40-50	0.03 - 0.035	0.055 - 0.065
50-60	0.0035 - 0.01	0.02 - 0.035

It appears that the sediments are relatively coarse up to the depth of approximately 30 ft. The transition zone between the coarse and fine sediments occurs between 30 and 40 ft. For depths 40 to 50 ft, the sediments are much finer. The typical particle sizes are on the order of 0.01 mm, with a silt content of 20% to 65%, and a clay content of 2% to 25% (see Ref G, Appendix H, GEOTECHNICAL ANALYSIS SUMMARY). They can be considered as "silt" or "silty sand". For depths greater than 50 ft, the typical particle sizes are very small (order of 0.001-0.01 mm), the percentage of clay is generally 20 to 80, and the percentage of silt 50 to 70 (see Ref G, Appendix H, GEOTECHNICAL ANALYSIS SUMMARY). Those sediments can be classified as "clayey silt" or "silty clay". Based on the above considerations, placing of the well screen within the fine silty and clayey sediments below the depth of 30 ft is not recommended.

It is recommended that the well be placed up to the depth of approximately 30 ft. Design of the filter pack will be based on the finest d_{70} particle size of all the samples taken within that interval. This is the sample MW-16-006, depth 24 to 26 feet. See Ref 2, Appendix H for the grain size distribution curve. For this sample:

$d_{70\ retained} = d_{30\ finer} = 0.15$ mm

$d_{40\ retained} = d_{60\ finer} = 0.30$ mm

The 40% retained size is 0.30 mm. This is close to the value of 0.25 mm, for which a multiplier of 4 to 6 can be used (based on the recommendation of Ref 1 pages 441-442). Selecting the value of 5 (average of the range 4 to 6) the particle size $d_{70\ retained}$ of the filter pack can be estimated as:

$$d_{70\ retained\ filter\ pack} = d_{30\ finer\ filter\ pack} = 5 * d_{70\ retained\ formation} = 5 * 0.15 = 0.75 \text{ mm}$$

The uniformity coefficient is defined as

$$f = d_{40\ retained} / d_{90\ retained} = d_{60\ finer} / d_{10\ finer}$$

See Ref 1, page 411. It is recommended that the uniformity coefficient of filter pack be slightly less than 2.5. Assume:

$f = 2.0$

The grain size distribution curve for the required filter pack was sketched on page 8 of this package, based on:

$d_{70\ retained\ filter\ pack} = d_{30\ finer\ filter\ pack} = 0.75$ mm
$f = 2.0$

Note that the "% finer" convention was used to sketch the curve. Based on the curve, the filter pack material will have the following properties (note: % finer convention used):

% Finer [%]	Sieve Designation
100	#10
80	#16
40	#20
15	#30
5	#40
0	#50

Based on the vendors literature (THE MORIE COMPANY, INC., see page 9 of this package), the closest available type of sand is the #0 well gravel. It has the following grain size distribution (note: given as "percent retained" in the source, here given as "percent finer"):

% Finer [%]	Sieve Designation
98.8	#16
52.0	#20
4.6	#30
0.3	#40
0.0	#60

The grain size distribution curve for the MORIE #0 well gravel has been sketched on page 8 of this package.

3. DESIGN OF THE SCREEN

The openings in the well screen should be selected to retain 90% of the filter pack material (Ref 1, page 443). Based on the curve on page 8 of this Appendix (MORIE #0 well gravel), this is approximately 0.6 mm (0.024 inch). The nearest lower standard screen slot size is 0.020 in, which corresponds to the #20 screen.

Extraction rates of the proposed wells have been estimated at approximately 50 gpm. The design will be performed assuming that the entire flow will pass through one half of the screen length in the depth interval of 10 to 30 ft. The design will be performed with a factor of safety with regard to flow rate of 2. Therefore, the screen design flow rate, and screen length are:

$$Q = 50*2 = 100 \text{ gpm} = 0.223 \text{ ft}^3/\text{s}$$

$$L = (30 - 10) / 2 = 10 \text{ ft}$$

Use an 8" diameter well.

PROJECT: Plattsburgh AFB, Site SS-016 MADE BY: M.O. DATE: 6/19/96
SUBJECT: Design of Extraction Well CHKD. BY: DAA DATE: 6/25/96

The open area of the #20 screen can be estimated at approximately 18% (Ref 1, Appendix 12A). Using that, and the design flow rate, the entrance velocity can be estimated as follows:

$$v = Q/A_{open} = Q / (\pi * D * L * \%_{open})$$

where A_{open} is the open area of the screen

For an 8" screen (D = 0.67 ft):

$$v = 0.223/[(\pi * 0.67 * 10 * 0.18] = 0.06 \text{ ft/s}$$

This velocity is lower than the recommended maximum velocity of 0.1 ft/s (see Ref 1, page 449). Therefore, an 8" diameter screen appears to be acceptable.

The velocity of water flowing within the screen or casing (i.e. the uphole velocity) can be estimated as

$$v = Q/A_c$$

where A_c is the cross sectional area of the pipe

For the design flow rate ($Q = 100$ gpm $= 0.223$ ft^3/s), and assuming that there is a 2" diameter pipe (D = 2/12 = 0.17 ft) within the casing for pumping the groundwater out of the well, the uphole velocity is

$$v = 0.223/[(\pi/4) * (0.67^2 - 0.17^2)] = 0.7 \text{ ft/s}$$

This is less than the maximum recommended uphole velocity of 5 ft/s (Ref 1, see pages 414 and 416). The screen appears to be sufficient.

PROJECT: Plattsburgh AFB, Site SS-016 | MADE BY: M.O. | DATE: 6/19/96
SUBJECT: Design of Extraction Well | CHKD. BY: GAA | DATE: 6/25/96

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6. SUMMARY

The calculations outlined in this Appendix were performed in order to design the filter pack and screen of the proposed groundwater/soil vapor extraction well at the SS-016 site. The conclusions are summarized below.

General:
The well should be screened to the depth of approximately 30 ft. This is due to the fact that below those depths, the sediments are of silty and clayey nature.

Filter pack:
The MORIE COMPANY #0 well gravel was selected as the filter pack material (see page 4 of this package for specs.). Alternatively, an equivalent material from a different vendor can be used, as long as it closely resembles the above mentioned #0 well gravel.

Screen:
The screen will be:

* 8" diameter, continuous slot
* #20 screen (slot size 0.020 in)
* minimum open area of 18%

7. REFERENCES

1. GROUNDWATER AND WELLS
   SECOND EDITION
   F.G Driscoll
   Johnson Filtration Systems, Inc., 1986

2. NOSE DOCK 8 (SS-016)
   REMEDIAL INVESTIGATION REPORT (Draft Final)
   URS Consultants, Inc., Dec 1995

PROJECT Plattsburgh AFB, Site SS-016
SUBJECT Design of Extraction Well

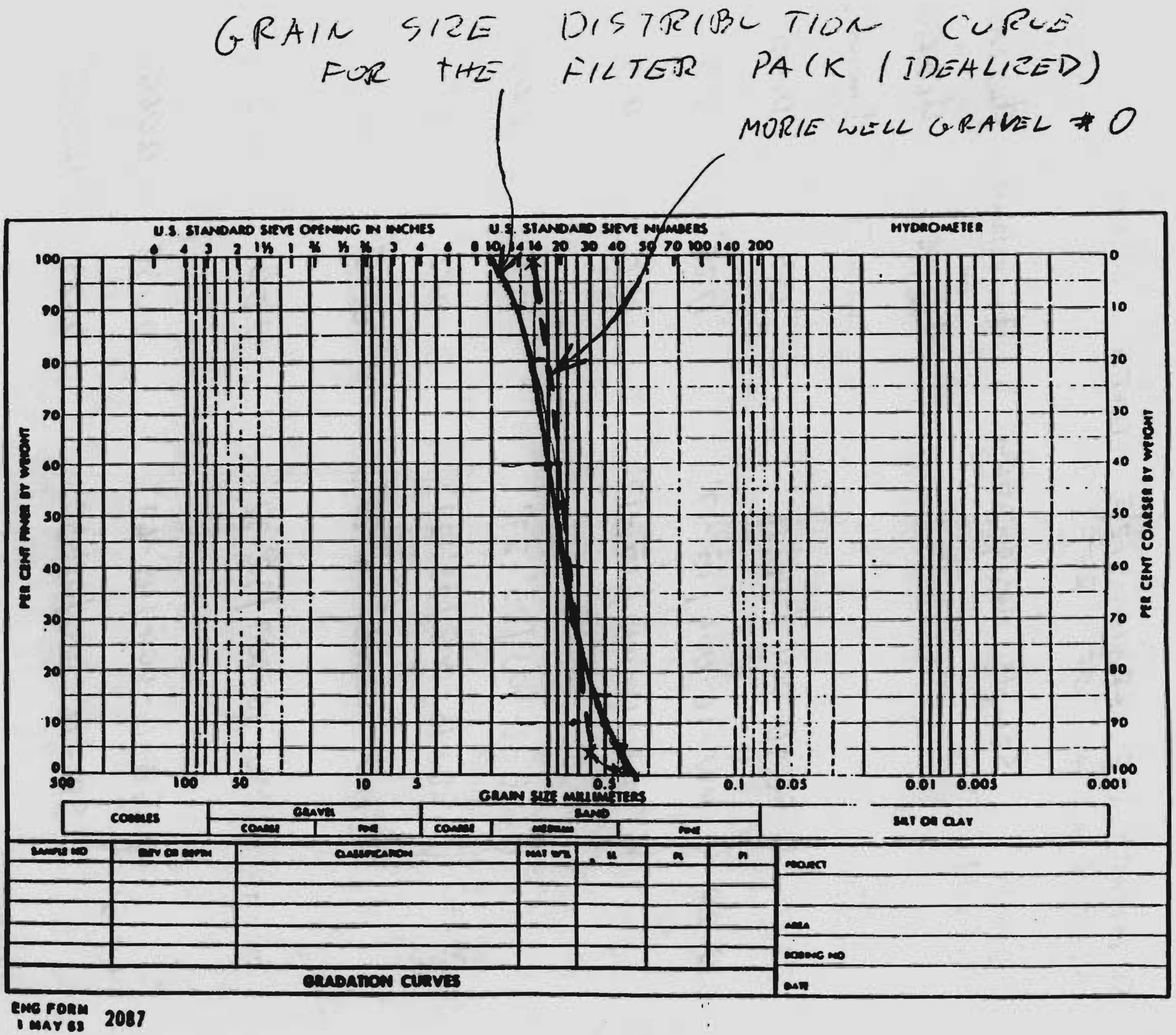
MADE BY MO DATE 6/13/96
CHKD. BY HAS DATE 6/26/96

REF. PAGE

SUMMARY OF GRAIN SIZE DATA FROM APPENDIX H OF REF 2

Depth interval [ft]	Sample designation	d_{70} Retained or d_{30} Finer [mm]	d_{40} Retained d_{60} Finer [mm]
10-20	SB-16-001 / 14'-16'	0.3	0.45
	MW-16-004 / 15'-17'	0.25	0.3
	MW-16-005 / 15'-17'	0.2	0.3
20-30	SB-16-003 / 25'-27'	0.3	0.45
	SB-16-005 / 25'-27'	0.2	0.3
	MW-16-006 / 24'-26'	0.15	0.3
30-40	MW-16-007 / 30'-32'	0.09	0.2
40-50	SB-16-004 / 45'-47'	0.035	0.065
	SB-16-002 / 48'-50'	0.03	0.055
~~40-50~~ 50-60	SB-16-003 / 55'-57'	0.01	0.03
	SB-16-004 / 55-57'	0.0035	0.02
	MW-16-007 / 55'-57'	0.008	0.03

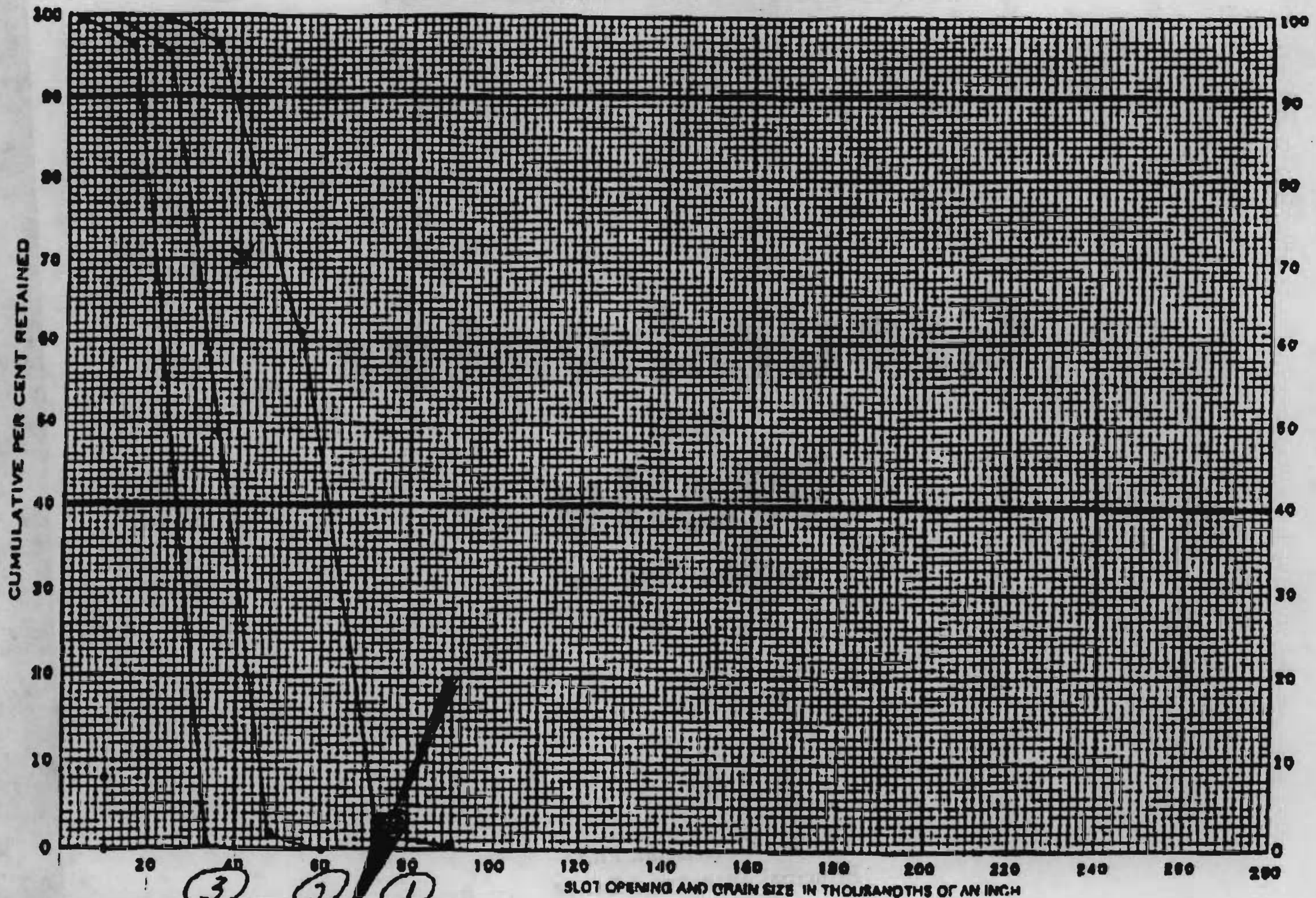
(8)


GRAIN SIZE DISTRIBUTION CURVE FOR THE FILTER PACK (IDEALIZED)
MORIE WELL GRAVEL # 0
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PER CENT FINER BY WEIGHT
PER CENT COARSER BY WEIGHT
GRAIN SIZE MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
SAMPLE NO
ELEV OR DEPTH
CLASSIFICATION
NAT W%
LL
PL
PI
PROJECT
AREA
BORING NO
DATE
GRADATION CURVES
ENG FORM 1 MAY 63 2087

9

MORIE SCREENINGS

NEW JERSEY WELL GRAVELS



SIEVE OPENING	CUMULATIVE PER CENT RETAINED		
US SIEVE/INCHES	#1	#0	#00N
¼ .250			
4 .187			
6 .132			
8 .094			
12 .066	2.2 98		
16 .047	81.7	1.2 99	
20 .033	97.4	48.0 52	.1
30 .023	99.6	95.4 5	40.7
40 .016	99.9	99.7 .1	97.4
60 .012	100.0	100.0	100.0
SCREEN SLOT	30	20	15

Notes: NO. 1 WELL GRAVEL (1)
NO. 0 WELL GRAVEL (2)
NO. 00N WELL GRAVEL (3)

SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOT SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF THE WELL SCREENS

Morie filter media meets the requirements of NSF Standard 61 and is NSF listed.

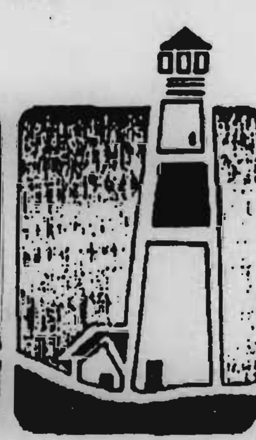
NSF

THE MORIE COMPANY, INC.

MINERAL AND INDUSTRIAL SAND AND GRAVEL

GEORGIA SILICA DIVISION

City, GA 31812



(10)

Groundwater
and
Wells

Second Edition

Fletcher G. Driscoll, Ph.D.
Principal Author and Editor

REF 1

Published by Johnson Filtration Systems Inc., St.Paul, Minnesota 55112

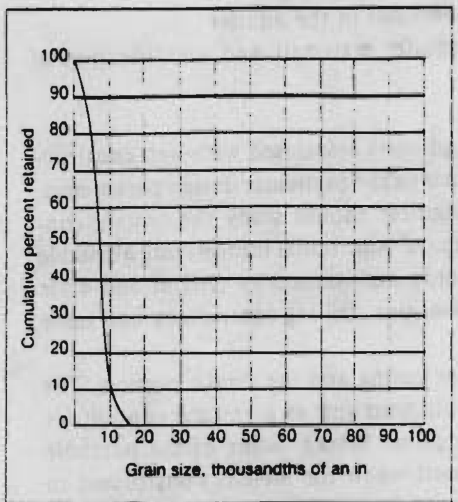


Figure 12.19. Class A curve for fine sand.

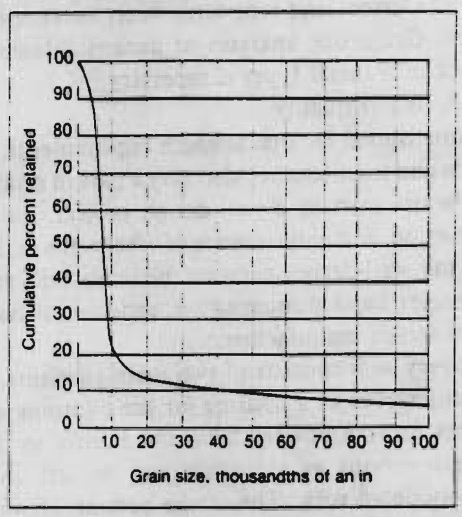


Figure 12.20. Class B curve for fine and very coarse sand.

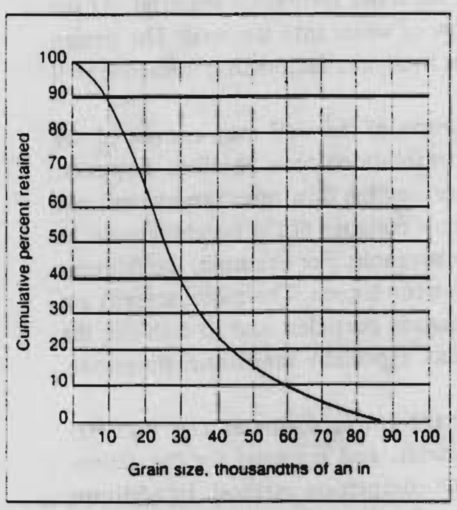


Figure 12.21. Class C curve for coarse and very coarse sand.

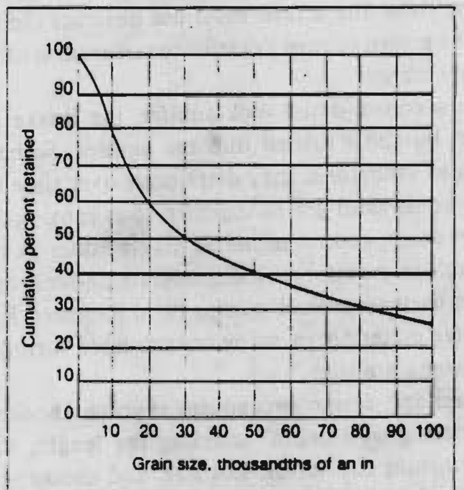


Figure 12.22. Class D curve for coarse sand and very fine gravel.

Slope and Shape of Curve

The slope of the major portion of a grain-size distribution curve can be described in several ways. One term that is used extensively is the uniformity coefficient, which was developed by Hazen at the same time he adopted the idea of effective size. Uniformity coefficient is defined as the 40-percent retained size of the sediment divided by the 90-percent retained size. The lower its value, the more uniform is the grading of the sample between these limits. Larger values represent less uniform grading. The uniformity coefficient is limited in practical application to materials that are rather uniformly graded. It is meaningful only when its value is less than 5. It is well suited for describing the desired uniformity of filter-pack materials. The uniformity coefficient for the sample in Figure 12.16 is 2.9 [0.026 in (0.66 mm) divided

2. Transmissivity and storage coefficient values for the aquifer
3. Current and long-term water balance conditions in the aquifer
4. Grain-size analyses of unconsolidated aquifer materials and identification of rock or mineral types if necessary
5. Water quality

Dimensional factors, strength requirements, and costs associated with well construction and maintenance also play a part in establishing the particular design parameters.

Before starting a well design project, the engineer should study the design, construction, and maintenance of other wells in the area. Additional information available to the well-design engineer includes well records maintained by federal and state agencies, local municipalities, agricultural associations, drilling contractors, and some well screen manufacturers.

Every well consists of two main elements, the casing and the intake portion. The casing serves as a housing for the pumping equipment and as a vertical conduit for water flowing upward from the aquifer to the pump intake. Some of the borehole length serving as a conduit may be left uncased when the well is constructed in consolidated rock. The intake portion of wells in unconsolidated and semiconsolidated aquifers is generally screened to prevent sediment from entering with the water and to serve as a structural retainer to support the loose formation material. At the same time, the screen must not obstruct the flow of water into the well. The design of the screen requires careful consideration of the hydraulic factors that influence well performance.

In a consolidated rock aquifer, the intake portion of the well may consist of the open borehole drilled into the aquifer. Some consolidated rock aquifers, however, such as sandstone, may deteriorate over time because high flow rates remove cement that holds sand grains together, thus causing a slow collapse of the borehole wall. In other cases, certain minerals may weather in the borehole. For example, the feldspar crystals in granitic rock disintegrate under aerating conditions. Therefore, screens are often used to protect pumps from loosened formation particles, and to stabilize the aquifer materials in many consolidated formations, especially sandstone, limestone, and some granites.

Standard design procedures involve choosing the casing diameter and material, estimating well depth, selecting the length, diameter, and material for the screen, determining the screen slot size, and choosing the completion method. In addition, the choice of a particular well design hinges on the type of drilling rigs that are available. See Chapter 10 for a description of the major well drilling methods. Design criteria presented below have been developed for typical hydrogeologic conditions. Design practices may vary in different regions, however, because of unusual hydrogeologic conditions; some successful, nonstandard designs are described at the end of this chapter.

CASING DIAMETER

Choosing the proper casing diameter for the well is important because it may significantly affect the cost of the structure, depending on the type of drilling equipment used. The diameter must be chosen to satisfy two requirements: (1) the casing must be large enough to accommodate the pump, with enough clearance for installation and efficient operation, and (2) the diameter of the casing must be sufficient to assure that the uphole velocity is 5 ft/sec (1.5 m/sec) or less.

The size of the pump required for the desired yield is the controlling factor in choosing the size of the casing. It is recommended that the casing diameter be two pipe sizes larger than the nominal diameter of the pump. In all cases, however, the casing must be at least one nominal size larger than the pump bowls. Table 13.1 shows casing sizes recommended for various pumping rates. Excessive head losses will occur in the system if the uphole velocity is greater than 5 ft/sec (1.5 m/sec). For the pipe sizes and pumping rates shown in the tables, these head losses will be small.

If the casing size is selected from Table 13.1 and if the well meets typical standards for plumbness, there will be adequate clearance for the pump bowls. For lineshaft pump installations, this clearance allows for proper alignment of the shafting to eliminate binding and excessive wear. If the pump is set below any screened section, there will be sufficient area around the bowls to allow water to pass downward with minimum head loss to the pump intake. However, heat build-up can be a problem for a submersible pump set in a sump beneath the screen, because the intake portion of the pump is located above the motor. The pump manufacturer should be consulted for motor cooling recommendations.

Drilling conditions, drilling methods, or economic factors sometimes make it necessary to complete the lower portion of the well with a smaller diameter casing or screen. When using the cable tool method, drillers must often reduce the size of their casing when the original casing cannot be driven any farther because of side-wall friction (Figure 13.1). A single string of casing can usually be driven 300 to 500 ft (91.5 to 152 m) depending on geologic conditions. The outer casing must be cleaned out completely before smaller diameter casing can be telescoped. Ideally, each casing string should be landed in clay or some other nonheaving sediment. If the casing ends in sand, water should be run continuously into the annulus between the two strings to prevent heaving and potential sand locking. Inner strings are generally set by pull-down jacks, rather than by driving, because too much of the driving energy is lost in the unsupported part of the casing, which is up inside the outer casing.

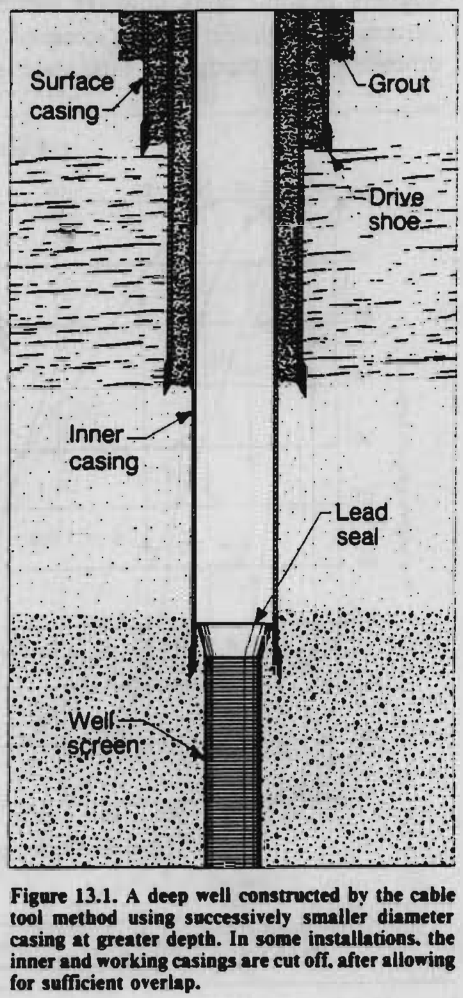


Figure 13.1. A deep well constructed by the cable tool method using successively smaller diameter casing at greater depth. In some installations, the inner and working casings are cut off, after allowing for sufficient overlap.

More than one inner casing can be telescoped depending on well depth. A common diameter sequence is 24 by 20 by 16 in (610 by 508 by 406 mm) for the outer casing and two inner strings. Unless the culating the hydraulic conductivity. Aquifer transmissivity can then be determined by adding the individual transmissivity values for all layers of the aquifer (transmissivity equals the hydraulic conductivity times the thickness for each layer).

5. Borehole geophysical logging techniques can help locate zones having the highest hydraulic conductivity. Velocity-meter surveys also are extremely useful. See Chapter 8 for an analysis of the various exploration methods.

Each technique listed above provides useful information on the zones that should be exploited. As many of these techniques should be used as possible. Economic factors governing a well project dictate the cost that can be justified in determining most accurately the productive zones of the aquifer.

Recommended screen lengths for four typical hydrogeological situations are given below.

1. *Homogeneous Unconfined Aquifer.* Theoretical considerations and experience have shown that screening of the bottom one-third to one-half of an aquifer less than 150 ft (45.7 m) thick provides the optimum design for homogeneous unconfined aquifers. In some cases, however, particularly in thick, deep aquifers, as much as 80 percent of the aquifer may be screened to obtain higher specific capacity and greater efficiency, even though the total yield is less.

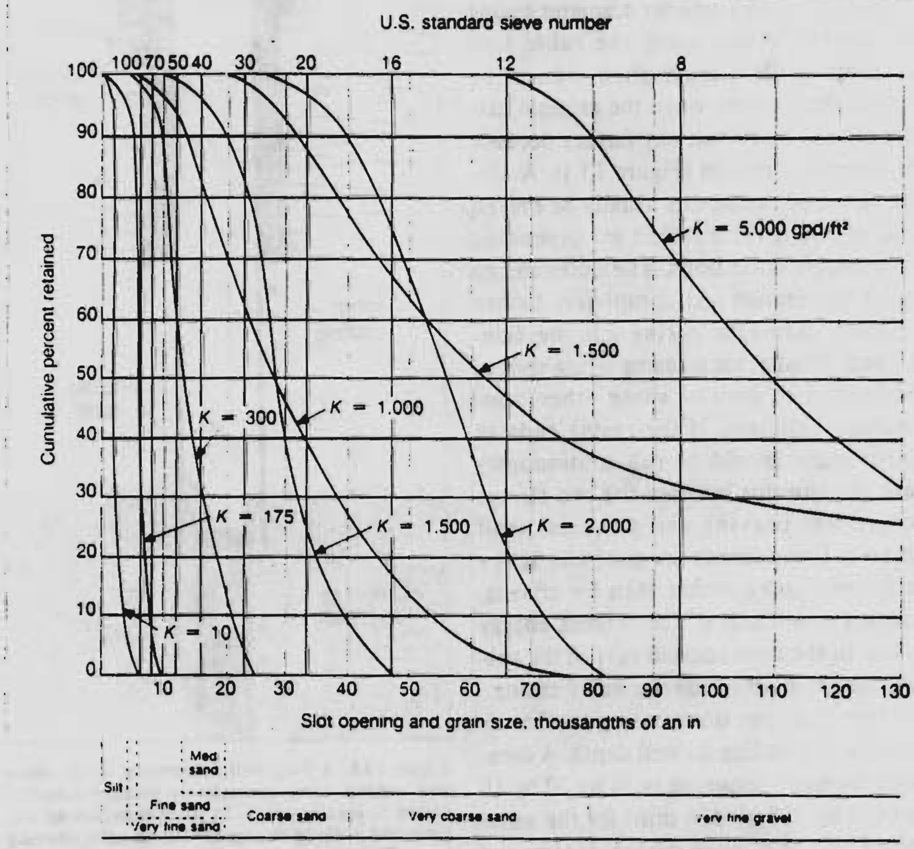


Figure 13.4. Hydraulic conductivity can be estimated on the basis of grain-size-distribution curves.

The grading of the filter pack should be based on the grain size of the finest layer to be screened. A filter pack selected in this manner ordinarily does not restrict the flow from the layers of coarsest material. The hydraulic conductivity of the pack is generally several times greater than that of the coarsest layers because the pack is cleaner and more uniform.

Filter pack material should consist of clean, well-rounded grains of a uniform size. These characteristics increase the permeability and porosity of the pack material. Pit-run or crushed materials are usually not satisfactory for filter packs. The chemical nature of the filter pack is as important as its physical characteristics. Filter pack material consisting mostly of siliceous, rather than calcareous, particles is preferred. Up to 5 percent calcareous material is a common allowable limit. This is important because acid treatment of the well might be required later, and most of the acid could be spent in dissolving calcareous particles of the filter pack rather than in removing incrusting deposits of calcium or iron. Similarily, if the groundwater is slightly acidic, partial dissolution of the pack may occur over time. Particles of shale, anhydrite, and gypsum in the filter pack material also are undesirable. Table 13.12 lists the desirable physical and chemical characteristics for a filter pack and the advantages of using these materials.

The steps outlined below are followed in designing a filter pack:

1. Choose the layers to be screened and construct sieve-analysis curves for these formations. Select the grading of the filter pack on the basis of the sieve analysis for the layer of finest material. Figure 13.10 shows the grading of two samples of typical water-bearing material from an aquifer 30 ft (9.1 m) thick. The finest material lies between 75 and 90 ft (22.9 and 27.4 m). The design of the filter pack in this example will be based on this layer. In some instances, it is good practice to ignore unfavorable portions of an aquifer and to use blank pipe between sections of screen positioned in the more permeable sections of the aquifer.

2. Multiply the 70-percent size of the sediment by a factor between 4 and 10. Use 4 to 6 as the multiplier if the formation is uniform and the 40-percent-retained size

Table 13.12. Desirable Filter Pack Characteristics and Derived Advantages

Characteristic	Advantage
Clean	Little loss of material during development Less development time
Well-rounded grains	Higher hydraulic conductivity and porosity Reduced drawdown Higher yield More effective development
90 to 95% quartz grains	No loss of volume caused by dissolution of minerals
Uniformity coefficient of 2.5 or less	Less separation during installation Lower head loss through filter pack

is 0.010 (0.25 mm) or less. Use a multiplier between 6 and 10 for semiconsolidated or unconsolidated aquifers when formation sediment has highly nonuniform gradation and includes silt or thin clay stringers, as commonly found in arid or semiarid areas. Using multipliers greater than 10 may result in a sand-pumping well. Place the result of this multiplication on the graph as the 70-percent size of the filter material. In Figure 13.10, 0.005 in (0.13 mm) is the 70-percent size of the sand between 75 and 90 ft. Using 5 as the multiplier, the 70-percent size of the filter material is 5 × 0.005 = 0.025 in (5 × 0.13 = 0.65 mm). This is the first point on a curve that represents the grading for the filter pack material.

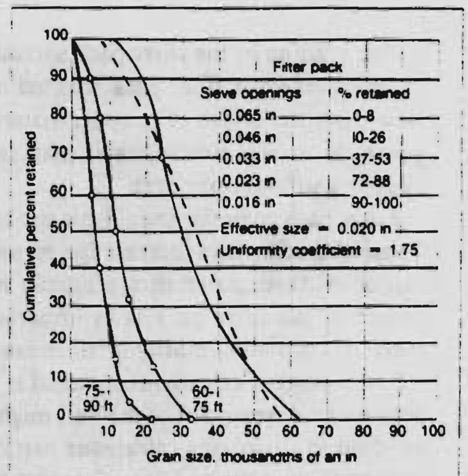


Figure 13.10 Grain-size curves for aquifer sand and corresponding curve for properly selected filter pack material.

3. Through the initial point on the filter pack curve, draw a smooth curve representing material with a uniformity coefficient of approximately 2.5 or less. In Figure 13.10, the curve drawn as a solid line has a uniformity coefficient of about 1.8. It could have been drawn somewhat differently, as shown by the dashed line which has a uniformity coefficient of 2.5. It is good practice to draw the filter pack curve so that the pack is as uniform as practicable. Thus, the material indicated by the solid-line curve is more desirable than the material indicated by the dashed-line curve.

4. Select a commercial filter pack that fulfills the dimensional and chemical requirements listed in Table 13.12. If a proper commercial pack cannot be purchased, but a local source of sand and gravel is available, the following procedure can be used to construct a suitable filter pack.

Prepare specifications for the filter pack material by first selecting four or five sieve sizes that cover the range of values for the curve, and then set down a permissible range for the percentage retained on each of the selected sieves. This range may be eight percentage points below and above the percentage retained at any point on the curve. In the example, the largest sieve would have an opening of 0.065 in (1.7 mm). The curve shows zero percent retained on this sieve, so up to 8 percent of the filter pack may contain 0.065-in material. The next smaller opening in the most commonly used series of sieves is 0.046 in (1.2 mm). The curve, as drawn, shows 18 percent retained on this sieve; 8 percent is added and subtracted to obtain the permissible range. Thus, on the 0.046-in sieve, the range is from 10 to 26 percent. This procedure is repeated until each of the sieves previously selected has been assigned a permissible range. In Figure 13.10, five sizes of sieve openings are shown to cover the desired gradation of the pack material. Giving the filter pack supplier an acceptable range at each of these points makes it possible to produce the desired material at reasonable cost. When designing filter pack material, the designer should keep in mind local sources of filter sand used for rapid sand filters*. Firms that produce these materials

*Rapid sand filters consist of sand beds used to filter drinking water supplies in water treatment plants.

have large stocks of clean, uniformly graded sands and gravels that readily fit the requirements for filter packing of water wells. Some firms supply sand materials to oil and gas companies for use as propping materials in hydraulic fracturing of formations. These materials are also suitable for filter packing of water wells. Drilling contractors should obtain grain-size-distribution curves for all local sources of potential filter pack materials. For economic reasons, these packs should be specified if possible.

5. As a final step, select a screen slot size that will retain 90 percent or more of the filter pack material. In our example, the correct slot size is 0.018 in (0.46 mm).

6. Calculate the volume of filter pack required from Table 13.13. The pack should extend well above the screen to compensate for settlement of the pack during development. Use of a caliper log may reveal the presence of washouts in the borehole, necessitating additional filter pack. It is good practice to have extra filter pack on the site, especially if the stability of the borehole is in doubt.

If the well designer and contractor carefully follow the foregoing steps, sand-pumping wells can be avoided. The pack will provide mechanical retention of the formation material and prevent sediment from moving through the filter pack into the well. Occasionally it may be necessary to install more than one size of filter pack in a borehole. For example, thick boulder beds may overlie sand deposits and the yield requirements may dictate that both layers be screened. If the use of more than one filter pack is contemplated, the screen manufacturer should be consulted for specific design recommendations.

Thickness of Filter Pack

The design theory of filter pack gradation is based on the mechanical retention of formation particles; therefore, a pack thickness of only two or three grain diameters is actually needed to retain and control a formation. Laboratory tests made by Johnson Division show that a properly sized pack with a thickness of less than 0.5 in (12.7 mm) successfully retains the formation particles regardless of the velocity of water passing through the filter pack. It is impossible, however, to place a filter pack that is only 0.5 in thick and expect the material to completely surround the well screen. To insure that a continuous layer of filter material will surround the entire screen, the design should specify that the annulus around the screen be at least 3 in (76 mm).

Filter-pack thickness does little to reduce the possibility of sand pumping, because the controlling factor is the ratio of the grain size for the pack material in relation to the formation material. Also, a filter pack that is too thick can make final development of the well more difficult, as explained in Chapter 15. Under most conditions, filter packs should not be more than 8 in (203 mm) thick because the energy created by the development procedure must be able to penetrate the pack to repair the damage done by drilling, break down any residual drilling fluid on the borehole wall, and remove fine particles near the borehole.

It has been suggested that the presence of a filter pack will augment the well yield because water from an overlying aquifer can percolate downward through the filter pack and into the well screen. In practice, however, calculations show this contribution to be insignificant in relation to total yield. For example, assume the conditions shown in Figure 13.11, where 90 percent of a confined aquifer has been screened. The overlying sediments are water bearing and are connected hydraulically to the screened of sand grains. On the other hand, if a coarse stabilizer is used in a formation that consists mainly of sand or silt held together by calcareous cement, a sand-pumping well could result. Guidelines for the selection of a formation stabilizer are given in Table 13.14.

Most stabilizer materials are placed by hand, but placement by pumping through a tremie pipe is also done. To prevent excessive bridging, the use of centralizers is recommended for screens of more than 30 ft (9.1 m). Even though the final depth of the stabilizer in the borehole will vary according to the amount of material removed during development, approximately 30 to 50 ft (9.1 to 15.2 m) of stabilizer should extend above the top of the screen before development begins.

WELL SCREEN DIAMETER

Screen diameter is selected to satisfy a basic principle: enough open area must be provided so that the entrance velocity of the water generally does not exceed the design standard of 0.1 ft/sec (0.03 m/sec). Screen diameter can be adjusted within rather narrow limits after the length of the screen and size of the screen openings have been selected. Screen length depends upon the thickness of the aquifer; screen openings depend upon the gradation of the sediment or the size of the filter pack.

Well yields are affected by screen diameter, although increasing the screen diameter has much less impact on well yield than increasing the screen length. The theoretical increase in yield that results from enlarging the well diameter can be calculated from the relationship developed in Equation 9.1, where:

$$Q = \frac{K\,(H^2 - h^2)}{1055 \log R/r}$$

This equation can be stated as

$$Q \sim \frac{C}{\log R/r}$$

where C represents all the constant terms.

Table 13.15 shows the figures obtained when R = 400 ft (122 m), a typical radius of influence for unconfined conditions. These comparisons indicate that well diameter requires careful consideration because an increase in screen diameter may not enhance specific capacity or well yield significantly. In some cases, however, it may be worthwhile to increase the well diameter to obtain 15 to 25 percent more water, depending on the cost factors involved.

Table 13.15. Well Diameter vs. Yield Ratio, in Gallons (%)

6 in (152 mm)	12 in (305 mm)	18 in (457 mm)	24 in (610 mm)	30 in (762 mm)	36 in (914 mm)	48 in (1219 mm)
100	110	117	122	127	131	137
—	100	106	111	116	119	125
—	—	100	104	108	112	117
—	—	—	100	104	107	112
—	—	—	—	100	103	108
—	—	—	—	—	100	105

APPENDIX 12.A.
Representative Open Areas of Screens

Screen Diameter	Slot Size	Continuous Slot in^2/ft	Continuous Slot %	Louvered (Minimum open area) in^2/ft	Louvered (Minimum open area) %	Louvered (Maximum open area) in^2/ft	Louvered (Maximum open area) %	Bridge Slot in^2/ft	Bridge Slot %	Bridge Slot in^2/ft	Bridge Slot %	Mill Slotted* (Vertical) in^2/ft	Mill Slotted* (Vertical) %	Slotted Pipe (Horizontal) slots/ft	Slotted Pipe (Horizontal) in^2/ft	Slotted Pipe (Horizontal) %	Plastic Continuous Slot in^2/ft	Plastic Continuous Slot %	Slotted Plastic† in^2/ft	Slotted Plastic† %	Concrete in^2/ft	Concrete %	Fiberglass Reinforced Plastic Continuous Slot‡ in^2/ft	Fiberglass Reinforced Plastic Continuous Slot‡ %
4" ID	20	44	25					—	—			—	—	—	—	—	22	13	—	—			25	12
	30	58	33					—	—			—	—	—	—	—	31	18	—	—			37	17
	40	72	41					13	8			—	—	—	—	—	40	23	13	8			48	23
	50	78	45					—	—			6	4	—	—	—	47	27	—	—			—	—
	60	90	52					19	12			8	5	90	16	3	52	30	18	11			—	—
														130	23	5								
														240	43	9								
	80	102	59					—	—			—	—	90	22	5	—	—	—	—			—	—
														130	31	7								
														240	58	12								
	90	105	60					29	17			—	—	—	—	—	—	—	—	—			—	—
	95	106	61					—	—			12	7	—	—	—	—	—	—	—			—	—
	100	112	64					—	—					90	27	6	—	—	26	16			—	—
														130	39	8								
														240	72	15								
	120	99	57					—	—			—	—	—	—	—	—	—	29	17			—	—
	125	100	58					41	24			16	10	—	—	—	—	—	—	—			—	—
6" ID	20	45	18	—	—	—	—	—	—			—	—				25	10	12	5			14	5
	30	61	25	—	—	—	—	—	—			—	—				36	14	18	7			—	—
	40	77	31	—	—	—	—	14	6			—	—				45	18	23	9			29	9
	50	88	35	—	—	—	—	—	—			9	4				54	22	28	11			—	—
	60	100	40	2	1	7	3	21	8			11	5				62	25	32	13			41	14
	90	124	50	—	—	—	—	31	12			—	—				—	—	—	—			59	20
	95	127	51	4	2	11	5	—	—			17	7				—	—	—	—			—	—
	100	131	53	—	—	—	—	—	—			—	—				—	—	46	18			65	22
	120	141	57	—	—	—	—	—	—			—	—				—	—	51	20			—	—
	125	127	51	5	2	15	7	43	17			23	9				—	—	—	—			—	—
8" ID	20	58	18	—	—	—	—			—	—	—	—				41	12	—	—				
	30	80	25	—	—	—	—			8	3	—	—				57	18	26	8				
	40	98	30	—	—	—	—			—	—	—	—				72	22	—	—				
	50	114	35	—	—	—	—			—	—	—	—				86	26	—	—				
	60	135	41	4	1	10	3			17	6	15	5				93	29	47	14				
	95	165	51	6	2	15	5			—	—	23	7				—	—	—	—				
	100	169	52	—	—	—	—					—	—				—	—	67	21				
	125	166	51	7	2	20	6			38	13	31	10				—	—	—	—				
10" ID	20	72	18	—	—	—	—			—	—	—	—						18	4				
	30	100	25	—	—	—	—			10	2	—	—						26	6				
	40	122	30	—	—	—	—			—	—	—	—						33	8				
	50	143	35	—	—	—	—			—	—	15	4						39	10				

19

[redacted]

20

NOSE DOCK 8 (SS-016)
REMEDIAL INVESTIGATION REPORT

Plattsburgh Air Force Base Installation Restoration Program

Volume 1 of 2

REF 2

prepared for:

United States Department of The Air Force
Plattsburgh Air Force Base
Plattsburgh, New York

Draft Final Report
& Appendix A
December 1995

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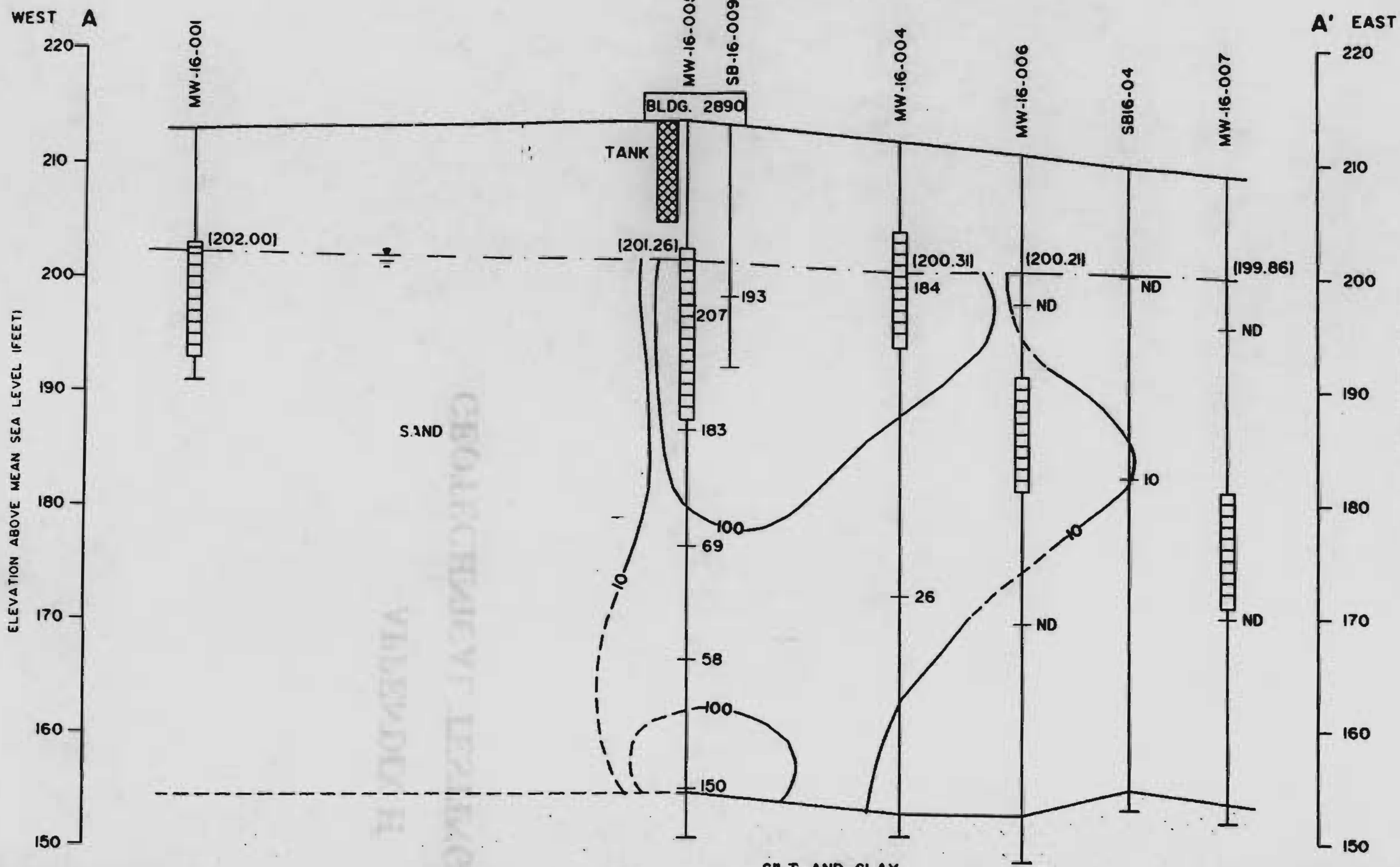


LEGEND

MW-16-005	MONITORING WELL NUMBER
(201.26)	GROUNDWATER POTENTIOMETRIC SURFACE (GROUNDWATER ELEVATIONS FROM 12/2/93)
207	CONCENTRATION OF NAPHTHALENES (ppb)
(screen symbol)	SCREENED INTERVAL OF MONITORING WELL
(tick symbol)	BOREHOLE TERMINATION
ND	NON-DETECT
——100——	ISOCONCENTRATION CONTOUR (ppb)
– –100– – –	INFERRED ISOCONCENTRATION CONTOUR (ppb)

NOTES:

1. CONTAMINANT CONCENTRATIONS SHOWN ARE BASED UPON CHEMICAL ANALYSIS OF GROUNDWATER SCREENING SAMPLES COLLECTED FROM BORINGS BETWEEN 9/08/93 AND 10/27/93. DATA FROM MONITORING WELL GROUNDWATER SAMPLES ARE NOT SHOWN. EXTRAPOLATIONS BETWEEN BORINGS ARE INTERPRETIVE. ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.
2. GEOLOGICAL CONDITIONS SHOWN ARE REPRESENTATIVE OF THE CONDITIONS ENCOUNTERED AT EACH BORING LOCATION TO THE DEPTH DRILLED. EXTRAPOLATIONS BETWEEN BORINGS HAVE BEEN INTERPRETED USING STANDARDLY ACCEPTED GEOLOGIC PRACTICES AND PRINCIPLES. ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.
3. ELEVATIONS BASED ON TRANSVERSE MERCATOR PROJECTION, EAST ZONE, NORTH AMERICAN DATUM 1983.

* VALUE DERIVED FROM LOWER ESTIMATE OF LEACHATE CONCENTRATION MODEL (APPENDIX S, TABLE 1).

50 0 50

HORIZONTAL SCALE IN FEET

VERTICAL EXAGGERATION = 5X

PLATTSBURGH A.F.B. SS-016
VERTICAL EXTENT OF
NAPHTHALENES CONTAMINATION

URS CONSULTANTS, INC.

FIGURE 5-20

CC-3609

APPENDIX H

GEOTECHNICAL TESTING RESULTS

SITE: SS-016
GEOTECHNICAL ANALYSIS SUMMARY

	GRAIN SIZE DISTRIBUTION						
Sample Location/Depth	% Gravel	% Sand	% Silt	% Clay	USCS Class*	Water Content	Permeability (Vertical/cm/s)
SB-16-001/14'-16'	0.0	98.5	0.6	0.9	SP	18.4%	---
SB-16-001/64'-66'	0.0	6.7	56.8	36.5	CL	27.5%	---
SB-16-002/48'-50'	0.0	25.1	64.9	10.0	ML	20.8%	---
SB-16-002/65'-67'	0.0	9.5	23.6	66.9	CH	34.5%	---
SB-16-003/25'-27'	0.0	97.2	2.2	0.6	SP	17.4%	---
SB-16-003/55'-57'	0.2	6.5	73.3	20.0	CL-ML	22.2%	---
SB-16-004/45'-47'	0.0	29.9	63.8	6.3	ML	23.5%	---
SB-16-004/55'-57'	0.0	5.1	60.0	34.9	CL	28.1%	---
SB-16-005/25'-27'	0.4	97.0	2.6	0.0	SP	19.2%	---
SB-16-005/60'-62'	0.0	4.8	26.0	69.2	CL	31.6%	---
SB-16-005/62'-64'	0.0	4.1	18.8	77.1	CH	42.4%	3.78X10[8]
MW-16-004/15'-17'	0.0	97.7	1.9	0.4	SP	19.0%	---
MW-16-004/59'-61'	0.0	10.2	50.0	39.8	CL	28.7%	---
MW-16-005/15'-17'	1.5	83.8	11.8	2.9	SP	5.3%	---
MW-16-005/59'-61'	0.0	7.6	75.0	17.4	ML	20.7%	---
MW-16-006/24'-26'	0.9	89.2	8.9	1.0	SP	18.1%	---
MW-16-006/60'-61'	1.0	3.4	18.2	77.4	CH	46.0%	---
MW-16-007/30'-32'	0.0	75.4	22.1	2.5	SM	19.1%	---

J 35291 SS 016 GAS mm
12 19 95 13.20

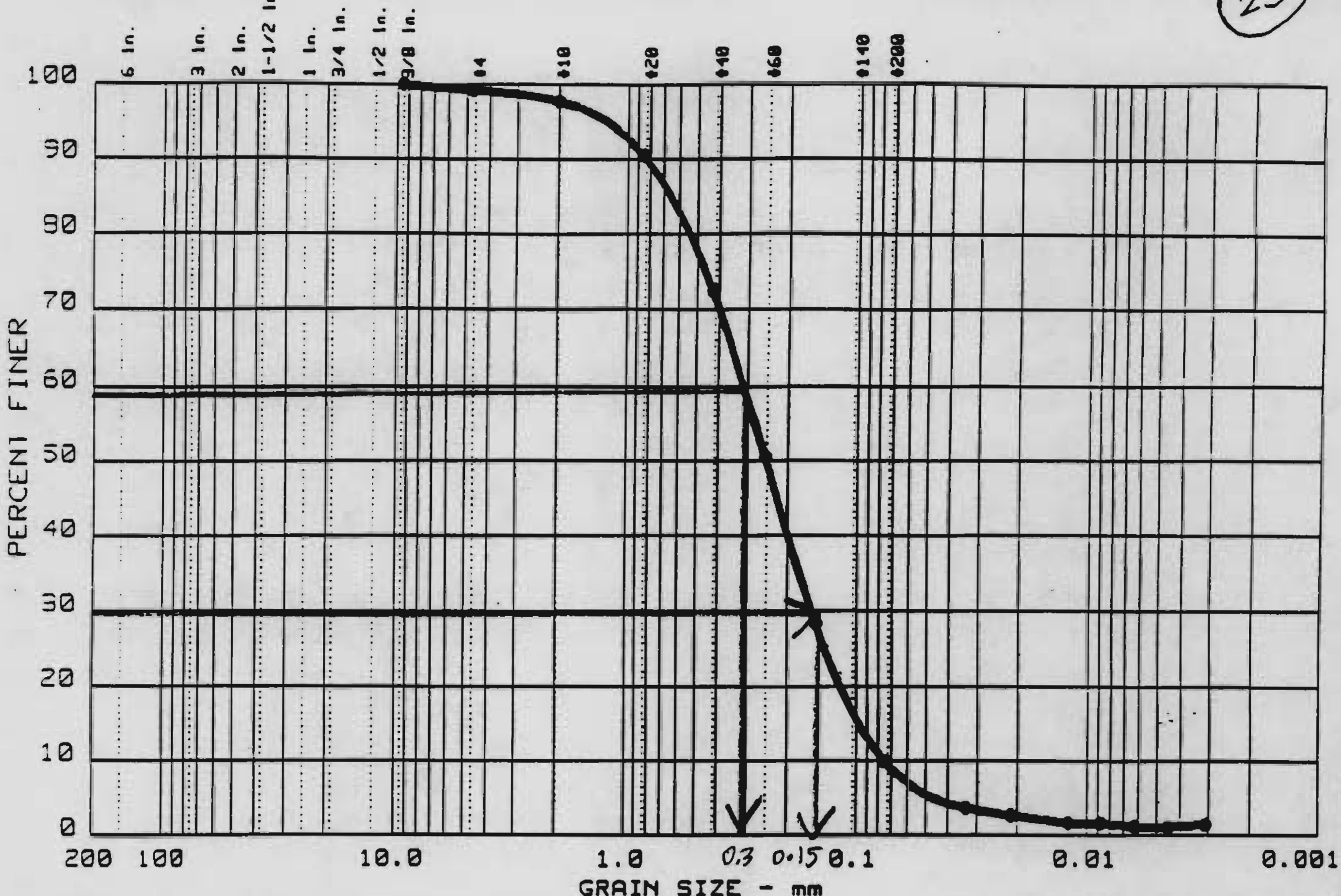
SITE: SS-016 (Continued)

Sample Location/Depth	GRAIN SIZE DISTRIBUTION % Gravel	% Sand	% Silt	% Clay	USCS Class*	Water Content	Permeability (Vertical/cm/s)
MW-16-007/55'-57'	0.0	7.5	71.3	21.2	CL-ML	22.8%	---
GS-016-001/0'-1'	1.9	93.2	3.7	1.2	SP	---	---
GS-016-002/0'-'1'	3.5	89.3	5.1	2.1	SP	---	---

* Determined from Atterberg Limits Analysis

GRAIN SIZE DISTRIBUTION TEST REPORT

(25)



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	16	0.0	0.9	89.2	8.9	1.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.65	0.31	0.25	0.156	0.0964	0.0748	1.05	4.1

MATERIAL DESCRIPTION	USCS	AASHTO
● TAN SAND, trace silt & clay & gravel		

Project No.: G008.015D
Project: PLATTSBURGH AIR FORCE BASE SITE SS-016
● Location: MW16-06 / 24'- 26'

Date: JANUARY 4, 1994

GRAIN SIZE DISTRIBUTION TEST REPORT
HUNTINGDON ENGINEERING & ENVIRONMENTAL

Remarks:
CLIENT: URS CONSULTANTS

WATER CONTENT: 18.1%
LAB NO. 1907.048

Figure No. 1

APPENDIX A-3
ESTIMATED INFLUENT CONCENTRATIONS

URS CONSULTANTS, INC.

SHEET NO. .... OF ....

PROJECT PAFB SS-016
SUBJECT Groundwater Dilution Factor

JOB NO. 0535291.23
MADE BY KEP DATE 6/7/96
CHKD. BY CWP DATE 6/25/96

REF. PAGE

Summary of Dilution Factor Calculations:

The attached Figures that identify the horizontal extent of contamination were used to demonstrate the influence of a pumping well at 50 gpm. The pumping well location is proposed to be near the former solvent tank.

The dilution factor calculation is based on the area of "clean" groundwater to the area of contaminated groundwater. Clean groundwater is identified by the area outside of isoconcentration lines within the influence of the pumping well. Contaminated groundwater is given by the isoconcentration lines within the pumping well influence

The calculations presented for ketones calculate the area of contamination within each level of contamination (i.e., 100 ppb area, 10 ppb area, and ND to 10 ppb area). For the remaining compound classes, only one area or the entire area of contamination was calculated. This is consistent with the methodology used for ketones since each level of contamination was summed for ketones.

PROJECT PAFB SS-016
SUBJECT GROUNDWATER DILUTION FACTOR

REF. PAGE

KETONES

ASSUMPTIONS: PUMPING AREA IS A CIRCLE WITH A RADIUS OF 220 FT AS SHOWN ON THE ATTACHED FIGURES.

100 ppb area

$A = L \times W$

$A = 110\ FT \times 40\ FT = \underline{4400\ FT^2}$

10 ppb area

$A = L \times W$

$A = 140\ FT \times 70\ FT = 9800\ FT^2 - 4400\ FT^2 = \underline{5400\ FT^2}$

ND to 10 ppb area

$h = 180\ FT$

$b = 220\ FT$

$A = 1/2\,bh = 1/2(220\ FT)(180\ FT) = 19800\ FT^2 - 9800\ FT^2 = \underline{10{,}000\ FT^2}$

CLEAN WATER AREA

$A = \pi r^2$

$A = \pi(220\ FT)^2 = 152{,}053\ FT^2 \approx 152{,}000\ FT^2$

$152{,}000\ FT^2 - 19{,}800\ FT^2 = \underline{132{,}200\ FT^2}$

PERCENT OF TOTAL PUMPING AREA:

% CLEAN: $\frac{132{,}200}{152{,}000} \times 100 = 86.97 \approx \underline{87.0\%}$

% 100 ppb $= \frac{4400}{152200} \times 100 = \underline{2.9\%}$

% ND - 10 ppb: $\frac{10{,}000}{152{,}200} \times 100 = 6.57 \approx \underline{6.6\%}$

% 10 ppb: $\frac{5400}{152200} \times 100 = 3.55 \approx \underline{3.6\%}$

URS CONSULTANTS, INC.

SHEET NO. .... OF ....

PROJECT PAFB SS-016

JOB NO. 0536291.23

SUBJECT GROUNDWATER DILUTION FACTOR

MADE BY KEP DATE 5/15/96

CHKD. BY CWP DATE 6/25/96

REF. PAGE

FOR KETONES, ASSUME WORST CASE SCENARIO THAT ALL ISOCONCENTRATION LINES FALL WITHIN 100 ppb RANGE. THEREFORE 100 ppb AREA WILL BE EQUAL TO THE SUM OF ALL AREAS EXCEPT FOR CLEAN WATER AREAS:

NEW 100 ppb AREA : 2.9 %
6.6 %
3.6 %
13.1 % ≈ 13 %

DILUTION FACTOR : 87 : 13 OR 6.7 : 1

AC-9237

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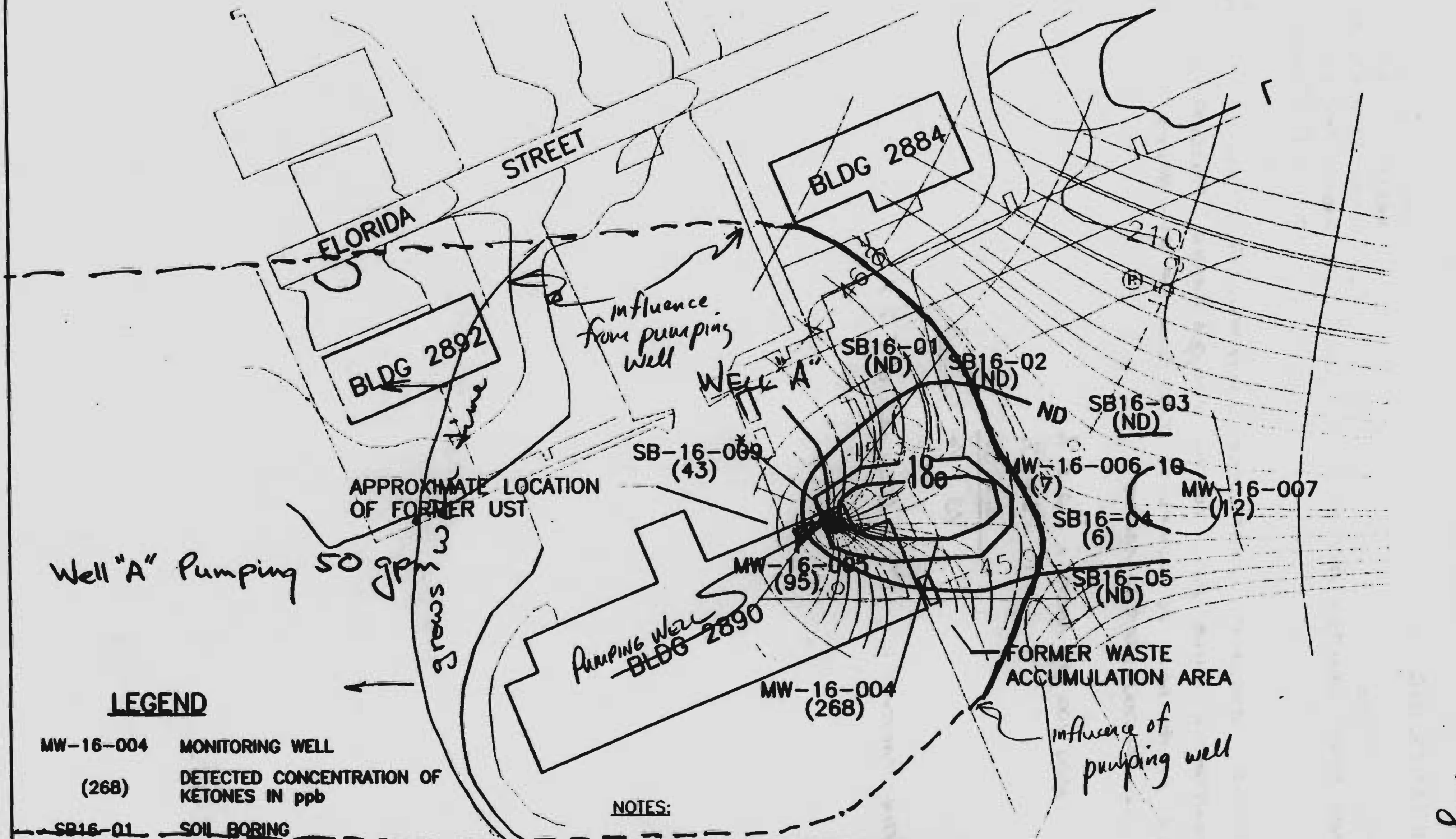


LEGEND

MW-16-004	MONITORING WELL
(268)	DETECTED CONCENTRATION OF KETONES IN ppb
SB16-01	SOIL BORING
—10—	ISOCONCENTRATION CONTOUR IN ppb
—ND—	INFERRED ISOCONCENTRATION CONTOUR

NOTES:

1. GROUNDWATER SCREENING SAMPLES WERE COLLECTED FROM 9/08/93 TO 10/27/93.

* VALUE DERIVED FROM LOWER ESTIMATE OF LEACHATE CONCENTRATION MODEL (APPENDIXS, TABLE 1).

100 0 100

SCALE IN FEET

URS CONSULTANTS, INC.

PLATTSBURGH A.F.B. SS-016
HORIZONTAL EXTENT OF KETONES CONTAMINATION

FIGURE 5-1

PROJECT PAFB SS-016
JOB NO. 0535291.23
SUBJECT GROUNDWATER DILUTION FACTOR
MADE BY KEP DATE 5/16/96
CHKD. BY CWP DATE 6/25/96

REF. PAGE

CHLORINATED HYDROCARBONS

THE CONTAMINATION AREA IS ASSUMED TO BE AN ELLIPSE INSIDE A 152,000 FT² CIRCLE THAT ESTIMATES BOTH THE CLEAN GROUNDWATER AREA AND THE CONTAMINATED GROUNDWATER AREA REPRESENTED BY THE ELLIPSE THE AREA OF THE ELLIPSE WILL BE CALCULATED TO ESTIMATE THE DILUTION FACTOR INTO A PUMPING WELL

CONTAMINATED AREA - REPRESENTED BY THE PARTIAL ELLIPSE
- ASSUME 67% OF THE ELLIPSE REPRESENTS THE CONTAMINATED AREA.

AREA OF ELLIPSE = πab
where $a = 125$ FT
$b = 75$ FT

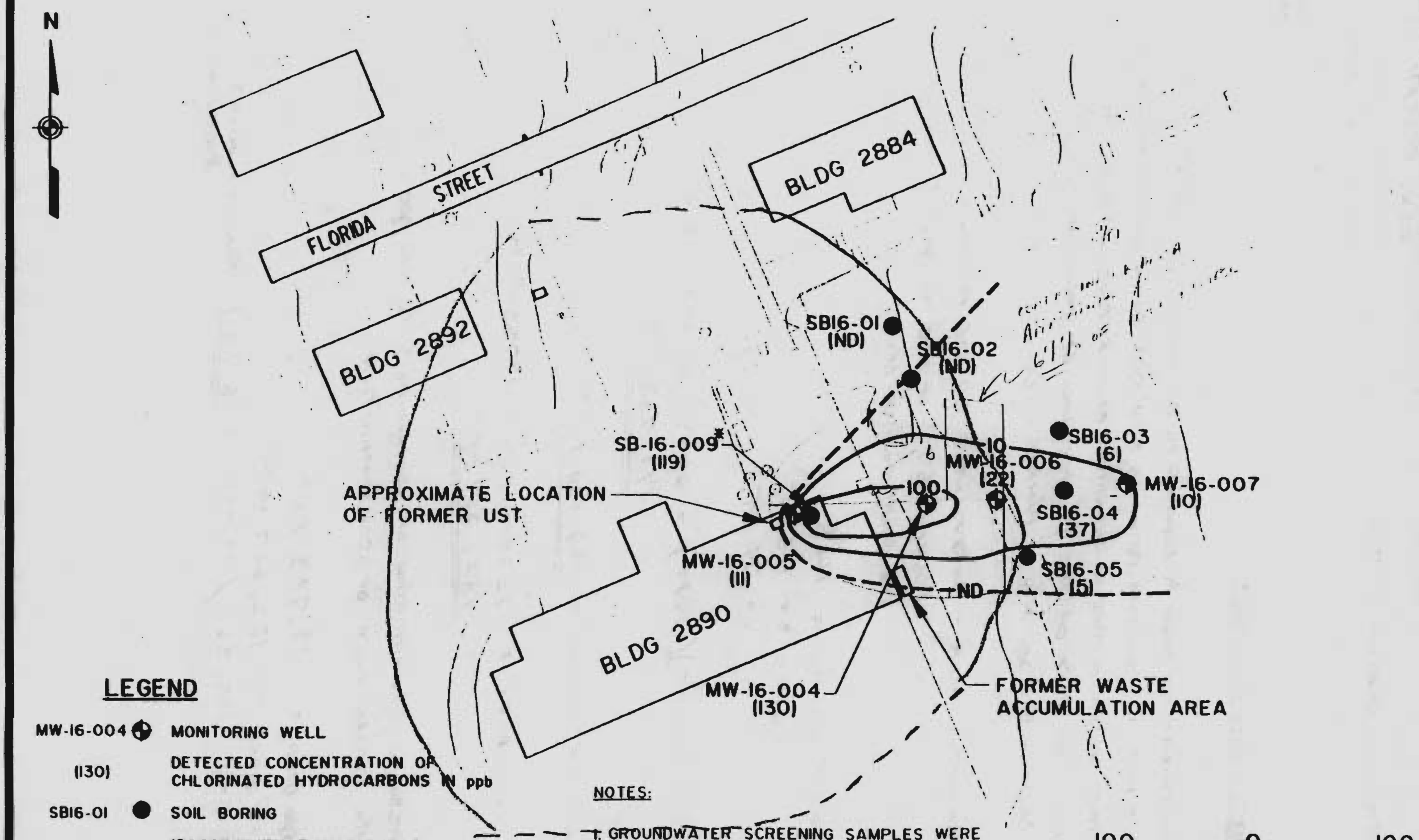
$A = \pi(125\text{ FT})(75\text{ FT}) = 29452.43\text{ FT}^2 \times 0.67$
$= \underline{19,733\text{ FT}^2}$

AREA OF CIRCLE = $\underline{152,000\text{ FT}^2}$

CLEAN AREA = $152000\text{ FT}^2 - 19733\text{ FT}^2$
$= \underline{132,267\text{ FT}^2}$

ASSUME CONCENTRATION OF CONTAMINANTS IS 100 ppb FOR ENTIRE AREA OF CONTAMINATION:

100 ppb AREA = $19,733\text{ FT}^2$
CLEAN AREA = $132,267\text{ FT}^2$
DF = 132,267 / 19,733 = $\underline{6.7 : 1}$ FOR CHLORINATED HYDROCARBONS



LEGEND

MW-16-004	MONITORING WELL
(130)	DETECTED CONCENTRATION OF CHLORINATED HYDROCARBONS IN ppb
SB16-01	SOIL BORING
—10—	ISOCONCENTRATION CONTOUR IN ppb
---ND---	INFERRED ISOCONCENTRATION CONTOUR

NOTES:

1. GROUNDWATER SCREENING SAMPLES WERE COLLECTED FROM 9/08/93 TO 10/27/93.

* VALUE DERIVED FROM LOWER ESTIMATE OF LEACHATE CONCENTRATION MODEL (APPENDIX S. TABLE 11.

100 0 100

SCALE IN FEET

URS CONSULTANTS, INC.

PLATTSBURGH A.F.B. SS-016 RI
HORIZONTAL EXTENT OF CHLORINATED HYDROCARBON CONTAMINATION

FIGURE 5-10

Page 6 of 17

PROJECT PAFB SS-016
SUBJECT GROUNDWATER DILUTION FACTOR

JOB NO. 05.35.291.23
MADE BY KEP DATE 5/10/9
CHKD. BY CWP DATE 6/26/9

REF. PAGE

NAPHTHALENES

THE CONTAMINATED AREA IS ASSUMED TO BE A PARTIAL ELLIPSE INSIDE A 152,000 FT² CIRCLE. THE CIRCLE ESTIMATES THE AREA OF BOTH CLEAN GROUND WATER AND CONTAMINATED GROUND WATER REPRESENTED BY THE PARTIAL ELLIPSE. THE AREA OF THE ELLIPSE WILL BE CALCULATED AND USED TO ESTIMATE THE DILUTION FACTOR INTO A PUMPING WELL.

CONTAMINATED AREA: - REPRESENTED BY PARTIAL ELLIPSE
- ASSUME 65% OF ELLIPSE REPRESENTS CONTAMINATED AREA.

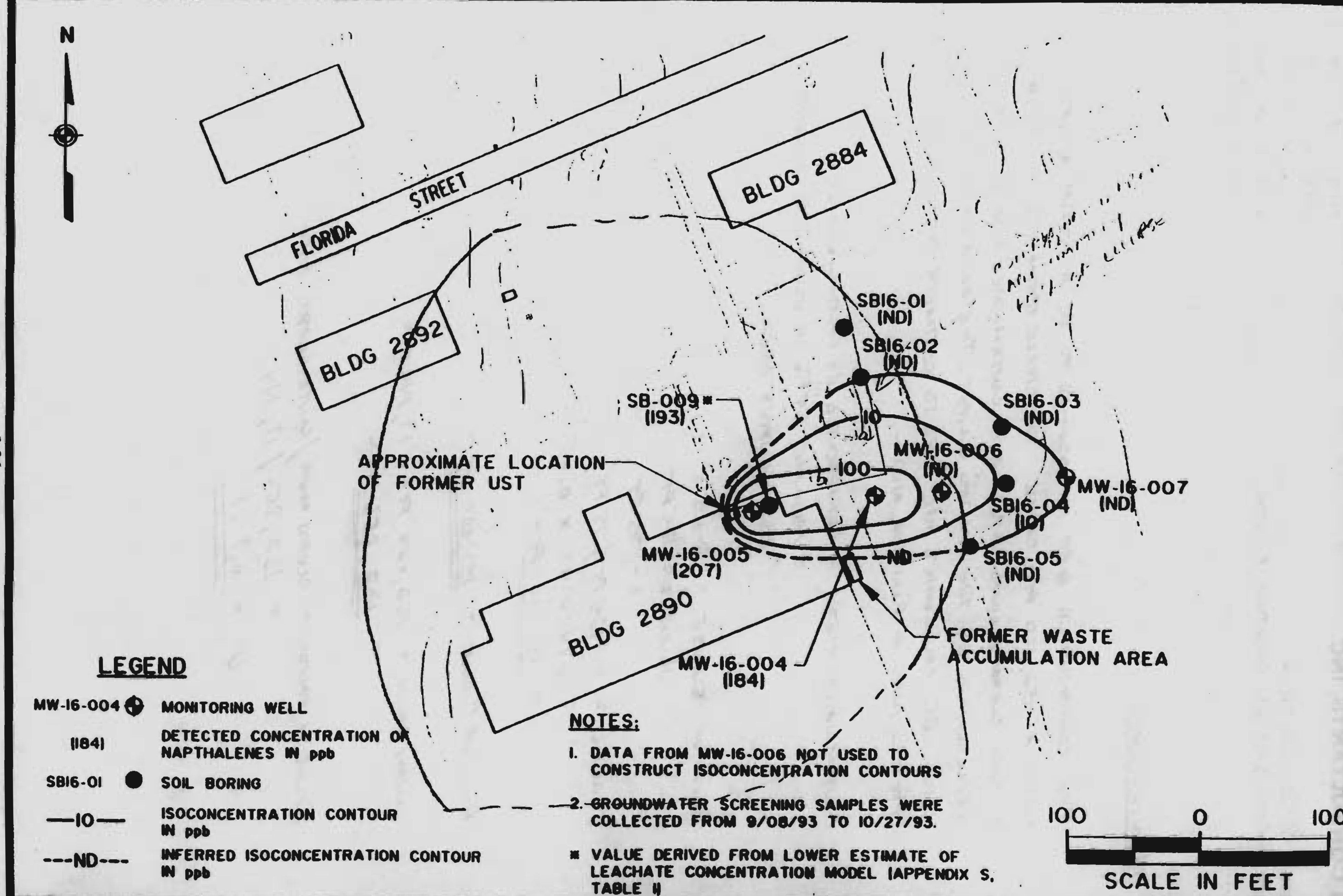
AREA OF ELLIPSE = πab
where a = 125 FT
b = 75 FT

$A_{ellipse} = \pi(125\ FT)(75\ FT)$
$= 29452.43 \times 0.65$
$= \underline{19,144\ FT^2}$

AREA OF CIRCLE = $\underline{152,000\ FT^2}$

CLEAN AREA = $152,000\ FT^2 - 19,144\ FT^2$
$= \underline{132,856\ FT^2}$

DILUTION FACTOR = CLEAN AREA / CONTAMINATED AREA
$= 132,856 / 19,144$
DF = $\underline{6.9:1}$



NOTES:

1. DATA FROM MW-16-006 NOT USED TO CONSTRUCT ISOCONCENTRATION CONTOURS
2. GROUNDWATER SCREENING SAMPLES WERE COLLECTED FROM 9/08/93 TO 10/27/93.

* VALUE DERIVED FROM LOWER ESTIMATE OF LEACHATE CONCENTRATION MODEL (APPENDIX S, TABLE 11)

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PLATTSBURGH A.F.B. SS-016
HORIZONTAL EXTENT OF NAPTHALENES CONTAMINATION

FIGURE 5-14

REF. PAGE

1,2 - DCE

THE CONTAMINATED AREA IS ASSUMED TO BE A PARTIAL ELLIPSE INSIDE A 152,000 FT^2 CIRCLE. THE CIRCLE ESTIMATES THE AREA OF BOTH CLEAN GROUND WATER AND CONTAMINATED GROUNDWATER REPRESENTED BY THE PARTIAL ELLIPSE. THE AREA OF THE ELLIPSE WILL BE CALCULATED AND USED TO ESTIMATE THE DILUTION FACTOR INTO A PUMPING WELL.

CONTAMINATED AREA: - REPRESENTED BY PARTIAL ELLIPSE
- ASSUME 60% OF ELLIPSE REPRESENTS CONT AREA.

AREA OF ELLIPSE = πab

where a = 125 FT

b = 75 FT

$A_{ELLIPSE} = \pi(125\ FT)(75\ FT)$

= 29452.43 × 0.60

= 17,671.46 ≈ 17,671 FT^2

AREA OF CIRCLE = 152,000 FT^2

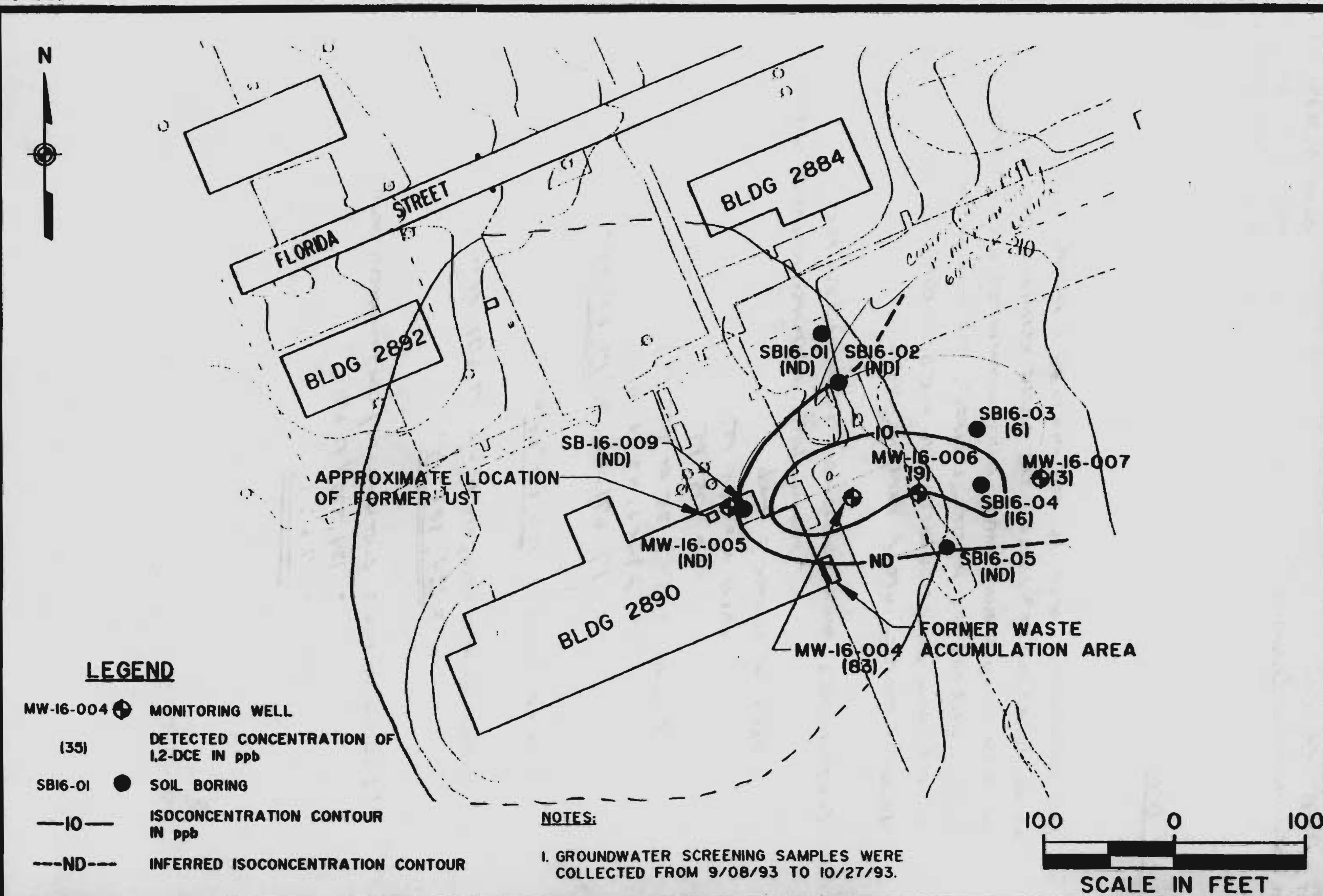
CLEAN AREA = 152,000 FT^2 - 17,671 FT^2

= 134,329 FT^2

DILUTION FACTOR = CLEAN AREA / CONTAMINATED AREA

= 134,329 / 17,671

DF = 7.6 : 1



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PLATTSBURGH A.F.B. SS-016
HORIZONTAL EXTENT OF 1,2-DCE CONTAMINATION

FIGURE 5-12

PROJECT PAFB SS-016
SUBJECT GROUNDWATER DILUTION FACTOR

JOB NO. 05.35.891.23
MADE BY KCP DATE 5/16/96
CHKD. BY CWP DATE 6/25/96

REF. PAGE

TCE

THE CONTAMINATED AREA IS ASSUMED TO BE RECTANGLE INSIDE A 152,000 FT² CIRCLE. THE CIRCLE ESTIMATES BOTH CLEAN GROUND WATER AND CONTAMINATED GROUNDWATER REPRESENTED BY THE RECTANGLE. THE AREA OF THE RECTANGLE WILL BE CALCULATED AND USED TO ESTIMATE THE DILUTION FACTOR INTO A PUMPING WELL.

CONTAMINATED AREA:

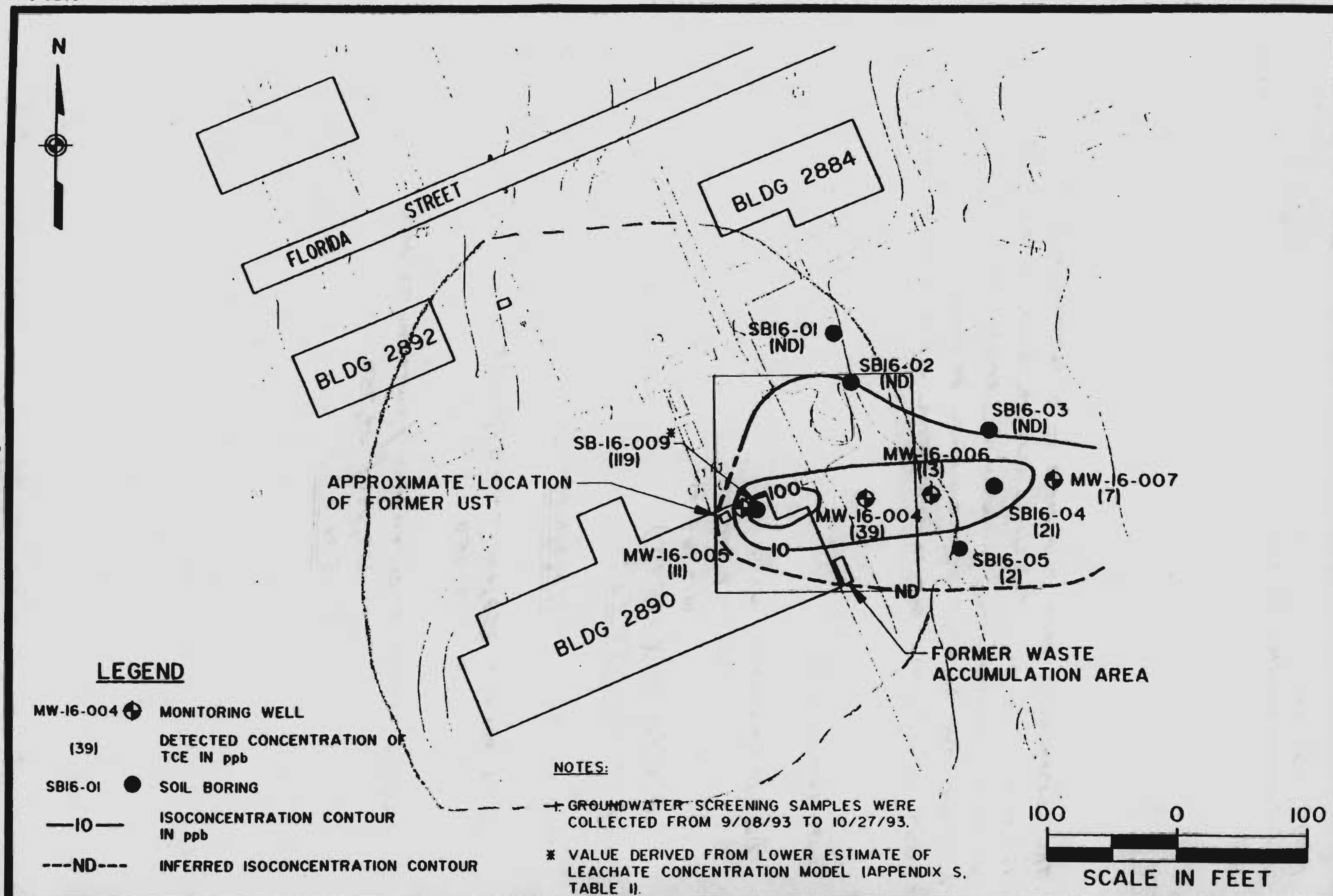
AREA OF RECTANGLE = L x W
where L = 150 FT
W = 165 FT

A = (150 FT)(165 FT)
A = 24,750 FT²

AREA OF CIRCLE = 152,000 FT²

CLEAN AREA = 152,000 FT² - 24,750 FT²
= 127,250

DILUTION FACTOR = CLEAN AREA / CONTAMINATED AREA
= 127,250 / 24,750
= 5.14 : 1



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PLATTSBURGH A.F.B. SS-016
HORIZONTAL EXTENT OF TCE CONTAMINATION

FIGURE 5-11

Page 1 of 17

PROJECT PAFB SS-016
SUBJECT GROUNDWATER DILUTION FACTOR

JOB NO. 05352?91.23
MADE BY KEP DATE 5/16/96
CHKD. BY CWP DATE 6/25/96

REF. PAGE

BTEX

THE CONTAMINATED AREA IS ASSUMED TO BE AN ELLIPSE INSIDE A 152,000 FT^2 CIRCLE. THE CIRCLE ESTIMATES BOTH CLEAN WATER AND THE CONTAMINATED WATER REPRESENTED BY THE ELLIPSE. THE AREA OF THE ELLIPSE WILL BE CALCULATED TO ESTIMATE THE DILUTION FACTOR INTO A PUMPING WELL.

CONTAMINATED AREA - REPRESENTED BY THE PARTIAL ELLIPSE
- ASSUME 65% OF THE ELLIPSE REPRESENTS THE CONTAMINATED AREA.

AREA OF ELLIPSE = πab

where $a = 125$ FT
$b = 75$ FT

$A_{ELLIPSE} = \pi(125\ FT)(75\ FT)$
$= 29{,}452.43\ FT^2 \times 0.65$
$= 19{,}144.73 \approx \underline{19{,}145\ FT^2}$

AREA OF CIRCLE $= \pi r^2$ where $r = 220$ FT
$= \pi(220)^2$
$= 152{,}053.08$
$\approx \underline{152{,}000\ FT^2}$

CLEAN AREA $= 152{,}000\ FT^2 -$ ~~29,452~~ 19,145 FT^2 CWP
$=$ ~~122,550 FT²~~ 132,855 FT^2 CWP

REF. PAGE

ASSUME THAT CONCENTRATION OF CONTAMINANTS IS 100 ppb FOR ENTIRE AREA OF CONTAMINATION:

100 ppb AREA = AREA OF CONTAMINATION = 19,145 FT²

CLEAN AREA = ~~1??,550~~ 132,855 CWP FT²

DILUTION FACTOR: $\frac{\text{~~1??,550~~ } 132,855 \text{ CWP}}{19,145} = \frac{\text{~~6.4~~ } 6.9 \text{ CWP}}{1}$

DF = ~~6.4~~ 6.9 CWP : 1 FOR BTEX COMPOUNDS

AC-9233

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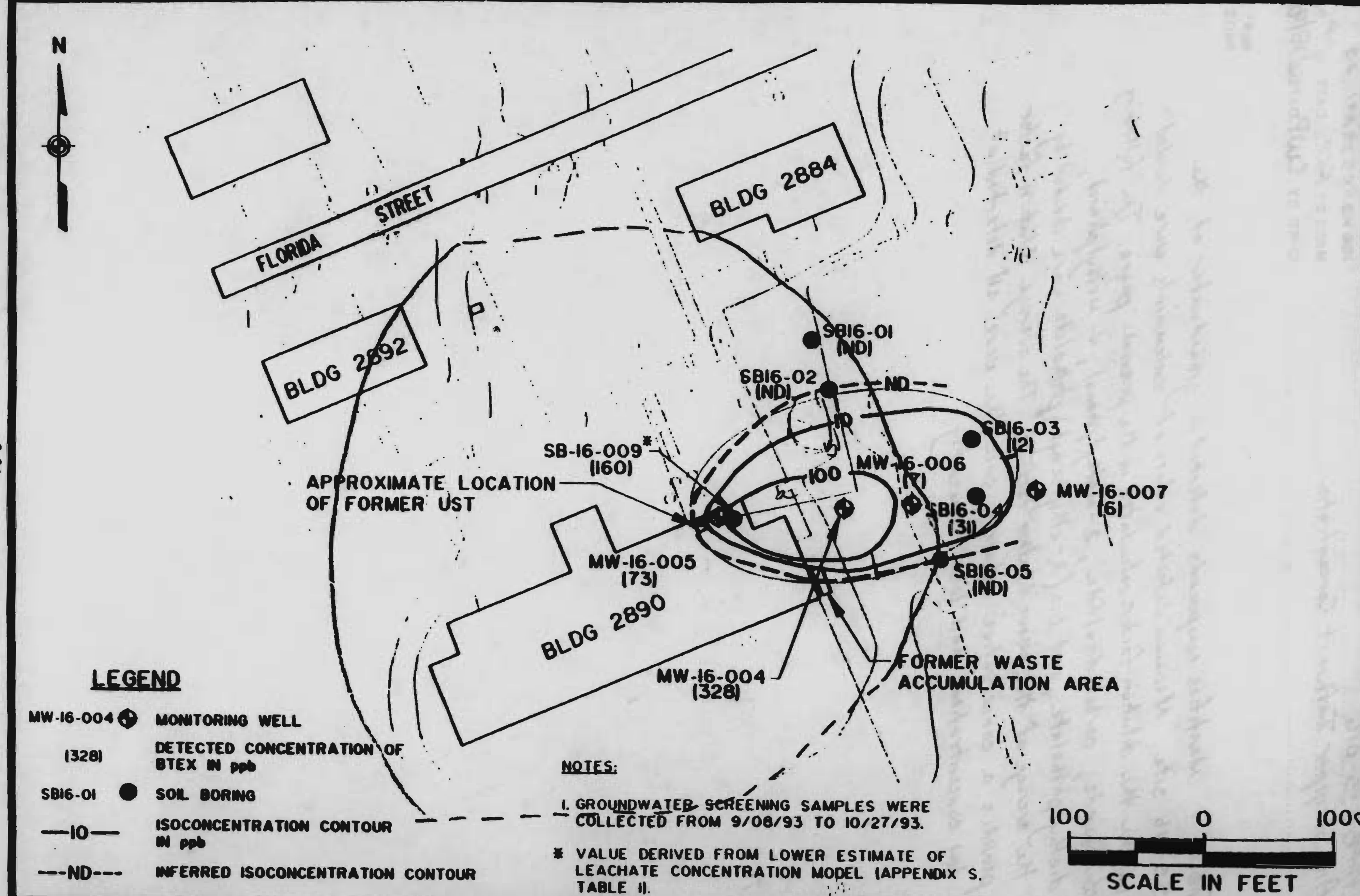


URS CONSULTANTS, INC.

PLATTSBURGH A.F.B. SS-016 RI
HORIZONTAL EXTENT OF BTEX CONTAMINATION

FIGURE 5-9

Page 15 of 17

PROJECT PAFB SS-016
SUBJECT Air Stripper Influent Concentrations

JOB NO. 053581.03
MADE BY KEP DATE 6/7/96
CHKD. BY CWP DATE 6/25/96

REF. PAGE

Table 1 identifies compounds detected in groundwater at the SS-016 site. Maximum detected values of contaminants were divided by the the dilution factor calculated in the previous pages. The following compounds; carbon disulfide, 2-methylphenol, 4-methylphenol, diethylphthalate, and bis(2-ethylhexyl)phthalate were divided by the average of the above dilution factors. The average dilution factor provides a conservative estimate since the were all detected at low concentrations and less frequently.

Table 1
Estimate of Groundwater Contamination into the Air Stripper

CHEMICAL	CAS Registry Number	Influent Conc. Untreated ppb (maximum)	Dilution Factor	Influent Conc. Untreated ppb (diluted)	Effluent Requirements ppb
Acetone	67-64-1	140	6.7	20.9	50
Carbon Disulfide	75-15-0	2	6.7	0.3	NS
1,1-Dichloroethane	75-34-3	3	6.7	0.4	5
1,2-Dichloroethene (total)	540-59-0	42	7.6	5.5	5
Chloroform	67-66-3	28	6.7	4.2	7
1,2-Dichloroethane	107-06-2	4	6.7	0.6	5
2-Butanone	78-93-3	16	6.7	2.4	50
1,2-Dichloropropane	78-87-5	10	6.7	1.5	5
Trichloroethylene	79-01-6	110	5.1	21.6	10
Toluene	108-88-3	88	6.9	12.8	5
Ethylbenzene	100-41-4	38	6.9	5.5	5
Xylene (total)	1330-20-7	250	6.9	36.2	5
1,2-Dichlorobenzene	95-50-1	2	6.7	0.3	4.7
2-Methylphenol	95-48-7	3	6.7	0.5	10
4-Methylphenol	106-44-5	110	6.7	16.5	10
Naphthalene	91-20-3	170	6.9	24.5	10
2-Methylnaphthalene	91-57-6	70	6.9	10.1	NS
Diethylphthalate	84-66-2	5	6.7	0.8	50
bis(2-Ethylhexyl)phthalate	117-81-7	2	6.7	0.3	NS

NS - not specified

Dilution factors:

ketones:	6.7
chlorinated hydrocarbons:	6.7
naphthalenes:	6.9
1,2-DCE:	7.6
TCE:	5.1
BTEX:	6.9
average:	6.7

average dilution factor was used for class of compounds not listed above; based on sample results, represents a conservative dilution factor

shading indicates influent concentration is above effluent requirements

APPENDIX A-4
AIR STRIPPER CALCULATIONS

PROJECT PAFB SS-016

SUBJECT Air Stripper Calculations

REF. PAGE

InFluent concentrations calculated in Appendix A-3 were sent to North East Environmental Products, Inc - manuFacturer of the ShallowTray Air stripper.

NorthEast Environmental inputed these inFluent concentrations into their computer model.

The results oF the model are shown in page 2.

A model 2341 was selected to be conservative.

It should be noted that 1,1,1-trichloroethane was substituted For 1,2-dichloropropane since this compound is not available in the computer program. 1,1,1-trichloroethane has properties very similar to 1,2-dichloropropane; therefore, estimated removal is expected to be similar. In addition, 1,1-dichloroethane could not be modeled because inFluent and required eFFluent concentrations were too low to be eFFectively used in model.

ShallowTray®

low profile air strippers

System Performance Estimate

Client and Proposal Information:

URS Consultants: Demetra Papademetriou
#16 Plattsburgh AFB, NY
696925-3

Model chosen:	2300
Water Flow Rate:	50.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	50.0 °F
Air Temp:	50.0 °F
A/W Ratio:	44.9
Safety Factor:	None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Air (lbs/hr) %removal	Model 2321 Effluent Air (lbs/hr) %removal	Model 2331 Effluent Air (lbs/hr) %removal	Model 2341 Effluent Air (lbs/hr) %removal
1,1,1-Trichloroethane	2 ppb 0 ppb	<1 ppb 0.000037 74.6400%	<1 ppb 0.000047 93.5687%	<1 ppb 0.000049 98.3690%	<1 ppb 0.000050 99.5864%
1,1-Dichloroethane	1 ppb 0 ppb	<1 ppb 0.000017 66.0417%	<1 ppb 0.000022 88.4683%	<1 ppb 0.000024 96.0840%	<1 ppb 0.000025 98.6702%
1,2-Dichloroethane	1 ppb 1 ppb	<1 ppb 0.000003 12.3543%	<1 ppb 0.000006 23.1824%	<1 ppb 0.000008 32.6727%	<1 ppb 0.000010 40.9905%
Ethyl Benzene	6 ppb 5 ppb	2 ppb 0.000108 71.4252%	<1 ppb 0.000138 91.8348%	<1 ppb 0.000147 97.6668%	<1 ppb 0.000150 99.3333%
t-1,2-Dichloroethylene	6 ppb 5 ppb	2 ppb 0.000103 68.1564%	<1 ppb 0.000135 89.8599%	<1 ppb 0.000146 96.7710%	<1 ppb 0.000149 98.9718%
Toluene	13 ppb 5 ppb	4 ppb 0.000221 67.7551%	1 ppb 0.000292 89.6027%	<1 ppb 0.000315 96.6474%	<1 ppb 0.000323 98.9190%
Trichloroethylene	22 ppb 3 ppb	6 ppb 0.000394 71.3735%	2 ppb 0.000507 91.8053%	<1 ppb 0.000539 97.6541%	<1 ppb 0.000548 99.3285%
p-Xylene	36 ppb 5 ppb	11 ppb 0.000635 70.2451%	3 ppb 0.000823 91.1464%	<1 ppb 0.000880 97.3656%	<1 ppb 0.000896 99.2161%

This custom modeling was done by North East Enviromental Products, Inc. as a performance estimate only. No warranty is expressed or implied. For complete details of NEEP's Perfomance Warranty contact your ShallowTray representative. Report Generated: 6/26/96

APPENDIX A-5
ESTIMATED AIR FLOW RATE

REF. PAGE

1. OBJECTIVE
   TO ESTIMATE EXTRACTION RATE FROM AN SVE WELL AT SS-016 SITE.

2. ASSUMPTIONS
   - UNSATURATED THICKNESS UNDERNEATH THE BUILDING
     $H \cong 15$ FT ≈ 450 cm
     REF 1, FIG 2-4
   - HYDRAULIC CONDUCTIVITY OF SOIL. ASSUME:
     $K \cong 1.5E-2$ CM/S   GEOM. MEAN OF 3 VALUES REPORTED IN TAB 3-5 OF THE DEC 95 DRAFT FINAL RI (NOSE DOCK 8) - REF 7
   - USE AN 8" WELL
     $R_w = \frac{1}{2} \times 8 = 4" \cong 10$ cm
   - ASSUME AVERAGE TEMPERATURE OF 10 °C.
   - SVE WELL WILL BE LOCATED UNDERNEATH THE CORNER OF THE BUILDING, APPROXIMATELY 15 FT FROM ITS EASTERN AND NORTHERN LIMITS. SINCE THE FLOOR OF THE BUILDING IS IMPERMEABLE TO AIR, USE 15FT AS THE RADIUS OF INFLUENCE
     $R_I \cong 15$ FT $\cong 450$ cm
     HOWEVER, SINCE THE WESTERN AND SOUTHERN LIMITS OF THE BUILDING ARE LOCATED FAR FROM THE WELL ($\approx$ 100 - 200 FT), THE AIR FLOW FROM THOSE DIRECTIONS WILL BE MUCH LOWER. THEREFORE, ASSUME THAT ONLY HALF OF THE AIR FLOW PREDICTED BY THE RADIAL FLOW FORMULA WILL BE ACHIEVED.
   - ASSUME THAT THE UPWELLING OF GROUND WATER UNDERNEATH THE SVE WELL WILL BE ELIMINATED BY THE GW EXTRACTION WELL.

REF. PAGE

3. CALCULATIONS
USE

$$Q = \frac{1}{2}(H \cdot \pi \cdot k/\mu) \cdot P_w \cdot \frac{1-\left(\frac{P_{ATM}}{P_W}\right)^2}{\ln\left(\frac{R_W}{R_I}\right)}$$

BASED ON REF 2, EQ 5. ONLY $\frac{1}{2}$ OF THE FLOW IS ASSUMED TO TAKE PLACE, AS EXPLAINED IN SECTION 2.
SEE PAGE 12 OF THIS PACKAGE FOR DEFINITIONS OF SYMBOLS.

CALCULATE "Q" AS A FUNCTION OF VACUUM APPLIED TO THE WELL. ASSUME VACUUM OF 1 TO 15 FT OF WATER.

CALCS PERFORMED ON A SPREAD SHEET (SEE PAGE 4 OF THIS CALC). GRAPHICAL PRESENTATION OF RESULTS ON PAGE 5.

SAMPLE CALCULATION - FOR VACUUM OF 10 FT OF WATER

$K = 1.5E-2$ cm/s
$H = 450$ cm
$R_W = 10$ cm
$R_I = 450$ cm

$$- \quad k = \frac{K \nu}{g}$$ Ref 3, Eq 4-20

$\nu_{AT\ 10°C\ WATER} = 1.3 \times 10^{-2}\ cm^2/s$ Ref 4, TAB C.1

$g = 981\ cm/s^2$

REF. PAGE

$$k = \frac{1.5 \times 10^{-2} \times 1.3 \times 10^{-2}}{981} \left[\frac{\frac{cm}{s} \cdot \frac{cm^2}{s}}{\frac{cm}{s^2}} = cm^2 \right]$$

$k = 1.99 \times 10^{-7}$ cm^2 OK

- μ_{AIR} AT 10°C $= 1.76 \times 10^{-4}$ g/cm-s Ref 5, TAB A-3

- $P_W = P_{ATM} - 10\ ft_{H_2O}$

$$P_W = 1.01 \times 10^6 - \frac{10}{33.9} \times 1.01 \times 10^6 = 712,065\ g/cm^2\text{-}s$$

Flow rate

$$Q = \frac{1}{2} \cdot \left(\frac{450 \cdot \pi \cdot 1.99 \times 10^{-7}}{1.76 \times 10^{-4}} \right) \cdot (712,065) \cdot \frac{1 - \left(\frac{1.01 \times 10^6}{712,065} \right)^2}{\ln\left(\frac{10}{450}\right)}$$

$$Q = \frac{1}{2} \cdot 1.60 \cdot 712,065 \cdot \frac{-1.012}{-3.81}$$

~~Q = 127,985 cm³/s = 270.7 cfm~~

~~≈ 270 OK~~

$Q = 151,309\ cm^3/s \approx 320$ cfm

OK

REF. PAGE

4. RECOMMENDED DESIGN FLOW RATE

It has been estimated that the extraction of groundwater will cause a drawdown of about 5 ft within the groundwater extraction well. The same well will be used for extraction of soi vapor. The application of vacuum to the well will cause the upwelling of groundwater table equal to the magnitude of the vacuum used.

To keep the unsaturated thickness close to that under existing conditions the vacuum used in the well should be roughly the same as the drawdown caused by the extraction of groundwater. Therefore, vacuum of 5 ft is recommended. From the calc. on page 4, this will correspond to 144 cfm of air flow. Assuming additional pressure losses in the piping and treatment units of 2 ft of water, the approximate size of the blower should be such that it delivers:

$Q \cong 150$ cfm of air flow

at $\Delta P \cong 7$ ft of water pressure loss

Calculation of the air flow rate to an SVE well as a function of vacuum applied to the well.
Based on :

$$Q = (H*pi*k/mi)*Pw*[1-(Patm/Pw)^2]/ln(Rw/Ri)$$

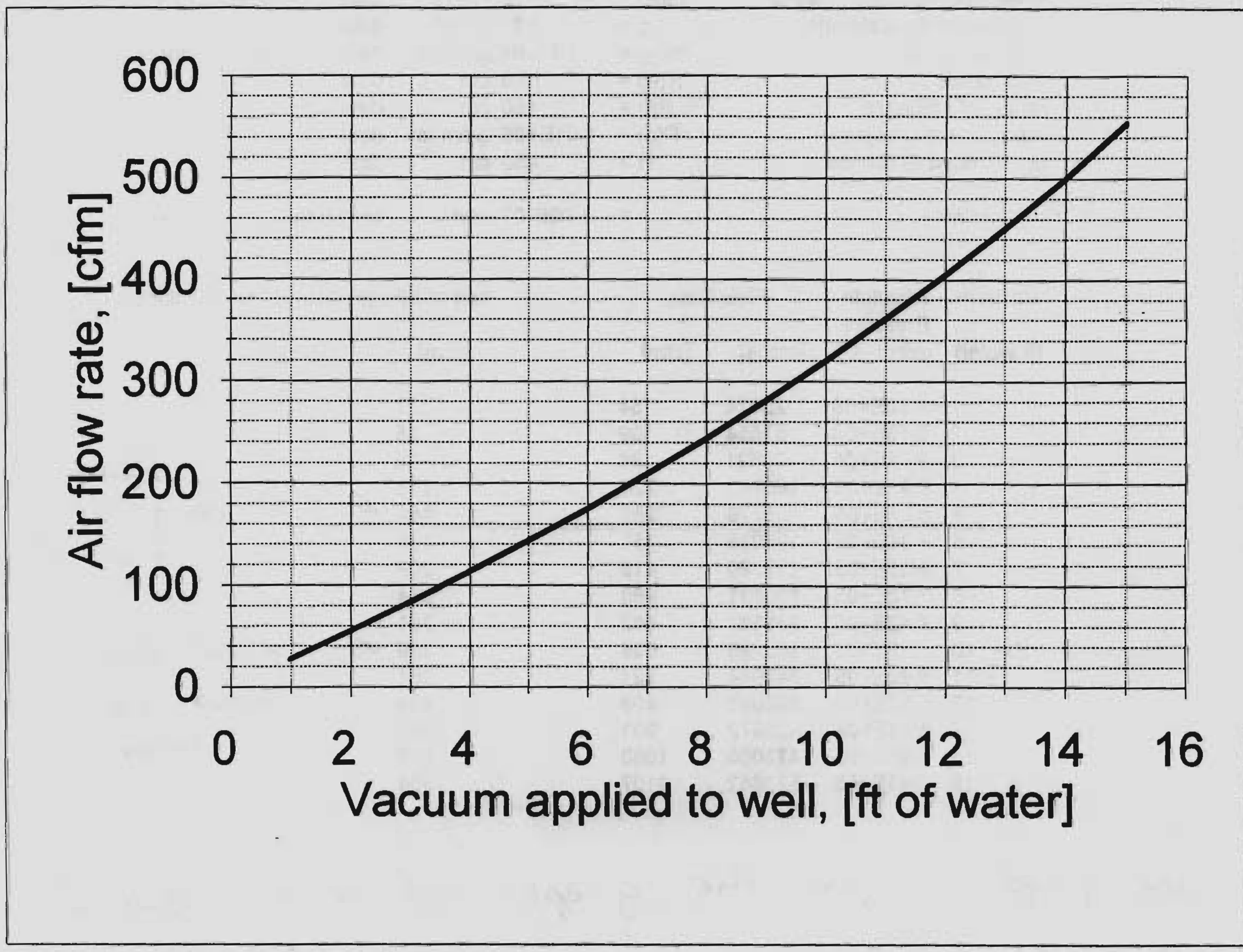
Note that only half of the flow calculated by the above formula is used. This is to account for thre presence of the large building foundation on one side of the SVE area.

hydraulic conductivity	K =	1.5E-02	cm/s	data	
kinematic viscosity of water	ni(w) =	1.3E-02	cm^2/s	data	at 10 degrees
gravitational acceleration	g =	981	cm/s^2	data	
viscosity of air	mi(a) =	1.8E-04	g/cm -s	data	at 10 degrees
well radius	R(w) =	10.0	cm	data	
radius of influence	R(i) =	450	cm	data	
atmospheric pressure	P(a) =	1.01E+06	$g/cm\ -s^2$	data	
unsaturated thickness	H =	450	cm	data	
permeability	k =	1.99E-07	cm^2	calculated	

Vacuum [ft water]	Absolute Pressure [g/cm -s²]	Flow Rate [cm³/s]	Flow Rate [cfm]	half of flow (to account for building) [cfm]
1	9.80E+05	25374	54	27
2	9.50E+05	51554	109	55
3	9.21E+05	78621	166	83
4	8.91E+05	106662	226	113
5	8.61E+05	135779	287	144 ← Recommended design flow rate
6	8.31E+05	166088	351	176
7	8.01E+05	197720	418	209
8	7.72E+05	230831	488	244
9	7.42E+05	265597	562	281
→ 10	7.12E+05	302226	639	320 ← Used for a hand calc. check
11	6.82E+05	340964	721	361
12	6.52E+05	382098	808	404
13	6.23E+05	425972	901	450
14	5.93E+05	473000	1000	500
15	5.63E+05	523682	1107	554

See page 5 for the graph of the results presented above (i.e. graph of ½ of radial flow rate vs. vacuum applied to well)

Air flow rate from the SVE well
vs. vacuum applied to the well



This is a graphical presentation of results from page 4

REF. PAGE

5. REFERENCES

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2 A PRACTICAL APPROACH TO THE DESIGN, OPERATION, AND MONITORING OF IN-SITU SOIL VENTING SYSTEMS
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REMEDIAL INVESTIGATION REPORT
DRAFT FINAL
DEC 1995

NOSE DOCK 8 (SS-016) ENGINEERING EVALUATION/ COST ANALYSIS

Plattsburgh Air Force Base Installation Restoration Program

REF 1

prepared for:

United States Department of The Air Force
Plattsburgh Air Force Base
Plattsburgh, New York

AIR MOBILITY COMMAND

Draft Report
February 1995

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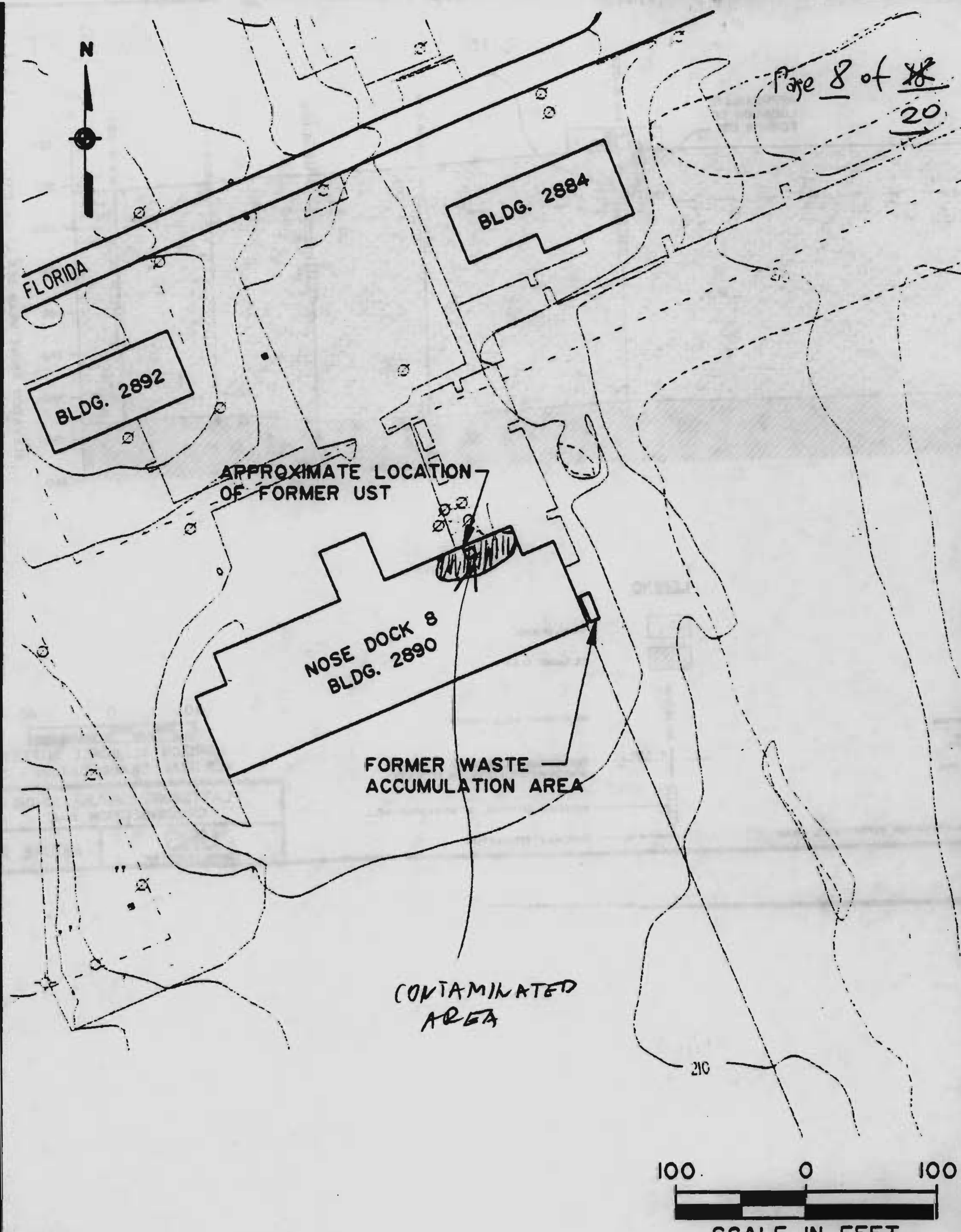
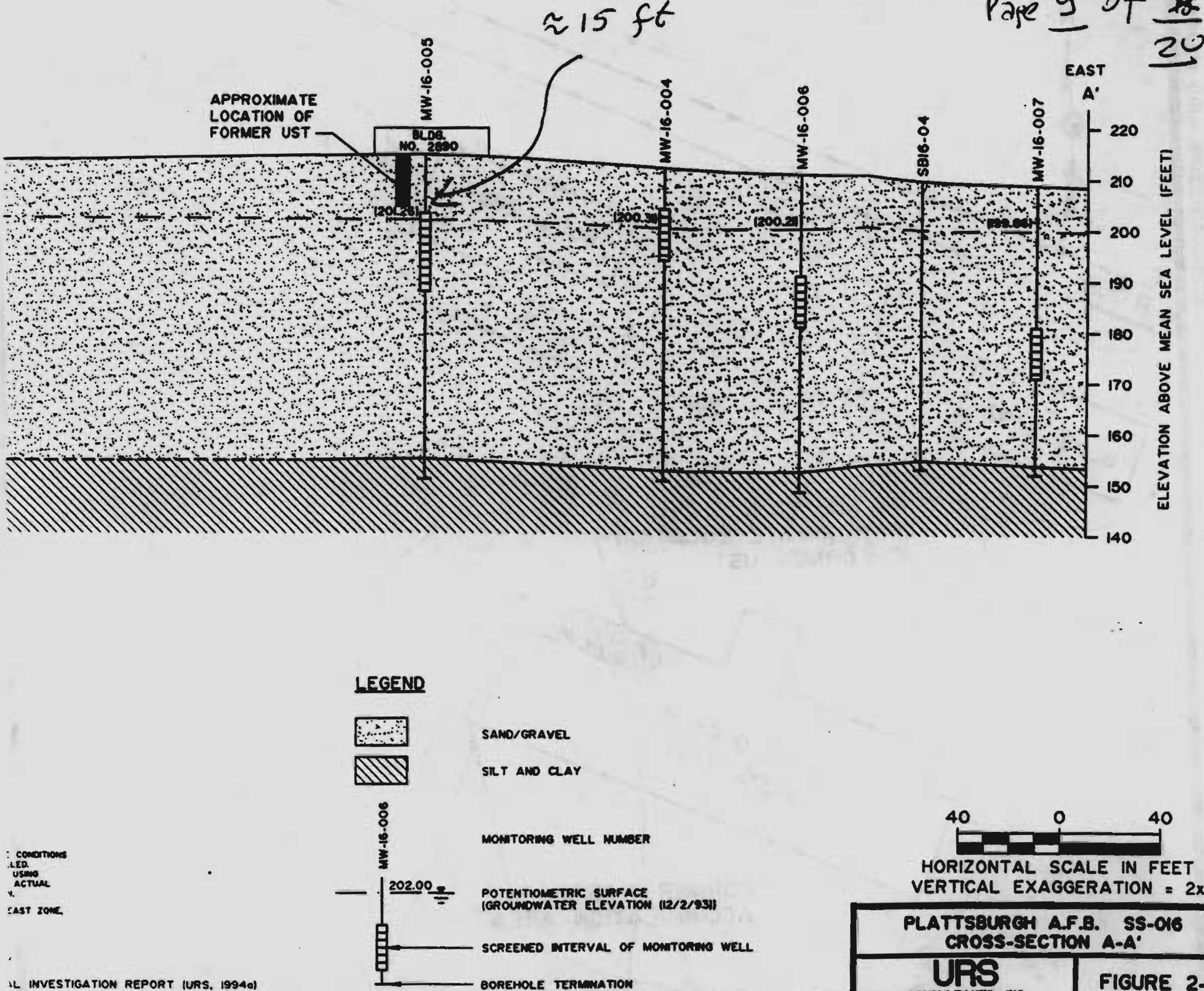


NOTE:
ORIGINALLY PRESENTED AS FIGURE 1-2 OF REMEDIAL INVESTIGATION REPORT (URS, 1994a)

URS CONSULTANTS, INC.	PLATTSBURGH A.F.B. SS-016 RI SITE FEATURES	FIGURE 2-1

AC-6704



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ACTUAL
N.
EAST ZONE.

L INVESTIGATION REPORT (URS, 1994a)

PLATTSBURGH A.F.B. SS-016
CROSS-SECTION A-A'

URS CONSULTANTS, INC.

FIGURE 2-4

A Practical Approach to the Design, Operation, and Monitoring of In-Situ Soil Venting Systems

P. C. Johnson, M. W. Kemblowski, J. D. Colthart, D. L. Byers, and C. C. Stanley*

Shell Development/*Shell Oil Company
Westhollow Research Center
Houston, TX 77251-1380

REF 2

Introduction

When operated properly, in-situ soil venting or vapor extraction can be one of the more cost-effective remediation processes for soils contaminated with gasoline, solvents, or other relatively volatile compounds. A "basic" system, such as that shown in Figure 1, couples vapor extraction (recovery) wells with blowers or vacuum pumps to remove vapors from the vadose zone and thereby reduce residual levels of soil contaminants. More complex systems incorporate trenches, air injection wells, passive wells, and surface seals. Above-ground treatment systems condense, adsorb, or incinerate vapors; in some cases vapors are simply emitted to the atmosphere through diffuser stacks. In-situ soil venting is an especially attractive treatment option because the soil is treated in place, sophisticated equipment is not required, and the cost is typically lower than other options.

The basic phenomena governing the performance of soil venting systems are easily understood. By applying a vacuum and removing vapors from extraction wells, vapor flow through the unsaturated soil zone is induced. Contaminants volatilize from the soil matrix and are swept by the carrier gas flow (primarily air) to the extraction wells or trenches. Many complex processes occur on the microscale, however, the three main factors that control the performance of a venting operation are the chemical composition of the contaminant, vapor flowrates through the unsaturated zone, and the flowpath of carrier vapors relative to the location of the contaminants.

The components of soil venting systems are typically off-the-shelf items, and the installation of wells and trenches can be done by most reputable environmental firms. However, the design, operation, and monitoring of soil venting systems is not trivial. In fact, choosing whether or not venting should be applied at a given site is a

$$[mg/l] = \frac{[ppm_{CH4}] * 16000\ mg\text{-}CH_4/mole\text{-}CH_4 * 10^{-6}}{(0.0821\ l\text{-}atm/^{\circ}K\text{-}mole) * (298\ K)} \quad (3)$$

For field instruments calibrated with other compounds (i.e. butane, propane) [ppm_v] values are converted to [mg/l] by replacing the molecular weight of CH_4 in Equation (3) by the molecular weight [mg/mole] of the calibration compound.

Acceptable or desirable removal rates $R_{acceptable}$, can be determined by dividing the estimated spill mass M_{spill}, by the maximum acceptable clean-up time τ:

$$R_{acceptable} = M_{spill}/\tau \quad (4)$$

For example, if 1500 kg (≈500 gal) of gasoline had been spilled at a service station and we wished to complete the clean-up within eight months, then $R_{acceptable}$ = 6.3 kg/d. Based on Figure 4, therefore, C_{est} would have to average >1.5 mg/l (2400 ppm_{CH4}) for Q=2800 l/min (100 cfm) if venting is to be an acceptable option. Generally, removal rates <1 kg/d will be unacceptable for most spills, so soils contaminated with compounds (mixtures) having saturated vapor concentrations less than 0.3 mg/l (450 ppm_{CH4}) will not be good candidates for venting, unless vapor flowrates exceed 100 scfm. Judging from the compounds listed in Table 1, this corresponds to compounds with boiling points (T_b)>150°C, or pure component vapor pressures <0.0001 atm evaluated at the subsurface temperature.

• ***What range of vapor flowrates can realistically be achieved?***

Question (3) requires that we estimate realistic vapor flowrates for our site specific conditions. Equation (5), which predicts the flowrate per unit thickness of well screen Q/H [cm^3/s], can be used for this purpose:

$$\frac{Q}{H} = \pi \frac{k}{\mu} P_w \frac{[1 - (P_{Atm}/P_w)^2]}{\ln(R_w/R_I)} \quad (5)$$

where:

k	= soil permeability to air flow [cm^2] or [darcy]
μ	= viscosity of air = 1.8×10^{-4} g/cm-s or 0.018 cp
P_w	= absolute pressure at extraction well [g/cm-s^2] or [atm]
P_{Atm}	= absolute ambient pressure = 1.01×10^6 g/cm-s^2 or 1 atm
R_w	= radius of vapor extraction well [cm]
R_I	= radius of influence of vapor extraction well [cm]

This equation is derived from the simplistic steady-state radial flow solution for compressible flow[2], but should provide reasonable estimates for vapor flowrates. If we can measure or estimate k, then the only unknown parameter is the empirical "radius of influence" R_I. Values ranging from 9 m (30 ft) to 30 m (100 ft) are reported in the literature for a variety of soil conditions, but fortunately Equation (2) is not very sensitive to large changes in R_I. For estimation purposes, therefore, a value of R_I=12 m (40 ft) can be used without a significant loss of accuracy. Typical vacuum well pressures range from 0.95 - 0.90 atm (20 - 40 in H_2O vacuum). Figure 5 presents predicted flowrates per unit well screen depth Q/H, expressed in "standard" volumetric units Q*/H (= Q/H(P_w/P_{Atm}) for a 5.1 cm radius (4" diameter) extraction well, and a wide range of soil permeabilities and applied vacuums. Here H denotes the thickness of the screened interval, which is often chosen to be equal to the thickness of the zone of soil contamination (this minimizes removing and treating any excess "clean" air). For other conditions the Q*/H values in Figure 5 can be multiplied by the following factors:

R_w = 5.1 cm (2")	R_I = 7.6 m (25')	- multiply by Q*/H by 1.09
R_w = 5.1 cm (2")	R_I = 23 m (75')	- multiply by Q*/H by 0.90
R_w = 7.6 cm (3")	R_I = 12 m (40')	- multiply by Q*/H by 1.08
R_w = 10 cm (4")	R_I = 12 m (40')	- multiply by Q*/H by 1.15
R_w = 10 cm (4")	R_I = 7.6 m (25')	- multiply by Q*/H by 1.27

As indicated by the multipliers given above, changing the radius of influence from 12 m (40 ft) to 23 m (75 ft) only decreases the predicted flowrate by 10%. The largest uncertainty in flowrate calculations will be due to the air permeability value k, which can vary by one to three orders of magnitude across a site and can realistically only be estimated from boring log data within an order of magnitude. It is prudent, therefore, to choose a range of k values during this phase of the decision process. For example, if boring logs

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REF 3

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Hydraulics of Groundwater

viscosity μ (or in the combined form of kinematic viscosity ν). The relevant solid matrix properties are mainly grain- (or pore-) size distribution, shape of grains (or pores), tortuosity, specific surface, and porosity. The hydraulic conductivity K may be expressed as (Nutting, 1930)

$$K = k\rho g/\mu = kg/\nu \tag{4-20}$$

where k (dimensions L^2)—called the *permeability*, or the *intrinsic permeability*, of the porous matrix—depends solely on properties of the solid matrix.

With (4-20), Darcy's law (4-9) may be written as

$$\mathbf{q} = -(k\rho g/\mu)\,\text{grad}\,\phi \tag{4-21}$$

Various formulas relating k to the various properties of the solid matrix are presented in the literature. Some of these formulas are purely empirical, as, for example

$$k = cd^2 \qquad (k \text{ in cm}^2,\ d \text{ in cm}) \tag{4-22}$$

where c is a coefficient with cg/ν in the range between 45 for clayey sand, and 140 for pure sand (often the value of 100 is used as an average), and d is the effective grain diameter, d_{10}, defined in Sec. 4-1.

Another example is the Fair and Hatch (1933) formula developed from dimensional considerations and verified experimentally

$$k = \frac{1}{\beta}\left[\frac{(1-n)^2}{n^3}\left(\frac{\alpha}{100}\sum_{(m)}\frac{P_m}{d_m}\right)^2\right]^{-1} \tag{4-23}$$

where β is a packing factor, found experimentally to be about 5, α is a sand shape factor, varying from 6.0 for spherical grains to 7.7 for angular ones, P_m is the percentage of sand held between adjacent sieves, and d_m is the geometric mean diameter of the adjacent sieves.

Purely theoretical formulas are obtained from theoretical derivations of Darcy's law. Often, such formulas include numerical coefficients which have to be determined empirically. An example is the Kozeny–Carman equation

$$k = C_0\frac{n^3}{(1-n)^2 M_S^2} \tag{4-24}$$

where M_S is the specific surface area of the porous matrix (defined per unit volume of solid) and C_0 is a coefficient for which Carman (1937) suggested the value of 1/5.

Under certain conditions, the permeability, k, may vary with time. This may be caused by external loads which change the structure and texture of the porous matrix by subsidence and consolidation, by the solution of the solid matrix (which over prolonged times may produce large channels and cavities), and by the swelling of clay, if present within the void space. When a soil contains argillaceous material, drying of the soil may shrink the clay, especially bentonite, causing the permeability to air of the dried soil to be higher than for water. Fresh water in a soil sample may cause the clay to swell as compared with salt water, thereby reducing k. Biological activity in the medium may produce a growth

Hydrology and Floodplain Analysis

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REF 4

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= 1.3 ×10^{-2} cm^2/s

TABLE C.1

Physical Properties of Water

TEMPERATURE (°C)	SPECIFIC WEIGHT γ (kN/m^3)	DENSITY ρ (kg/m^3)	MODULUS OF ELASTICITY* $E/10^6$ (kN/m^2)	DYNAMIC VISCOSITY $\mu \times 10^3$ (N-s/m^2)	KINEMATIC VISCOSITY $\nu \times 10^6$ (m^2/s)	SURFACE TENSION† σ (N/m)	VAPOR PRESSURE p_v (kN/m^2)
0	9.805	999.8	1.98	1.781	1.785	0.0765	0.61
5	9.807	1000.0	2.05	1.518	1.519	0.0749	0.87
10	9.804	999.7	2.10	1.307	1.306	0.0742	1.23
15	9.798	999.1	2.15	1.139	1.139	0.0735	1.70
20	9.789	998.2	2.17	1.002	1.003	0.0728	2.34
25	9.777	997.0	2.22	0.890	0.893	0.0720	3.17
30	9.764	995.7	2.25	0.798	0.800	0.0712	4.24
40	9.730	992.2	2.28	0.653	0.658	0.0696	7.38
50	9.698	988.0	2.29	0.547	0.553	0.0679	12.33
60	9.642	983.2	2.28	0.466	0.474	0.0662	19.92
70	9.589	977.8	2.25	0.404	0.413	0.0644	31.16
80	9.530	971.8	2.20	0.354	0.364	0.0626	47.34
90	9.466	965.3	2.14	0.315	0.326	0.0608	70.10
100	9.399	958.4	2.07	0.282	0.294	0.0589	101.33

* At atmospheric pressure.

† In contact with air.

Adapted from Vennard and Street, 1975.

Engineering Fluid Mechanics

Third Edition

John A. Roberson and Clayton T. Crowe
Washington State University, Pullman

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= 1.76×10⁻⁴ g/cm-s

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TABLE A-3 MECHANICAL PROPERTIES OF AIR AT STANDARD ATMOSPHERIC PRESSURE

Temperature	Density	Specific weight	Dynamic viscosity	Kinematic viscosity
	kg/m^3	N/m^3	$N \cdot s/m^2$	m^2/s
−20°C	1.40	13.7	1.61×10^{-5}	1.16×10^{-5}
−10°C	1.34	13.2	1.67×10^{-5}	1.24×10^{-5}
0°C	1.29	12.7	1.72×10^{-5}	1.33×10^{-5}
10°C	1.25	12.2	1.76×10^{-5}	1.41×10^{-5}
20°C	1.20	11.8	1.81×10^{-5}	1.51×10^{-5}
30°C	1.17	11.4	1.86×10^{-5}	1.60×10^{-5}
40°C	1.13	11.1	1.91×10^{-5}	1.69×10^{-5}
50°C	1.09	10.7	1.95×10^{-5}	1.79×10^{-5}
60°C	1.06	10.4	2.00×10^{-5}	1.89×10^{-5}
70°C	1.03	10.1	2.04×10^{-5}	1.99×10^{-5}
80°C	1.00	9.81	2.09×10^{-5}	2.09×10^{-5}
90°C	0.97	9.54	2.13×10^{-5}	2.19×10^{-5}
100°C	0.95	9.28	2.17×10^{-5}	2.29×10^{-5}
120°C	0.90	8.82	2.26×10^{-5}	2.51×10^{-5}
140°C	0.85	8.38	2.34×10^{-5}	2.74×10^{-5}
160°C	0.81	7.99	2.42×10^{-5}	2.97×10^{-5}
180°C	0.78	7.65	2.50×10^{-5}	3.20×10^{-5}
200°C	0.75	7.32	2.57×10^{-5}	3.44×10^{-5}
	$slugs/ft^3$	lbf/ft^3	$lbf\text{-}s/ft^2$	ft^2/s
0°F	0.00269	0.0866	3.39×10^{-7}	1.26×10^{-4}
20°F	0.00257	0.0828	3.51×10^{-7}	1.37×10^{-4}
40°F	0.00247	0.0794	3.63×10^{-7}	1.47×10^{-4}
60°F	0.00237	0.0764	3.74×10^{-7}	1.58×10^{-4}
80°F	0.00228	0.0735	3.85×10^{-7}	1.69×10^{-4}
100°F	0.00220	0.0709	3.96×10^{-7}	1.80×10^{-4}
120°F	0.00213	0.0685	4.07×10^{-7}	1.91×10^{-4}
150°F	0.00202	0.0651	4.23×10^{-7}	2.09×10^{-4}
200°F	0.00187	0.0601	4.48×10^{-7}	2.40×10^{-4}
300°F	0.00162	0.0522	4.96×10^{-7}	3.05×10^{-4}
400°F	0.00143	0.0462	5.40×10^{-7}	3.77×10^{-4}

NOSE DOCK 8 (SS-016)
REMEDIAL INVESTIGATION REPORT

Plattsburgh Air Force Base Installation Restoration Program

Volume 1 of 2

REF 7

DEPARTMENT OF THE AIR FORCE · UNITED STATES OF AMERICA · MCMXLVII

prepared for:

United States Department of The Air Force
Plattsburgh Air Force Base
Plattsburgh, New York

Draft Final Report
& Appendix A
December 1995

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TABLE 3-5

**NOSE DOCK 8 (SS-016) - REMEDIAL INVESTIGATION
HYDRAULIC CONDUCTIVITY OF WATER TABLE AQUIFER
DETERMINED FROM IN-SITU SLUG TESTS**

WELL I.D.	SCREENED INTERVAL		UNIT SCREENED	HYDRAULIC CONDUCTIVITY			
				SLUG IN TEST		SLUG OUT TEST	
	DEPTH (ft.)	ELEVATION (ft.)		(cm/sec)	(ft./day)	(cm/sec)	(ft./day)
MW-16-004	8 - 18	203.88 - 193.88	Sand	NA	NA	1.78E-02	50.54
MW-16-005	11.5 - 26.5	202.13 - 187.13	Sand	NA	NA	1.57E-02	44.49
MW-16-006	19.5 - 29.5	191.11 - 181.11	Sand	1.05E-02	29.68	NA	NA

NA - Not available
NOTE: See Appendix G for field data.

GEOMETRIC MEAN $= \left[(1.05E\text{-}2)(1.57E\text{-}2)(1.78E\text{-}2)\right]^{1/3} =$

$= 1.43E\text{-}2$ cm/s

use $1.5E\text{-}2$ cm/s

J:\35291\QPRO\SS-016\CH-3\TAB3-4 WB1/sk
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APPENDIX A-6
ESTIMATED AIR EMISSIONS

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Actual Contaminant Emissions:

Actual contaminant emissions from the combined groundwater treatment (via air stripper) and soil (soil vapor extraction) treatment systems were estimated in the Air and Treated Water Discharge Permit Application of May 26, 1995.

Emissions from each treatment system was individually estimated. The sum of emissions was used for comparison to the New York State Guidelines for the Control of Toxic Ambient Air Contamination

A sample calculation for toluene is provided.

Toluene = 3.17×10^{-2} lb/hr and 277.60 lb/yr

Air Guide-1 - Guidelines: (Ref 2)

Actual Annual Impact: The maximum Actual Annual Impact, Ca, from treatment off-gas is calculated using the effective stack height, he, and the annual emissions rate, Qa, in the following equation:

$$Ca\,(\mu g/m^3) = \frac{6.0 \times Qa}{he^{2.25}}$$ where Qa is in lb/yr and he in feet

$$Ca = \frac{6.0\,(277.6\ \text{lb/yr})}{28^{2.25}} = 9.2 \times 10^{-1}\ \mu g/m^3$$

Potential Annual Impact: The maximum Potential Annual Impact, Cp, from treatment off-gas is calculated using the effective stack height, he, and the hourly emission rate, Q, in the following equation:

$$Cp\,(\mu g/m^3) = \frac{52500 \times Q}{he^{2.25}}$$ where Q is in lb/hr; he in feet

$$Cp = 52500\,(3.17 \times 10^{-2}\ \text{lb/hr}) = 9.2 \times 10^{-1}\ \mu g/m^3$$

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Reduction of Impacts

The stack height to building ratio (h_s/h_b): 28/25 = 1.12 which does not meet the conditions described in Ref 2 and, therefore, does not reduce the impacts Ca and Cp from above.

SHORT-TERM IMPACT: The maximum Short-term Impact, C_{ST}, from the treatment off-gas is calculated from the following:

$C_{ST}(\mu g/m^3) = C_p \times 65$ where C_p is the maximum Potential Annual Impact as adjusted by the above reduction factor.

$$C_{ST} = (9.2 \times 10^{-1}\ \mu g/m^3)(65) = 59.8\ \mu g/m^3$$

Annual Guideline Concentration (AGC) and Short-Term Guideline Conc. (SGC)

The calculated annual impacts Ca and Cp are evaluated against its AGS (Ref 2) and C_{ST} is compared to SGCs to determine the acceptability of the source

For Toluene:

Ca	Cp	AGC	Exceed AGC (Y/N)	C_{ST}	SGC	Exceed SGC (Y/N)
9.2×10^{-1}	9.2×10^{-1}	2,000	N	59.8	89,000	N

Other compounds that may be found in the treatment off-gas are compared to their associated AGC and SGC in the attached Table (Table 1)

TABLE1
PLATTSBURGH AIR FORCE BASE - SS-016

Comparison of Contaminant Emissions from Air Stripper and SVE to Air Guide-1

CHEMICAL	CAS Registry Number	Air Stripper/SVE Influent Design Value (µg/l)	SVE Emissions (lb/hr)	Air Stripper Emissions (lb/hr)	Combined Air Stripper/SVE Emissions (lb/hr)	Contaminant Emissions (lb/yr)	Calculated Max. Actual Annual Impact (µg/m³) Ca	AGC (µg/m³)	% of Allowable Emissions	Calculated Max. Potential Annual Impact (µg/m³) Cp	AGC (µg/m³)	% of Allowable Emissions	Calculated Max. Short Term Impact (µg/m³) Cst	SGC (µg/m³)	% of Allowable Emissions
Acetone	67-64-1	29.0	5.00E-05	4.35E-04	4.85E-04	4.25	1.4E-02	14,000	0.000101%	1.4E-02	14,000	0.000101%	9.2E-01	140,000	0.000656%
Carbon Disulfide	75-15-0	2.0	2.32E-03	3.00E-05	2.35E-03	20.57	6.8E-02	7	0.977768%	6.8E-02	7	0.976652%	4.4E+00	710	0.625863%
1,1-Dichloroethane	75-34-3	3.0	1.15E-03	4.50E-05	1.19E-03	10.44	3.5E-02	500	0.006947%	3.5E-02	500	0.006939%	2.3E+00	190,000	0.001187%
1,2-Dichloroethene (total)	540-59-0	33.0	7.32E-02	4.99E-04	7.37E-02	645.51	2.1E+00	1,900	0.113030%	2.1E+00	1,900	0.112901%	1.4E+02	190,000	0.073385%
Chloroform	67-66-3	23.0	5.36E-03	3.44E-04	5.70E-03	49.97	1.7E-01	23	0.722831%	1.7E-01	23	0.722006%	1.1E+01	980	1.101427%
1,2-Dichloroethane	107-06-2	4.0	3.31E-04	6.00E-05	3.91E-04	3.43	1.1E-02	3.9E-02	29.236245%	1.1E-02	3.9E-02	29.202870%	7.4E-01	950	0.077926%
2-Butanone	78-93-3	16.0	4.80E-05	2.40E-04	2.88E-04	2.52	8.4E-03	300	0.002799%	8.4E-03	300	0.002796%	5.5E-01	140,000	0.000389%
1,2-Dichloropropane	78-87-5	10.0	1.51E-03	1.43E-04	1.65E-03	14.46	4.8E-02	1.5E-01	32.063240%	4.8E-02	1.5E-01	32.026638%	3.1E+00	83,000	0.003762%
Trichloroethene	79-01-6	79.0	4.97E-02	1.19E-03	5.09E-02	446.06	1.5E+00	4.5E-01	329.778346%	1.5E+00	4.5E-01	329.401887%	9.6E+01	33,000	0.291970%
Toluene	108-88-3	67.0	3.07E-02	9.99E-04	3.17E-02	277.60	9.2E-01	2,000	0.046178%	9.2E-01	2,000	0.046125%	6.0E+01	89,000	0.067374%
Ethylbenzene	100-41-4	35.0	1.57E-02	5.29E-04	1.62E-02	141.85	4.7E-01	1,000	0.047193%	4.7E-01	1,000	0.047139%	3.1E+01	100,000	0.030641%
Xylene (total)	1330-20-7	167.0	6.05E-02	2.50E-03	6.30E-02	551.64	1.8E+00	300	0.611755%	1.8E+00	300	0.611057%	1.2E+02	100,000	0.119156%
1,2-Dichlorobenzene	95-50-1	2.0	2.68E-04	1.50E-05	2.83E-04	2.48	8.2E-03	200	0.004120%	8.2E-03	200	0.004115%	5.3E-01	30,000	0.001783%
2-Methylphenol	95-48-7	3.0	5.38E-07	2.25E-05	2.30E-05	0.20	6.7E-04	24	0.002799%	6.7E-04	24	0.002796%	4.4E-02	2,400	0.001817%
4-Methylphenol	106-44-5	68.0	2.09E-06	5.13E-04	5.15E-04	4.51	1.5E-02	24	0.062516%	1.5E-02	24	0.062444%	9.7E-01	2,400	0.040589%
Naphthalene	91-20-3	101.0	8.21E-03	7.57E-04	8.97E-03	78.57	2.6E-01	120	0.217842%	2.6E-01	120	0.217593%	1.7E+01	12,000	0.141435%
2-Methylnaphthalene	91-57-6	56.0	2.25E-04	4.23E-04	6.48E-04	5.68	1.9E-02	120	0.015741%	1.9E-02	120	0.015723%	1.2E+00	12,000	0.010220%
Diethylphthalate	84-66-2	5.0	3.83E-03	3.75E-05	3.87E-03	33.88	1.1E-01	12	0.939192%	1.1E-01	12	0.938120%	7.3E+00	1,200	0.609778%
bis(2-Ethylhexyl)phthalate	117-81-7	2	4.14E-08	1.50E-05	1.50E-05	0.13	4.4E-04	12	0.003655%	4.4E-04	12	0.003650%	2.8E-02	1,200	0.002373%

NOTES:

1. Air Stripper/SVE Influent Design Value - The level of contaminant assumed to be in the influent water stream to the air stripper and is the level of contamination used to derive the concentration of contaminants in the air stream from the SVE system.
2. Contaminant Emissions - Accounts the sum of emissions attributed to both the air stripper and SVE system.
3. Assumed height of stack (ft.): 28; building height is 25 ft
4. SGC - Short-term Guideline Concentration
   AGC - Annual Guideline Concentration
   Ca - maximum Actual Annual Impact
   Cp - maximum Potential Annual Impact
   Cst - maximum Short-Term Impact

APPENDIX A-7
INFILTRATION GALLERY CALCULATIONS

1. PURPOSE

This calculation was performed to estimate the size of the infiltration pit that may be required at the SS-016 site. The structure would be designed to return to the aquifer the treated groundwater previously extracted as a result of the effort to control the spread of the plume.

2. METHODOLOGY

It will be assumed that the gallery will be constructed by placing a series of horizontal, perforated pipes within a stone bedding, at a certain depth within the unsaturated portion of the aquifer. The water will be injected into the pipe and will accumulate within the bedding. From there, it will percolate down into the water table.

First, it will be checked if the ground can accept the flow rate vertically down into the aquifer. The rate of infiltration will be evaluated by assuming that the stone bedding acts like an open ditch. Based on Ref 1, Eq 15a:

$$q = k (B + A H)$$

Where:

- q - Infiltration rate per unit length of trench, [ft^2/d]
- k - Hydraulic conductivity, [ft/d]
- B - Width of water surface in the trench, [ft]
- A - Coefficient, function of $\cot \alpha$ and H, [-]
- $\cot \alpha$ - Side slope of trench, [-]
- H - Depth of water in the trench, [ft]

The required length of the gallery will be calculated as:

$$L = Q / q$$

Where:

- L - Required length of the gallery, [ft]
- Q - Infiltration rate, [ft^3/d]

Then, it will be determined if the aquifer can accept the infiltrating water without mounding to the surface. To do that, it will be assumed that the infiltration pit acts as a recharge area within the aquifer. Based on Eq 2 of Ref 2, the height of the mound underneath the recharge area is:

$$h^2 = h_i^2 + (Q/2\pi K)\{W(u_0) - (r/R)^2 \exp(-u_0) + [1-\exp(u_0)]/u_0\}$$

$$u_0 = R^2S/4Kbt$$
$$\nu = Kb/S$$
$$b = \text{average } h \text{ (assume } = h_i)$$

Valid for: $r < R$
$t > r^2/2\nu$

Where:

- h - Saturated thickness, [ft]
- h_i - Initial saturated thickness, [ft]
- Q - Infiltrating flow rate, [ft^3/d]
- K - Hydraulic conductivity, [ft/d]
- R - Radius of recharge area, [ft]
- r - Distance from the center of recharge area, [ft]
- S - Storage coefficient, [-]
- t - Time since the beginning of recharge, [d]

The maximum h will occur at r = 0 (center of the mound). Also, for small values of u_0 ($u_0 < 0.01$), the well function can be approximated as (Ref 3, page 321):

$$W(u) = -0.5772 - \ln u = \ln(0.56/u)$$

From that, the maximum height of the mound is:

$$h^2 = h_i^2 + (Q/2\pi K)\{\ln(0.56/u_0) + [1-\exp(u_0)]/u_0\}$$

For small values of u_0 ($u_0 < 0.01$), the last term is very close to 1. So:

$$h^2 = h_i^2 + (Q/2\pi K)[\ln(0.56/u_0) + 1.0]$$

3. PARAMETERS

The following values of parameters will be assumed:

- **Hydraulic conductivity of the aquifer - k**
  The slug tests performed on site (Ref 4, Table 3-5), indicate the values of the horizontal hydraulic conductivity on the order of 1E-2 cm/s. For horizontal K, use:

k_h = 1E-2 cm/s = 30 ft/d

Assume that the vertical conductivity is one order of magnitude lower. For vertical K, use:

k_v = 1E-3 cm/s = 3 ft/d

* **Side slopes of the trench - cot α**
  Assume a 1:1 excavation:
  cot α = 1
* **Depth of water within the stone bedding - H**
  Assume that water will accumulate at the bottom of the excavation to the depth of:
  H = 3 ft
  This would correspond to a 7 ft deep trench, with 4 ft between the ground surface and the water table (for frost protection).
* **Width of water surface in the trench - B**
  Assume 35 ft wide pit:
  B = 35 ft
* **Infiltration rate - Q**
  Use 25 gpm (half of anticipated flow rate).
  Q = 25 gpm = 4,800 ft^3/d
* **Saturated thickness of aquifer - h_i**
  Aquifer is approximately 50 ft thick (Ref 4, Figures 3-8, 9 and 10). Since it is becoming silty and less permeable with depth (Ref 4, Section 3.7.2.1), use half of the saturated thickness:
  h_i = 25 ft
* **Storage coefficient of aquifer - S**
  For unconfined aquifers, usually between 0.01 and 0.25. Here, to be conservative, assume 0.01.
  S = 0.01
* **Time frame - t**
  Assume steady state will be reached after approximately 1 year. Use:
  t = 400 days

4. CALCULATIONS

A) Infiltration capacity of the ground

Estimate the value of the coefficient A:

B / H = 35 / 3 = 12

From Ref 1, Fig 9-6, for B/H = 12 and cot α = 1.0, the value of A is:

$$A = 3.8$$

Express q as a function of k:

$$q = k (35 + 3.8 * 3)$$
$$q = 46.4 k$$

Use vertical hydraulic conductivity of $k = k_v$ = 3 ft/d.

$$q = 46.4 * 3 = 139.5 \text{ ft}^2/\text{d}$$

Calculate length of trench required to infiltrate the design flow rate:

$$L = 4,800 / 139.2 = \mathbf{35 \ ft}$$

B) Ability of aquifer to accept infiltrating water

Estimate the height of mound. Use horizontal hydraulic conductivity of $K = k_h$ = 30 ft/d.

$$R = (B^2/\pi)^{1/2} = (35^2/\pi)^{1/2} = 20 \text{ ft}$$

$$u_0 = 20^2*0.01/4*30*25*400 = 3.3E-6 < 0.01 \quad \text{OK}$$

$$h^2 = 25^2 + (4,800/2\pi*30)[\ln(0.56/3.3E-6) + 1.0]$$
$$h^2 = 625 + 25.5 (12.0 + 1.0) = 958 \text{ ft}^2$$
$$h = 31 \text{ ft}$$

The rise at the center of the mound is:

$$\text{rise} = 31 - 25 = 6 \text{ ft}$$

With the 10 ft unsaturated thickness on site (Ref 4, Figures 3-8, 9 and 10), this would leave 4 ft between the water table and ground surface. This appears to be acceptable.

5. CONCLUSIONS

This calculation was performed in order to design the infiltration gallery for the SS-016 site. The function of the gallery is to return the groundwater extracted to control the plume back into the aquifer, following treatment. The design was based on the total flow rate of 50 gpm. The horizontal and vertical hydraulic conductivities of the aquifer material were assumed as 1E-3 cm/s and 1E-2 cm/s, respectively. The saturated thickness of the permeable portion of the aquifer was assumed to be 25 ft.

It appears that two 35 by 35 feet, 7 feet deep infiltration galleries should be sufficient. To provide a factor of safety, three galleries will be used. The galleries will be constructed by placing perforated pipes within gravel medium. Gravel will start at 7 feet below ground surface, and its layer will be 4.5 feet thick. Pipes will be placed in the center of the gravel layer, approximately 2 feet above the bottom of excavation. The water will be pumped into the pipes and will enter the gravel-filled gallery through perforations in pipes. From there, it will infiltrate into the ground. The water level within the galleries should remain at approximately 4 feet below the ground surface.

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REF 1

Groundwater and Seepage

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Along the bottom of the ditch, where $0 < t < \beta$,

$$z = -\frac{q}{k\pi J_2 \cos \pi\sigma}\left\{\sin^{-1} t\left[\int_0^t \frac{t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(\beta^2-t^2)^{1-\sigma}} - J_1\right] - \int_0^t \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(\beta^2-t^2)^{1-\sigma}}\right\} \qquad (10a)$$

At points c, where $t = \beta$ and $z = B_1/2$, we find

$$\frac{B_1}{2} = \frac{q}{\pi k J_2 \cos \pi\sigma}\int_0^\beta \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(\beta^2-t^2)^{1-\sigma}} \qquad (10b)$$

Along the side of the ditch bc, where $\beta < t < 1$,

$$z = \frac{B_1}{2} + \frac{q}{k\pi J_2 \cos \pi\sigma} e^{\pi\sigma i}\left[\sin^{-1} t \int_\beta^t \frac{t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}} - \int_\beta^t \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}}\right] \qquad (11a)$$

At points b, where $t = 1$ and $z = B/2 + iH$, we obtain

$$\frac{B-B_1}{2} = \frac{q}{k\pi J_2}\left[\frac{\pi}{2}J_2 - \int_\beta^1 \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}}\right] \qquad (11b)$$

$$H = \frac{q}{k\pi J_2}\tan \pi\sigma\left[\frac{\pi}{2}J_2 - \int_\beta^1 \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}}\right] \qquad (11c)$$

Along the free surface ba, where $1 < t < \infty$, from Eq. (11a) we find

$$z = \frac{B}{2} + Hi + \frac{q}{k\pi J_2 \cos \pi\sigma}\left[-\cosh^{-1} t \int_1^t \frac{t\,dt}{(t^2-1)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}} - iJ_2 e^{\pi\sigma i}\cosh^{-1} t + \int_1^t \frac{t \cosh^{-1} t\,dt}{(t^2-1)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}}\right] \qquad (12a)^*$$

Separating this equation into real and imaginary parts, we obtain for the equation of the free surface ba,

$$x - \frac{B}{2} = \frac{q}{k\pi J_2 \cos \pi\sigma}\left[\int_1^t \frac{t \cosh^{-1} t\,dt}{(t^2-1)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}} + J_2 \sin \pi\sigma \cosh^{-1} t - \cosh^{-1} t \int_1^t \frac{t\,dt}{(t^2-1)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}}\right] \qquad (12b)$$

We shall now derive the expression for the discharge from the ditch. Defining

$$\int_0^\beta \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}} = f_1(\sigma,\beta)$$
$$\int_\beta^1 \frac{t \sin^{-1} t\,dt}{(1-t^2)^{\frac{1}{2}+\sigma}(t^2-\beta^2)^{1-\sigma}} = f_2(\sigma,\beta) \qquad (13)$$

* We note that $(1-t^2)^{\frac{1}{2}+\sigma} = ie^{\pi\sigma i}(t^2-1)^{\frac{1}{2}+\sigma}$. Also for real values of $t > 1$, $\sin^{-1} t = \pi/2 - i\cosh^{-1} t$.

we have, in place of Eq. (10b),

$$B_1 = \frac{2q}{k\pi J_2 \cos \pi\sigma} f_1(\sigma,\beta) \qquad (14a)$$

and in place of Eqs. (11b) and (11c),

$$\frac{B-B_1}{2} = \left[\frac{\pi}{2}J_2 - f_2(\sigma,\beta)\right]\frac{q}{\pi k J_2}$$
$$H = \frac{q}{\pi k J_2}\tan \pi\sigma\left[\frac{\pi}{2}J_2 - f_2(\sigma,\beta)\right] \qquad (14b)$$

whence

$$B = B_1 + \frac{q}{k}\left[1 - \frac{2f_2(\sigma,\beta)}{\pi J_2}\right]$$
$$H = \frac{q}{2k}\tan \sigma\pi\left[1 - \frac{2f_2(\sigma,\beta)}{\pi J_2}\right] \qquad (14c)$$

We note in Eqs. (14c) that the quantity of seepage is dependent upon the parameters σ and β and one of the dimensions B, B_1, or H, which are related by $B - B_1 = 2H \cot \sigma\pi$. As was done in the previous sections, Vedernikov takes the quantity of seepage in the form

$$q = k(B + AH) \qquad (15a)$$

where, from Eqs. (14c), A is given by

$$A = \frac{2}{\tan \sigma\pi}\,\frac{f_2(\sigma,\beta) - f_1(\sigma,\beta)/\cos \sigma\pi}{J_2\pi/2 - f_2(\sigma,\beta)} \qquad (15b)$$

Taking a series of values for α and β, Vedernikov obtained the correspondence between A and B/H as given in Fig. 9-6. In this figure $m = \cot \alpha$ is the side slope of the ditch.

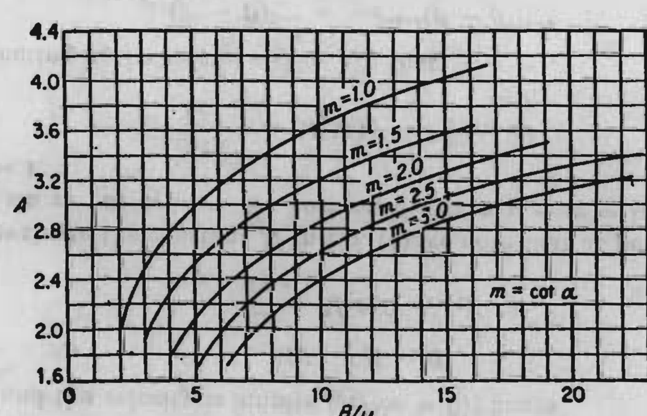

FIG. 9-6. (*After Vedernikov* [151].)

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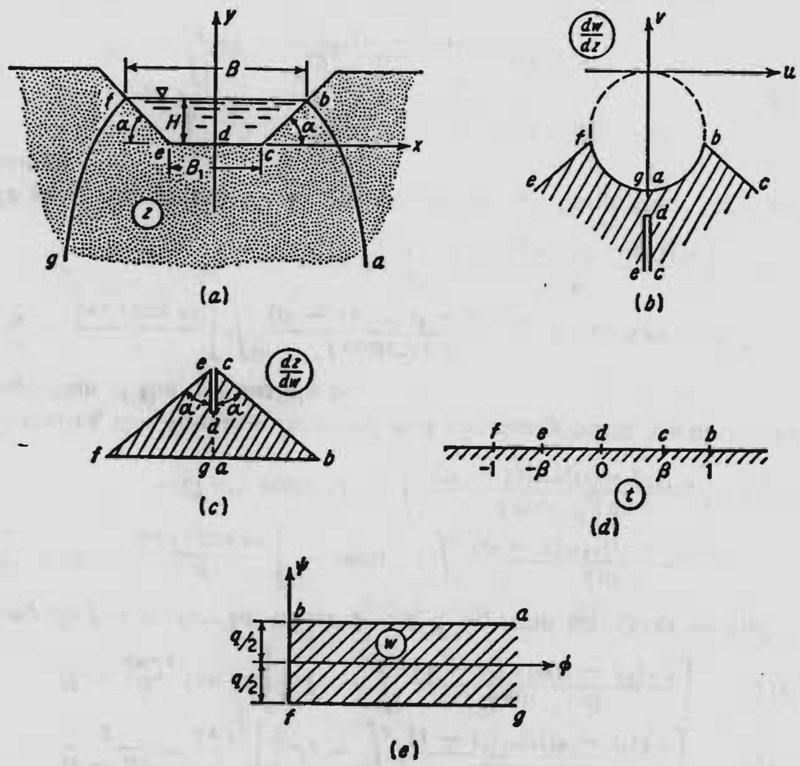

FIG. 9-5

Taking an auxiliary t plane as shown in Fig. 9-5d, we obtain for the mapping of the dz/dw plane onto the lower half plane of t

$$\frac{dz}{dw} = M \int_0^t \frac{t\,dt}{(1-t^2)^{1/2+\sigma}(\beta^2-t^2)^{1-\sigma}} + N = M\Phi(t) + N \qquad (1)$$

where $\sigma = \alpha/\pi$, and $\Phi(t)$ is the indicated integral. In particular, we shall define

$$J_1 = \Phi(\beta) = \int_0^\beta \frac{t\,dt}{(1-t^2)^{1/2+\sigma}(\beta^2-t^2)^{1-\sigma}}$$
$$J_2 = \int_\beta^1 \frac{t\,dt}{(1-t^2)^{1/2+\sigma}(t^2-\beta^2)^{1-\sigma}} \qquad (2)$$

Substituting $(t^2-\beta^2)/(1-\beta^2) = x$ into the second of Eqs. (2), we find that (cf. Sec. B-7)

$$J_2 = \frac{1}{2\beta'}\int_0^1 x^{\sigma-1}(1-x)^{-1/2-\sigma}\,dx = \frac{1}{2\beta'}B(\sigma, \tfrac{1}{2}-\sigma) = \frac{\Gamma(\sigma)\Gamma(\frac{1}{2}-\sigma)}{2\beta'\sqrt{\pi}} \qquad (3)$$

where $\beta' = (1-\beta^2)^{1/2}$.

To eliminate the constant N in Eq. (1), we note that at points c, $t = \beta$, and the velocity is infinite ($dz/dw = 0$); hence

$$MJ_1 + N = 0$$

and
$$\frac{dz}{dw} = M[\Phi(t) - J_1] \qquad (4)$$

To evaluate the constant M in Eq. (4) we note that at points b, where $u = k \sin \pi\sigma \cos \pi\sigma$, $v = -k\cos^2 \pi\sigma$, $dw/dz = u - iv = kie^{-\pi i\sigma}\cos \pi\sigma$, and $t = 1$,

$$\frac{1}{ki}e^{\pi i\sigma} = M[\Phi(1) - J_1]\cos \pi\sigma$$

Now, noting in the second of Eqs. (2) that

$$(\beta^2 - t^2)^{1-\sigma} = -e^{-i\pi\sigma}(t^2-\beta^2)^{1-\sigma}$$

we have

$$\Phi(t) = J_1 - e^{i\pi\sigma}\int_\beta^t \frac{t\,dt}{(1-t^2)^{1/2+\sigma}(t^2-\beta^2)^{1-\sigma}}$$
$$\Phi(1) = J_1 - e^{\pi i\sigma}J_2 \qquad (5)$$

hence

$$M = \frac{i}{kJ_2\cos \pi\sigma} \qquad (6)$$

and
$$\frac{dz}{dw} = \frac{i}{kJ_2\cos\pi\sigma}[\Phi(t) - J_1] \qquad (7)$$

The mapping of the w plane (Fig. 9-5e) onto the lower half of the t plane is given by (cf. Sec. 4-7)

$$w = \frac{iq}{\pi}\sin^{-1} t \qquad (8)$$

Now multiplying Eq. (7) by the derivative of Eq. (8) with respect to t, we find that

$$\frac{dz}{dt} = \frac{dz}{dw}\frac{dw}{dt} = -\frac{q[\Phi(t) - J_1]}{k\pi J_2\cos\pi\sigma\sqrt{1-t^2}}$$

which, after integration with respect to t, yields

$$z = -\frac{q}{k\pi J_2\cos\pi\sigma}\left[\int_0^t \frac{\Phi(t)\,dt}{\sqrt{1-t^2}} - J_1\sin^{-1} t\right] \qquad (9a)$$

For the integral in Eq. (9a) we integrate by parts.

$$\int_0^t \frac{\Phi(t)\,dt}{\sqrt{1-t^2}} = \Phi(t)\sin^{-1} t - \int_0^t \frac{t\sin^{-1} t\,dt}{(1-t^2)^{1/2+\sigma}(\beta^2-t^2)^{1-\sigma}} \qquad (9b)$$

We shall now consider Eqs. (9) for the various parts of the flow region.

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Estimation of Leak Rates from Underground Storage Tanks

by Benjamin S. Lévy[a], Peter J. Riordan[b], and Robert P. Schreiber[c]

Ref 2

Abstract

A methodology for estimating the rate and volume of leakage from an underground storage tank (UST) is presented; by estimating leak rate and volume, the leak duration may be calculated. This is accomplished by measuring liquid hydrocarbon thickness upon the water table at two or more monitoring wells located at differing distances from the leaking UST. The methodology is based on Hantush (1967, 1968) and uses type-curve fitting. Two solutions are developed: one for the case of a flat, rigid water table, and another for the case of a deflected water table. These solutions provide upper and lower estimates for leak rate and duration. The use of the technique is demonstrated by its application to a field case. The technique is best applied to sites with medium- to coarse-grained sands and gravels with minimal capillary effects; application of the technique to sites of fine-grained porous media may produce unreasonable results.

Introduction

The need for improved monitoring of the thousands of underground storage tanks (USTs) in the United States has prompted research into the movement and monitoring of liquid hydrocarbons in the subsurface. Observation of liquid hydrocarbon pooled on the water table has been used as one means for determining whether a UST leak has occurred. This paper presents an analytical approach developed to analyze the spreading of fluids which are immiscible in water and are less dense than water. These fluids, such as gasoline and oil, tend to pool upon the water table if introduced in sufficient quantity.

The development and propagation of a mound of liquid hydrocarbon upon a water table below a leaking UST was addressed with an analytical technique, based on equations from Hantush (1967), that constitutes a pragmatic approach to modeling of liquid hydrocarbon flow in the subsurface. Using this analytical technique, the leak rate, volume, and duration can be estimated based on measurements of liquid hydrocarbon thickness in monitoring wells. The analyst may assume that the water table is flat or that it is deflected by the liquid hydrocarbon, placing upper and lower limits on the estimates of leak rate and duration. Analysis of a field site with the technique substantiated its applicability.

Theory

Hantush (1967) developed analytical expressions to describe the growth of a ground-water mound in response to percolating water from a circular recharge basin. According to Hantush (1967), the flow of water below a circular recharge basin is approximated by:

$$\partial^2 Z/\partial r^2 + (1/r) \cdot \partial Z/\partial r + 2wf(r)/K = (1/\nu) \cdot \partial Z/\partial t \quad (1)$$

with the initial and boundary conditions of:

$$Z(r, 0) = 0; \qquad Z(\infty, t) = 0; \qquad \partial Z(0, t)/\partial r = 0;$$

and $f(r) = 1$ for $r \leqslant R$; $f(r) = 0$ for $r > R$;

where $\nu = Kb/S$; $Z = h^2 - h_i^2$; K = fluid conductivity, [L/T]; S = storage coefficient, $[L^3/L^2/L]$; r = radial distance away from the recharge area, [L]; t = time since recharge began, [T]; h = height of water table above base of aquifer, [L]; h_i = initial height of water table, [L]; w = percolation rate per unit area, $[L^3/T/L^2]$; b = average saturated thickness, [L]; and R = radius of circular recharge area, [L].

Hantush's solution to equation (1) is:

$$h^2 - (h_i)^2 = (Q/2\pi K) \cdot [W(u_0) - (r/R)^2 \cdot e^{-u_0} + (1 - e^{-u_0})/u_0] \quad \ldots (2)$$

for $r < R$ and $t > r^2/2\nu$, and

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$$h^2 - (h_i)^2 = (Q/2\pi K) \cdot [W(u) + (u_0/2)\, e^{-u}] \quad (3)$$

for $r > R$ and $t > R^2/2\nu$, and

$$u = r^2S/4Kbt \quad (4)$$

$$u_0 = R^2S/4Kbt \quad (5)$$

where Q = percolation rate, $[L^3/T]$, which may be expressed in terms of:

$$Q = \pi r^2 w \quad (6)$$

The expression for the growth of a ground-water mound from a circular recharge area can approximate the accumulation of liquid hydrocarbon upon the water table (Figure 1). To do this, the kinematic viscosity of the fluid must be estimated for the liquid hydrocarbon; the hydraulic conductivity of the porous medium is scaled accordingly to reflect the permeability of the medium to the liquid hydrocarbon, instead of to water.

General Assumptions

It is assumed that:

- the leak in the UST can be approximated by a circular recharge area through which percolating liquid hydrocarbon flows at a steady rate, causing the growth of a mound of liquid hydrocarbon upon the water table;
- no significant portion of the liquid hydrocarbon is lost to dissolution or volatilization;
- the measured liquid hydrocarbon in monitoring wells can be corrected to accurately reflect the actual thickness of liquid hydrocarbon in the formation;
- the aquifer is homogeneous and isotropic;
- the hydraulic conductivity and the storage coefficient are constant in time and space;
- the aquifer is infinite in areal extent;
- the aquifer base is horizontal and impermeable; and
- the percolation begins instantaneously and is constant with time.

Estimates of duration represent the length of time during which liquid hydrocarbon has accumulated upon the water table and do not incorporate any time required to traverse the vadose zone from the leaky UST to the water table.

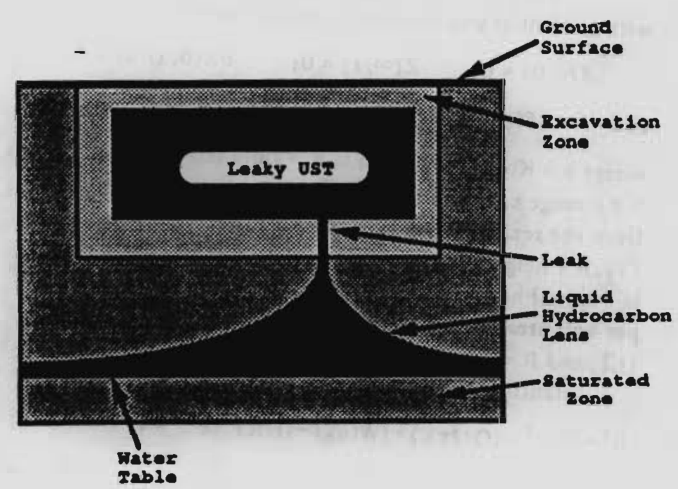

Fig. 1. Cross section of typical UST site.

Assumptions Concerning Measured Hydrocarbon Thickness

For the purpose of the application of the leak rate and duration estimation technique, values of liquid hydrocarbon thickness obtained in a field case were used. These values had been measured in monitoring wells and had not been corrected for density and capillary fringe effects (Katyal, 1989; personal comm.). As an approximation, the CONCAWE factor, described by de Pastrovich *et al.* (1979), was used to correct the liquid hydrocarbon thickness measured in the monitoring wells to liquid hydrocarbon thickness in the surrounding aquifer. The CONCAWE factor relates the liquid hydrocarbon thickness measured in a monitoring well to that in the aquifer by:

$$h = h' \cdot (\rho_w - \rho_o)/\rho_o \quad (7)$$

where ρ_w = liquid density of water, $[M/L^3]$; ρ_o = liquid density of liquid hydrocarbon, $[M/L^3]$; and h' = liquid hydrocarbon thickness measured in the monitoring well, [L].

This is not to suggest that the CONCAWE factor accounts entirely for the differences between measured monitoring well thickness and formation thickness of hydrocarbon. It is not the purpose of this paper to investigate the details of this issue.

Much recent research, however, has focused on the determination of the actual thickness from measurement of apparent thickness in monitoring wells. Knowing whether the liquid hydrocarbon thickness detected in a monitoring well reflects the actual thickness in the formation will be very important to investigators seeking to assess the extent of contamination and the severity of a leak.

Correction factors for the weight of liquid hydrocarbon product and the thickness of the capillary fringe have been proposed (de Pastrovich *et al.*, 1979; Hall *et al.*, 1984), although Hampton and Miller (1988) suggest that there is no clear relationship in their review of correction factors. Other research has focused on the estimation of actual product thickness from hydraulic analysis of well response (Hughes *et al.*, 1988) and from geophysical applications (Keech, 1988).

Development

Nondeflected Water Table

Equation (3) can be used to estimate the growth of the liquid hydrocarbon mound upon the water table. If it is assumed that no liquid hydrocarbon exists on the water table prior to the initiation of the leak (i.e., $h_i = 0$), then equation (3) reduces to:

$$h^2 = (Q/2\pi K) \cdot [W(u) + (u_0/2) \cdot e^{-u}] \quad (8)$$

Equation (8) assumes that the water table is not deflected under the overlying weight of the liquid hydrocarbon. This condition is further considered below to allow for the deflection of the water table.

Equation (8) can be rearranged as a function of u:

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Hydraulics of Groundwater

This is also the solution given by Theis (1935) in the form

$$\left.\begin{aligned} s(r,t) &= \phi_0 - \phi(r,t) = (Q_w/4\pi T)\, W(u); \\ W(u) &= -\,Ei(-u) = \int_{x=u}^{\infty} (e^{-x}/x)\, dx \end{aligned}\right\} \qquad (8\text{-}61)$$

where $W(u)$ is the *well function* of $u = Sr^2/4Tt$ for a *confined aquifer* (Jacob, 1940). The integral $-Ei(-u)$ is the *exponential integral* (Jahnke and Emde, 1945). Table 8-2 and Fig. 8-14a give values of $W(u)$. Theis (1935) obtained (8-61) by analogy to heat flow.

Equation (5-190) gives the drawdown $s = s(r, t)$ for an anisotropic aquifer.

Figure 8-14b shows the drawdown $s(r, t)$. An *inflection point* occurs at $u = 1$ (that is, $t = Sr^2/4T$). Thereafter, the *rate of drawdown* $\partial s/\partial t$ $(= -\partial\phi/\partial t)$ decreases, but theoretically *never vanishes*.

The well function (or the exponential integral) is obtained from the series

$$W(u) = -\,0.5772 - \ln u + u - u^2/2 \times 2! + u^3/3 \times 3! - u^4/4 \times 4! + \cdots$$

For small values of u, say, $u < 0.01$ (i.e., for a large time at a given distance), this series may be approximated by its first two terms (Cooper and Jacob, 1946; Jacob, 1950)

$$s(r,t) \cong \frac{Q_w}{4\pi T}\left(-\,0.5772 - \ln\frac{r^2 S}{4Tt}\right) = \frac{Q_w}{4\pi T} \ln \frac{2.25\,Tt}{r^2 S} \qquad (8\text{-}62)$$

With this approximation, plotting $s = s(\ln t)$, $s = s(\ln r)$ and $s = s[\ln(r^2/t)]$ gives straight lines (see Sec. 11-1).

a confined aquifer (after Wenzel, 1942)

$N \times 10^{-7}$	$N \times 10^{-6}$	$N \times 10^{-5}$	$N \times 10^{-4}$	$N \times 10^{-3}$	$N \times 10^{-2}$	$N \times 10^{-1}$	N
15.5409	13.2383	10.9357	8.6332	6.3315	4.0379	1.8229	0.2194
15.1354	12.8328	10.5303	8.2278	5.9266	3.6374	1.4645	0.1000
14.8477	12.5451	10.2426	7.9402	5.6394	3.3547	1.2227	0.04890
14.6246	12.3220	10.0194	7.7172	5.4167	3.1365	1.0443	0.02491
14.4423	12.1397	9.8371	7.5348	5.2349	2.9591	0.9057	0.01305
14.2881	11.9855	9.6830	7.3807	5.0813	2.8099	0.7942	0.006970
14.1546	11.8520	9.5495	7.2472	4.9482	2.6813	0.7024	0.003779
14.0368	11.7342	9.4317	7.1295	4.8310	2.5684	0.6253	0.002073
13.9314	11.6280	9.3263	7.0242	4.7261	2.4679	0.5598	0.001148
13.8361	11.5330	9.2310	6.9289	4.6313	2.3775	0.5034	0.0006409
13.7491	11.4465	9.1440	6.8420	4.5448	2.2953	0.4544	0.0003601
13.6691	11.3665	9.0640	6.7620	4.4652	2.2201	0.4115	0.0002034
13.5950	11.2924	8.9899	6.6879	4.3916	2.1508	0.3738	0.0001155
13.5260	11.2234	8.9209	6.6190	4.3231	2.0867	0.3403	0.0000658
13.4614	11.1589	8.8563	6.5545	4.2591	2.0269	0.3106	0.0000376
13.4008	11.0982	8.7957	6.4939	4.1990	1.9711	0.2840	0.0000216
13.3437	11.0411	8.7386	6.4368	4.1423	1.9187	0.2602	0.0000124
13.2896	10.9870	8.6845	6.3828	4.0887	1.8695	0.2387	0.0000071

[redacted] Pg 13 of

NOSE DOCK 8 (SS-016)
REMEDIAL INVESTIGATION REPORT

Plattsburgh Air Force Base Installation Restoration Program

Volume 1 of 2

Ref 4

DEPARTMENT OF THE AIR FORCE
MCMXLVII
UNITED STATES OF AMERICA

prepared for:

United States Department of The Air Force
Plattsburgh Air Force Base
Plattsburgh, New York

Draft Final Report & Appendix A
December 1995

G1622

3.7.2 Site Geology

The stratigraphic sequence at SS-016 comprises, from the top down: stratified deposits of sand/gravel: silt and clay, glacial till, and limestone bedrock. Figure 3-7 depicts the locations of cross-sections A-A', B-B', and C-C', which are shown on Figures 3-8 to 3-10, respectively. The depth and thickness of the unconsolidated deposits vary across the SS-016 area, although the composition and texture of the deposits appear to be similar. Each of these units is described below. A summary of the geotechnical analyses performed on samples of each of the units is provided in Table 2-2. The complete geotechnical testing report may be found in Appendix H.

3.7.2.1 Sand/Gravel

This unit is characterized as generally fine to medium stratified sand with occasional interstratified layers of coarser sand, silt, and gravel. Typically, the sand is brown above the water table, but gray beneath it. This is due to reducing conditions below the water table. The thickness of the sand unit ranged from approximately 45 feet at SB-16-04 to 59 feet at SB-16-05. The sand unit commonly becomes finer-grained with depth, grading texturally into the underlying silt and clay unit. Table 3-2 depicts the grain-size distributions and other geotechnical characteristics of the sand and underlying silt and clay units defined as part of this study.

3.7.2.2 Silt and Clay

This unit is characterized as a gray, soft to hard silt and clay. The plasticity index of the unit generally increases with depth, as does clay content. The silt and clay unit was encountered at depths ranging from 45 feet at SB-16-04 to 60 feet at SB-16-01 and SB-16-05. The thickness of the silt and clay unit was not determined as part of this study. However the thickness of the unit was determined at several locations across PAFB during previous investigations.

Malcolm Pirnie (1993) reported that the silt and clay unit ranges from 23 feet thick at the western edge of the base (PZ-4) to 4 feet thick at the eastern side of the "old base" (PZ-1). The silt and clay unit was absent at PZ-3 (northeast portion of PAFB), MW-23-007 (southwest side of LF-023), and at cone penetrometer location CP-02-007 (along the west edge of the flightline apron).

3.7.2.3 Glacial Till

Borings made during this study were not advanced to the till layer, however, glacial till was encountered in all of the basewide bedrock piezometer borings installed by Malcolm Pirnie (1993). The thickness of the till at the piezometer locations ranged from 5 feet to 111 feet (Malcolm Pirnie 1993).

The glacial till was characterized by Malcolm Pirnie (1993) as a poorly-sorted silty sand and clay matrix with frequent gravel and cobbles, and occasional boulders. The till was typically gray and medium to very dense. Split-spoon refusal was common while sampling in this unit, and at several locations intact till cores were initially mistaken for bedrock.

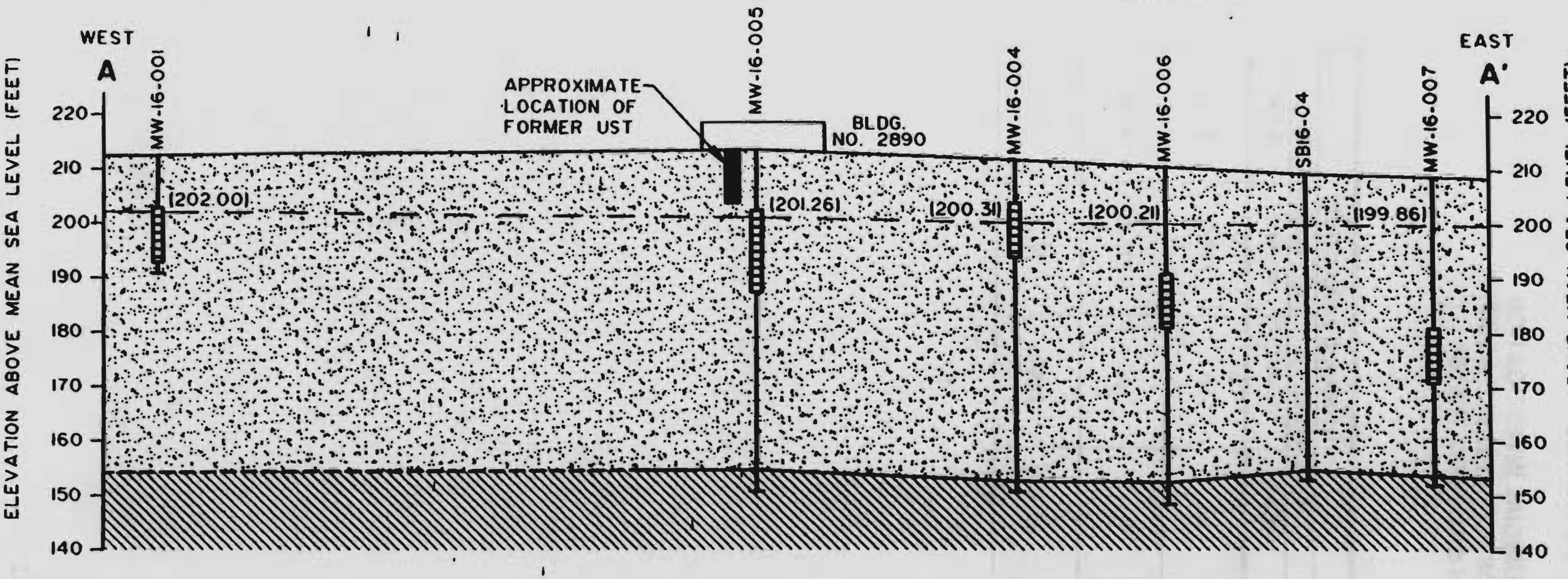
Together, the glacial till and overlying silt and clay make up a low-permeability confining layer separating the sand and bedrock aquifers. Figure 3-11 shows the top-of-confining-layer, inclusive of all

TABLE 3-5

NOSE DOCK 8 (SS-016) - REMEDIAL INVESTIGATION HYDRAULIC CONDUCTIVITY OF WATER TABLE AQUIFER DETERMINED FROM IN-SITU SLUG TESTS

WELL I.D.	SCREENED INTERVAL		UNIT SCREENED	HYDRAULIC CONDUCTIVITY			
				SLUG IN TEST		SLUG OUT TEST	
	DEPTH (ft.)	ELEVATION (ft.)		(cm/sec)	(ft./day)	(cm/sec)	(ft./day)
MW-16-004	8 - 18	203.88 - 193.88	Sand	NA	NA	1.78E-02	50.54
MW-16-005	11.5 - 26.5	202.13 - 187.13	Sand	NA	NA	1.57E-02	44.49
MW-16-006	19.5 - 29.5	191.11 - 181.11	Sand	1.05E-02	29.68	NA	NA

NA - Not available
NOTE: See Appendix G for field data.



LEGEND

SAND

SILT AND CLAY

MW-16-006 — MONITORING WELL NUMBER

202.00 — POTENTIOMETRIC SURFACE (GROUNDWATER ELEVATION (12/2/93))

SCREENED INTERVAL OF MONITORING WELL

BOREHOLE TERMINATION

60 0 60

SCALE IN FEET
HORIZONTAL SCALE IN FEET
VERTICAL EXAGGERATION = 2x

NOTES:

1. GEOLOGICAL CONDITIONS SHOWN ARE REPRESENTATIVE OF THE CONDITIONS ENCOUNTERED AT EACH BORING LOCATION TO THE DEPTH DRILLED. EXTRAPOLATIONS BETWEEN BORINGS HAVE BEEN INTERPRETED USING STANDARDLY ACCEPTED GEOLOGIC PRACTICES AND PRINCIPLES ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.
2. ELEVATIONS BASED ON TRANSVERSE MERCATOR PROJECTION, EAST ZONE, NORTH AMERICAN DATUM 1983.

URS CONSULTANTS, INC.

PLATTSBURGH A.F.B. SS-016
CROSS-SECTION A-A'

FIGURE 3-8

APPENDIX B
PERMIT EQUIVALENCY SUBMISSION

APPENDIX B-1
WATER DISCHARGE INFORMATION

Please print or type in the unshaded areas only.

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*

Approval expires 5-31-92

FORM 2C NPDES

U.S. ENVIRONMENTAL PROTECTION AGENCY
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER
EXISTING MANUFACTURING, COMMERCIAL, MINING AND SILVICULTURAL OPERATIONS
Consolidated Permits Program

I. OUTFALL LOCATION

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. OUTFALL NUMBER *(list)*	B. LATITUDE 1. DEG.	2. MIN.	3. SEC.	C. LONGITUDE 1. DEG.	2. MIN.	3. SEC.	D. RECEIVING WATER *(name)*
001	44	39	31	73	27	41	Storm Sewer
			OR				
001	44	39	29	73	27	37	Groundwater Injection

II. FLOWS, SOURCES OF POLLUTION, AND TREATMENT TECHNOLOGIES

A. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item B. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined *(e.g., for certain mining activities)*, provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

B. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

1. OUTFALL NO *(list)*	2. OPERATION(S) CONTRIBUTING FLOW: a. OPERATION *(list)*	b. AVERAGE FLOW *(include units)*	3. TREATMENT: a. DESCRIPTION	b. LIST CODES FROM TABLE 2C-1
001	Groundwater Withdrawal	50 gpm	Low Profile Air Stripper	XX
			(50 gpm water, 300 cfm air)	
			Carbon Adsorption	2-A
			Outfall to Storm Sewer	4-A
		OR		
001	Groundwater Withdrawal	50 gpm	Low Profile Air Stripper	XX
			(50 gpm, 300 cfm Air)	
			Carbon Adsorption	2-A
			Outfall to Groundwater	4-D

OFFICIAL USE ONLY *(effluent guidelines sub-categories)*

CONTINUED FROM THE FRONT

C. Except for storm runoff, leaks, or spills, are any of the discharges described in Items II-A or B intermittent or seasonal?

☐ YES (*complete the following table*) ☒ NO (*go to Section III*)

1. OUTFALL NUMBER (*list*)	2. OPERATION(*s*) CONTRIBUTING FLOW (*list*)	3. FREQUENCY a. DAYS PER WEEK (*specify average*)	3. FREQUENCY b. MONTHS PER YEAR (*specify average*)	4. FLOW a. FLOW RATE (*in mgd*) 1. LONG TERM AVERAGE	4. FLOW a. FLOW RATE (*in mgd*) 2. MAXIMUM DAILY	4. FLOW b. TOTAL VOLUME (*specify with units*) 1. LONG TERM AVERAGE	4. FLOW b. TOTAL VOLUME (*specify with units*) 2. MAXIMUM DAILY	4. FLOW c. DURATION (*in days*)
NA								

III. PRODUCTION

A. Does an effluent guideline limitation promulgated by EPA under Section 304 of the Clean Water Act apply to your facility?

☐ YES (*complete Item III-B*) ☒ NO (*to to Section IV*)

B. Are the limitations in the applicable effluent guideline expressed in terms of production (*or other measure of operation*)?

☐ YES (*complete Item III-C*) ☒ NO (*go to Section IV*)

C. If you answered "yes" to Item III-B, list the quantity which represents an actual measurement of your level of production, expressed in the terms and units used in the applicable effluent guideline, and indicate the affected outfalls.

1. AVERAGE DAILY PRODUCTION a. QUANTITY PER DAY	b. UNITS OF MEASURE	c. OPERATION, PRODUCT, MATERIAL, ETC. (*specify*)	2. AFFECTED OUTFALLS (*list outfall numbers*)
NA			

IV. IMPROVEMENTS

A. Are you now required by any Federal, State or local authority to meet any implementation schedule for the construction, upgrading or operation of waste-water treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

☒ YES (*complete the following table*) ☐ NO (*go to Item IV-B*)

1. IDENTIFICATION OF CONDITION, AGREEMENT, ETC.	2. AFFECTED OUTFALLS a. NO.	2. AFFECTED OUTFALLS b. SOURCE OF DISCHARGE	3. BRIEF DESCRIPTION OF PROJECT	4. FINAL COMPLIANCE DATE a. REQUIRED	4. FINAL COMPLIANCE DATE b. PROJECTED
Federal Facilities Agreement (FFA) Docket No. II CERCLA - FFA - 10201			Interagency Agreement Between USAF, USEPA, and New York State Department of Environmental Conservation (NYSDEC)		

B. OPTIONAL: You may attach additional sheets describing any additional water pollution control programs (*or other environmental projects which may affect your discharges*) you now have underway or which you plan. Indicate whether each program is now underway or planned, and indicate your actual or planned schedules for construction. ☐ MARK "X" IF DESCRIPTION OF ADDITIONAL CONTROL PROGRAMS IS ATTACHED

CONTINUE ON PAGE

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*

CONTINUED FROM PAGE 2

V. INTAKE AND EFFLUENT CHARACTERISTICS

A, B, & C: See instructions before proceeding — Complete one set of tables for each outfall — Annotate the outfall number in the space provided.
NOTE: Tables V-A, V-B, and V-C are included on separate sheets numbered V-1 through V-9.

D. Use the space below to list any of the pollutants listed in Table 2c-3 of the instructions, which you know or have reason to believe is discharged or may be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it to be present and report any analytical data in your possession.

1. POLLUTANT	2. SOURCE	1. POLLUTANT	2. SOURCE
Carbon Disulfide	2ug/L, MW-16-003		
Xylene	250ug/L, MW-16-004		

VI. POTENTIAL DISCHARGES NOT COVERED BY ANALYSIS

Is any pollutant listed in Item V-C a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ YES *(list all such pollutants below)* ☒ NO *(go to Item VI-B)*

Phenanthrene
Di-n-butylphthalate
Fluoranthene
Butylbenzylphthalate
Benzo(a)anthracene
Chrysene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
alpha-BHC
beta-BHC
4,4'-DDE
Endosulfan Sulfate
4,4'-DDT
Endrin Ketone
Cadmium

CONTINUED FROM THE FRONT

VII. BIOLOGICAL TOXICITY TESTING DATA

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☐ YES *(identify the test(s) and describe their purposes below)* [XX] NO *(go to Section VIII)*

VIII. CONTRACT ANALYSIS INFORMATION

Were any of the analyses reported in Item V performed by a contract laboratory or consulting firm?

[XX] YES *(list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below)* ☐ NO *(go to Section IX)*

A. NAME	B. ADDRESS	C. TELEPHONE *(area code & no.)*	D. POLLUTANTS ANALYZED *(list)*
Ecology and Environment, Inc.	4493 Walden Avenue Lancaster, NY 14086		

IX. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. NAME & OFFICIAL TITLE *(type or print)*	B. PHONE NO. *(area code & no.)*
C. SIGNATURE	**D. DATE SIGNED**

LEASE PRINT OR TYPE IN THE UNSHADED AREAS ONLY. You may report some or all of
is information on separate sheets *(use the same format)* instead of completing these pages.
E INSTRUCTIONS.

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*

OUTFALL NO 001

/. INTAKE AND EFFLUENT CHARACTERISTICS *(continued from page 3 of Form 2-C)*

PART A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

POLLUTANT	2. EFFLUENT (SEE NOTE BELOW) a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	3. UNITS *(specify if blank)* a. CONCENTRATION	b. MASS	4. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
Biochemical xygen Demand BOD)	20	NA	NA	NA	5	NA	0	mg/L	NA	Unknown	Unknown	0
Chemical xygen Demand COD)	240	NA	NA	NA	45	NA	0	mg/L	NA	Unknown	Unknown	0
Total Organic arbon *(TOC)*	Unknown	NA	NA	NA	Unknown	NA	0	mg/L	NA	Unknown	Unknown	0
Total Suspended olids *(TSS)*	20	NA	NA	NA	6	NA	0	mg/L	NA	Unknown	Unknown	0
Ammonia *(as N)*	Unknown	NA	NA	NA	Unknown	NA	0	mg/L	NA	Unknown	Unknown	0
Flow	VALUE 50 gpm		VALUE 50 gpm		VALUE 50 gpm		Design Value	NA	NA	VALUE 50 gpm		Design Value
Temperature vinter)	VALUE NA		VALUE NA		VALUE 10		0	°C		VALUE NA		
Temperature ummer)	VALUE NA		VALUE NA		VALUE 25		0	°C		VALUE NA		
pH	MINIMUM 6	MAXIMUM 8	MINIMUM NA	MAXIMUM NA			0	STANDARD UNITS				

PART B - Mark "X" in column 2-a for each pollutant you know or have reason to believe is present. Mark "X" in column 2-b for each pollutant you believe to be absent. If you mark column 2a for any pollutant which is limited either directly, or indirectly but expressly, in an effluent limitations guideline, you must provide the results of at least one analysis for that pollutant. For other pollutants for which you mark column 2a, you must provide quantitative data or an explanation of their presence in your discharge. Complete one table for each outfall. See the instructions for additional details and requirements.

. POLLUTANT AND CAS NO. *(if available)*	2. MARK 'X' a. BELIEVED PRESENT	b. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE *(if available)* (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE *(if available)* (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE *(optional)* a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
Bromide 24959-67-9)												Unknown		0
Chlorine, otal Residual												Unknown		0
Color												Unknown		0
. Fecal oliform												Unknown		0
Fluoride 16984-48-8)												Unknown		0
Nitrate– itrite *(as N)*												Unknown		0

NOTE: Estimated based on data from similar site.

ITEM V-B CONTINUED FROM FRONT

1. POLLUTANT AND CAS NO. (if available)	2. MARK 'X'		3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. BELIEVED PRESENT	b. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
			(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
. Nitrogen, otal Organic (as N)			Unknown									Unknown		0
. Oil and Grease			Unknown									Unknown		0
Phosphorus (as P), Total 7723-14-0)			Unknown									Unknown		0
. Radioactivity														
1) Alpha, Total			Unknown									Unknown		0
2) Beta, Total			Unknown									Unknown		0
3) Radium, Total			Unknown									Unknown		0
4) Radium 226, Total			Unknown									Unknown		0
. Sulfate (as SO_4) 14808-79-8)			Unknown									Unknown		0
. Sulfide (as S)			Unknown									Unknown		0
n. Sulfite (as SO_3) 14265-45-3)			Unknown									Unknown		0
n. Surfactants			Unknown									Unknown		0
o. Aluminum, Total 7429-90-5)			Unknown									Unknown		0
p. Barium, Total 7440-39-3)	X		231							ug/L		231	MW-16-002	10/12
. Boron, Total 7440-42-8)			Unknown									Unknown		0
. Cobalt, Total 7440-48-4)			Unknown									Unknown		0
. Iron, Total 7439-89-6)			Unknown									Unknown		0
. Magnesium, Total 7439-95-4)			Unknown									Unknown		0
. Molybdenum, Total 7439-98-7)			Unknown									Unknown		0
v. Manganese, Total 7439-96-5)			Unknown									Unknown		0
w. Tin, Total 7440-31-5)			Unknown									Unknown		0
x. Titanium, Total 7440-32-6)			Unknown									Unknown		0

CONTINUE ON PAGE V-3

EPA I.D. NUMBER *(copy from Item 1 of Form 1)*	OUTFALL NUMBER
	001

ITINUED FROM PAGE 3 OF FORM 2-C

ART C - If you are a primary industry and this outfall contains process wastewater, refer to Table 2c-2 in the instructions to determine which of the GC/MS fractions you must test for. Mark "X" in column 2-a for all such GC/MS fractions that apply to your industry and for ALL toxic metals, cyanides, and total phenols. If you are not required to mark column 2-a *(secondary industries, nonprocess wastewater outfalls, and nonrequired GC/MS fractions)*, mark "X" in column 2-b for each pollutant you know or have reason to believe is present. Mark "X" in column 2-c for each pollutant you believe is absent. If you mark column 2a for any pollutant, you must provide the results of at least one analysis for that pollutant. If you mark column 2b for any pollutant, you must provide the results of at least one analysis for that pollutant if you know or have reason to believe it will be discharged in concentrations of 10 ppb or greater. If you mark column 2b for acrolein, acrylonitrile, 2,4 dinitrophenol, or 2-methyl-4, 6 dinitrophenol, you must provide the results of at least one analysis for each of these pollutants which you know or have reason to believe that you discharge in concentrations of 100 ppb or greater. Otherwise, for pollutants for which you mark column 2b, you must either submit at least one analysis or briefly describe the reasons the pollutant is expected to be discharged. Note that there are 7 pages to this part; please review each carefully. Complete one table *(all 7 pages)* for each outfall. See instructions for additional details and requirements.

OLLUTANT AND CAS NUMBER *(if available)*	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE *(optional)*		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE *(if available)*		c. LONG TERM AVRG. VALUE *(if available)*		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
TALS, CYANIDE, AND TOTAL PHENOLS															
Antimony, al (7440-36-0)											ug/L		Unknown		0
Arsenic, Total 40-38-2)		X		< 24.8							ug/L		24.8	MW-16-004	4/12
Beryllium, al, 7440-41-7)											ug/L		Unknown		0
Cadmium, al (7440-43-9)			X	ND							ug/L		ND		0/12
Chromium, al (7440-47-3)		X		< 24.3							ug/L		24.3	MW-16-004	3/12
Copper, Total 0-50-8)											ug/L		Unknown		0
Lead, Total 9-92-1)		X		< 27.6							ug/L		27.6	MW-16-004	6/12
Mercury, Total 39-97-6)			X	ND							ug/L		ND		0/12
Nickel, Total 40-02-0)											ug/L		Unknown		0
. Selenium, al (7782-49-2)			X	ND							ug/L		ND		0/12
. Silver, Total 40-22-4)		X		< 6.5							ug/L		6.5	MW-16-005	1/12
. Thallium, al (7440-28-0)											ug/L		Unknown		0
. Zinc, Total 40-66-6)											ug/L		Unknown		0
. Cyanide, al (57-12-5)											ug/L		Unknown		0
. Phenols, al											ug/L		Unknown		0
OXIN															
7,8-Tetra-orodibenzo-P-xin (1764-01-6)				DESCRIBE RESULTS									Unknown		

CONTINUE ON REVERSE

1. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. MAXIMUM DAILY VALUE (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. MAXIMUM 30 DAY VALUE (if available) (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. LONG TERM AVRG. VALUE (if available) (2) MASS	d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. LONG TERM AVERAGE VALUE (2) MASS	b. NO. OF ANALYSES
/MS FRACTION – VOLATILE COMPOUNDS															
. Acrolein 07-02-8)											ug/L		Unknown		
. Acrylonitrile 07-13-1)											ug/L		Unknown		
. Benzene -43-2)			X	ND							ug/L		ND		0/19
. Bis (Chloro-thyl) Ether 42-88-1)											ug/L		Unknown		
. Bromoform 5-25-2)			X	ND							ug/L		ND		0/19
. Carbon trachloride 3-23-5)			X	ND							ug/L		ND		0/19
. Chlorobenzene 08-90-7)			x	ND							ug/L		ND		0/19
. Chlorodi-omomethane 24-48-1)			X	ND							ug/L		ND		0/19
. Chloroethane 5-00-3)			X	ND							ug/L		ND		0/19
V. 2-Chloro-ylvinyl Ether 10-75-8)											ug/L		Unknown		
V. Chloroform 7-66-3)		X		< 5							ug/L		28	MW-16-007	1/19
V. Dichloro-omomethane 5-27-4)			X	ND							ug/L		ND		0/19
V. Dichloro-luoromethane 5-71-8)											ug/L		Unknown		
V. 1,1-Dichloro-ane (75-34-3)		X		< 3							ug/L		3	MW-16-004	1/19
V. 1,2-Dichloro-ane (107-06-2)		X		< 4							ug/L		4	MW-16-005	2/19
V. 1,1-Dichloro-ylene (75-35-4)			X	ND							ug/L		ND		0/19
V. 1,2-Dichloro-opane (78-87-5)		X		< 5							ug/L		10	MW-16-004	3/19
V. 1,3-Dichloro-pylene (542-75-6)			X	ND							ug/L		ND		0/38
V. Ethylbenzene 00-41-4)		X		< 5							ug/L		38	MW-16-004	4/19
V. Methyl omide (74-83-9)			X	ND							ug/L		ND		0/19
V. Methyl loride (74-87-3)			X	ND							ug/L		ND		0/19

ONTI ON P

NTINUED FROM PAGE V-4

POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	a. (2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	b. (2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	c. (2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	a. (2) MASS	b. NO. OF ANALYSES
C/MS FRACTION — VOLATILE COMPOUNDS (continued)															
2V. Methylene hloride (75-09-2)			X	ND							ug/L		ND		0/19
3V. 1,1,2,2-Tetra- loroethane 9-34-5)			X	ND							ug/L		ND		0/19
3V. Tetrachloro- hylene (127-18-4)			X	ND							ug/L		ND		0/19
5V. Toluene 08-88-3)		X		< 5							ug/L		88	MW-16-004	4/19
6V. 1,2-Trans- ichloroethylene 56-60-5)		X		< 5							Ug/L		42	MW-16-004	5/19
7V. 1,1,1-Tri- lorcethane 1-55-6)			X	ND							ug/L		ND		0/19
8V. 1,1,2-Tri- loroethane 9-00-5)			X	ND							ug/L		ND		0/19
9V. Trichloro- hylene (79-01-6)		X		< 5							ug/L		110	MW-16-004	6/19
0V. Trichloro- uoromethane 5-69-4)											ug/L		Unknown		
1V. Vinyl hloride (75-01-4)			X	ND							ug/L		ND		0/19
C/MS FRACTION — ACID COMPOUNDS															
A. 2-Chlorophenol 95-57-8)			X	ND							ug/L		ND		0/12
A. 2,4-Dichloro- henol (120-83-2)			X	ND							ug/L		ND		0/12
A. 2,4-Dimethyl- henol (105-67-9)			X	ND							ug/L		ND		0/12
A. 4,6-Dinitro-O- resol (534-52-1)			X	ND							ug/L		ND		0/12
A. 2,4-Dinitro- henol (51-28-5)			X	ND							ug/L		ND		0/12
A. 2-Nitrophenol 88-75-5)			X	ND							ug/L		ND		0/12
A. 4-Nitrophenol 100-02-7)			X	ND							ug/L		ND		0/12
A. P-Chloro-M- resol (59-50-7)			X	ND							ug/L		ND		0/12
A. Pentachloro- henol (87-86-5)			X	ND							ug/L		ND		0/12
0A. Phenol 108-95-2)			X	ND							ug/L		ND		0/12
1A. 2,4,6-Tri- hlorophenol 88-06-2)			X	ND							ug/L		ND		0/12

CONTINUE ON REVERSE

ONTINUED FROM THE FRONT

. POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
C/MS FRACTION – BASE/NEUTRAL COMPOUNDS															
B. Acenaphthene 83-32-9)			X	ND							ug/L		ND		0/12
'B. Acenaphtylene 208-96-8)			X	ND							ug/L		ND		0/12
3B. Anthracene 120-12-7)			X	ND							ug/L		ND		0/12
4B. Benzidine 92-87-5)											ug/L		Unknown		
5B. Benzo *(a)* Anthracene (56-55-3)			X	ND							ug/L		ND		0/12
6B. Benzo *(a)* Pyrene (50-32-8)			X	ND							ug/L		ND		0/12
7B. 3,4-Benzo-fluoranthene (205-99-2)			X	ND							ug/L		ND		0/12
8B. Benzo *(ghi)* Perylene (191-24-2)			X	ND							ug/L		ND		0/12
9B. Benzo *(k)* Fluoranthene (207-08-9)			X	ND							ug/L		ND		0/12
10B. Bis *(2-Chloroethoxy)* Methane (111-91-1)			X	ND							ug/L		ND		0/12
11B. Bis *(2-Chloroethyl)* Ether (111-44-4)			X	ND							ug/L		ND		0/12
2B. Bis *(2-Chloroisopropyl)* Ether (102-60-1)											ug/L		Unknown		
13B. Bis *(2-Ethylhexyl)* Phthalate (117-81-7)		X		< 2							ug/L		2	MW-16-005	3/12
14B. 4-Bromophenyl Phenyl Ether (101-55-3)			X	ND							ug/L		ND		0/12
15B. Butyl Benzyl Phthalate (85-68-7)			X	ND							ug/L		ND		0/12
16B. 2-Chloronaphthalene 91-58-7)			X	ND							ug/L		ND		0/12
17B. 4-Chlorophenyl Phenyl Ether (7005-72-3)			X	ND							ug/L		ND		0/12
18B. Chrysene 218-01-9)			X	ND							ug/L		ND		0/12
19B. Dibenzo *(a,h)* Anthracene 53-70-3)			X	ND							ug/L		ND		0/12
20B. 1,2-Dichlorobenzene (95-50-1)		X		< 2							ug/L		2	MW-16-004	2/12
21B. 1,3-Dichlorobenzene (541-73-1)			X	ND							ug/L		ND		0/12

CONTINUE ON PAGE V-

LPA I.D. NUMBER (copy from Item 1 of Form 1) | OUTFALL NUMBER

NTINUED FROM PAGE V-6

POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X' a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	3. EFFLUENT a. MAXIMUM DAILY VALUE (1) CONCENTRATION	(2) MASS	b. MAXIMUM 30 DAY VALUE (if available) (1) CONCENTRATION	(2) MASS	c. LONG TERM AVRG. VALUE (if available) (1) CONCENTRATION	(2) MASS	d. NO. OF ANALYSES	4. UNITS a. CONCENTRATION	b. MASS	5. INTAKE (optional) a. LONG TERM AVERAGE VALUE (1) CONCENTRATION	(2) MASS	b. NO. OF ANALYSES
MS FRACTION – BASE/NEUTRAL COMPOUNDS *(continued)*															
B. 1,4-Dichloro-zene (106-46-7)			X	ND							ug/L		ND		0/12
B. 3,3'-Dichloro-zidine -94-1)			X	ND							ug/L		ND		0/12
B. Diethyl halate -66-2)		X		< 5							ug/L		5	MW-16-005	1/12
B. Dimethyl halate 31-11-3)			X	ND							ug/L		ND		0/12
B. Di-N-Butyl halate -74-2)			X	ND							ug/L		ND		0/12
B. 2,4-Dinitro-uene (121-14-2)			X	ND							ug/L		ND		0/12
B. 2,6-Dinitro-uene (606-20-2)			X	ND							ug/L		ND		0/12
B. Di-N-Octyl halate 17-84-0)			X	ND							ug/L		ND		0/12
B. 1,2-Diphenyl-irazine *(as Azo-zene)* (122-66-7)											ug/1		Unknown		
B. Fluoranthene 06-44-0)			X	ND							ug/L		ND		0/12
B. Fluorene -73-7)			X	ND							ug/L		ND		0/12
Hexachlorobenzene -74-1)			X	ND							ug/L		ND		0/12
B. Hexa-lorobutadiene 7-68-3)			X	ND							ug/L		ND		0/12
B. Hexachloro-clopentadiene 7-47-4)			X	ND							ug/L		ND		0/12
B. Hexachloro-hane (67-72-1)			X	ND							ug/L		ND		0/12
B. Indeno *2, 3-cd)* Pyrene 93-39-5)			X	ND							ug/L		ND		0/12
B. Isophorone 8-59-1)			X	ND							ug/L		ND		0/12
B. Naphthalene 1-20-3)		X		< 5							ug/L		170	MW-16-004	5/12
B. Nitrobenzene 8-95-3)			X	ND							ug/L		ND		0/12
B. N-Nitro-dimethylamine 2-75-9)											ug/L		Unknown		
B. N-Nitrosodi-Propylamine 21-64-7)			X	ND							ug/L		ND		0/12

CONTINUE ON REVERSE

ONTINUED FROM THE FRONT

POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
C/MS FRACTION – BASE/NEUTRAL COMPOUNDS (continued)															
3B. N-Nitro-diphenylamine (6-30-6)			X	ND									ND		0/12
4B. Phenanthrene (5-01-8)			X	ND									ND		0/12
5B. Pyrene (29-00-0)			X	ND									ND		0/12
6B. 1,2,4 - Tri-hlorobenzene (20-82-1)			X	ND									ND		0/12
C/MS FRACTION – PESTICIDES															
P. Aldrin (309-00-2)			X	ND									ND		0/8
P. α-BHC (319-84-6)			X	ND									ND		0/8
P. β-BHC (319-85-7)			X	ND									ND		0/8
P. γ-BHC (58-89-9)			X	ND									ND		0/8
P. δ-BHC (319-86-8)			X	ND									ND		0/8
P. Chlordane (57-74-9)			X	ND									ND		0/8
P. 4,4'-DDT (50-29-3)			X	ND									ND		0/8
P. 4,4'-DDE (72-55-9)			X	ND									ND		0/8
P. 4,4'-DDD (72-54-8)			X	ND									ND		0/8
0P. Dieldrin (60-57-1)			X	ND									ND		0/8
1P. α-Endosulfan (115-29-7)			X	ND									ND		0/8
2P. β-Endosulfan (115-29-7)			X	ND									ND		0/8
3P. Endosulfan ulfate (1031-07-8)			X	ND									ND		0/8
4P. Endrin (72-20-8)			X	ND									ND		0/8
5P. Endrin ldehyde (7421-93-4)			X	ND									ND		0/8
6P. Heptachlor (76-44-8)			X	ND									ND		0/8

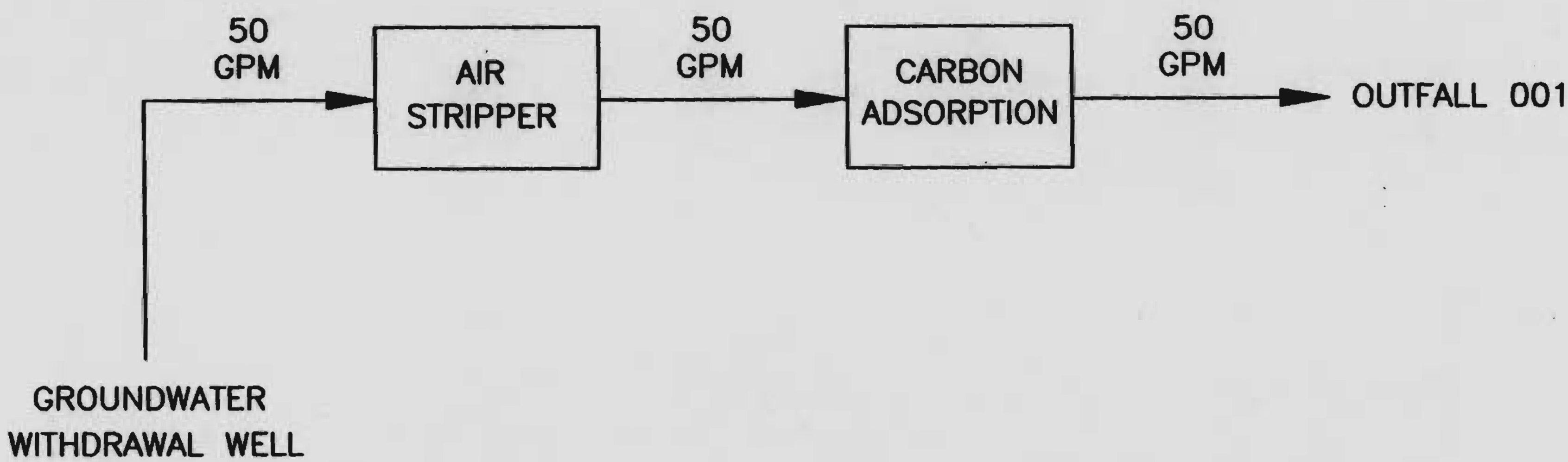
CONTINUE ON PAGE V-9

EPA I.D. NUMBER (copy from Item 1 of Form 1)	OUTFALL NUMBER

TINUED FROM PAGE V-8

POLLUTANT AND CAS NUMBER (if available)	2. MARK 'X'			3. EFFLUENT							4. UNITS		5. INTAKE (optional)		
	a. TESTING REQUIRED	b. BELIEVED PRESENT	c. BELIEVED ABSENT	a. MAXIMUM DAILY VALUE		b. MAXIMUM 30 DAY VALUE (if available)		c. LONG TERM AVRG. VALUE (if available)		d. NO. OF ANALYSES	a. CONCENTRATION	b. MASS	a. LONG TERM AVERAGE VALUE		b. NO. OF ANALYSES
				(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS	(1) CONCENTRATION	(2) MASS				(1) CONCENTRATION	(2) MASS	
MS FRACTION — PESTICIDES (continued)															
Heptachlor xide (24-57-3)			X	ND									ND		0/8
PCB-1242 (69-21-9)			X	ND									ND		0/8
PCB-1254 (97-69-1)			X	ND									ND		0/8
PCB-1221 (104-28-2)			X	ND									ND		0/8
PCB-1232 (141-16-5)			X	ND									ND		0/8
PCB-1248 (72-29-6)			X	ND									ND		0/8
PCB-1260 (096-82-5)			X	ND									ND		0/8
PCB-1016 (674-11-2)			X	ND									ND		0/8
Toxaphene (01-35-2)			X	ND									ND		0/8

AC-7569 \0535291.23\CAD\SS016\TREAT\ 1=1 6/25/96-2 ETM



PLATTSBURGH AIR FORCE BASE
INSTALLATION RESTORATION PROGRAM
NOSE DOCK 8 (SS-016)
PLATTSBURGH, CLINTON COUNTY, NEW YORK

NO SCALE

URS CONSULTANTS, INC.

ITEM TTC – SCHEMATIC OF WATER FLOW

FIGURE

OP	LOCATION	FACILITY	EMISSION POINT
			I

A ADD
C CHANGE
D DELETE

READ INSTRUCTIONS CONTAINED IN FORM 76-11-12 BEFORE ANSWERING ANY QUESTION

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

COPIES
WHITE - ORIGINAL
GREEN - DIVISON OF AIR
WHITE - REGIONAL OFFICE
WHITE - FIELD REP.
YELLOW - APPLICANT

PROCESS, EXHAUST OR VENTILATION SYSTEM

APPLICATION FOR PERMIT TO CONSTRUCT OR CERTIFICATE TO OPERATE

SECTION A

1. NAME OF OWNER / FIRM: Department of Air Force AFBCA/OL-3A
2. NUMBER AND STREET ADDRESS: 324 U.S. Oval
3. CITY - TOWN - VILLAGE: Plattsburgh
4. STATE: NY
5. ZIP: 12903
6. OWNER CLASSIFICATON: A. [ ] COMMERCIAL B. [ ] INDUSTRIAL C. [ ] UTILITY D. [X] FEDERAL E. [ ] STATE F. [ ] MUNICIPAL G. [ ] EDUC. INST. H. [ ] HOSPITAL I. [ ] RESIDENTIAL J. [ ] OTHER
7. NAME & TITLE OF OWNERS REPRESENTATIVE: Michael Sorrel
8. TELEPHONE:
9. NAME OF AUTHORIZED AGENT:
10. TELEPHONE:
11. NUMBER AND STREET ADDRESS:
12. CITY - TOWN - VILLAGE:
13. STATE:
14. ZIP:
15. NAME OF P.E. OR ARCHITECT PREPARING APPLICATION:
16. N.Y.S. P.E. OR ARCHITECT LICENSE NO.:
17. TELEPHONE:
18. SIGNATURE OF OWNERS REPRESENTATIVE OR AGENT WHEN APPLYING FOR A PERMIT TO CONSTRUCT:
19. FACILITY NAME (IF DIFFERENT FROM OWNER / FIRM): Nose Dock 8
20. FACILITY LOCATION (NUMBER AND STREET ADDRESS): Florida Street
21. CITY - TOWN - VILLAGE: Plattsburgh Air Force Base
22. ZIP: 12903
23. BUILDING NAME OR NUMBER: Building 2890
24. FLOOR NAME OR NUMBER: N/A
25. START UP DATE: 09 / 96 (MO / YR)
26. DRAWING NUMBERS OF PLANS SUBMITTED: Figure 1 and 2
27. PERMIT TO CONSTRUCT: A. [XX] NEW SOURCE B. [ ] MODIFICATION
28. CERTIFICATE TO OPERATE: A. [ ] NEW SOURCE B. [ ] MODIFICATION C. [ ] EXISTING SOURCE

SEC. B

29. EMISSION POINT ID.	30. GROUND ELEVATION (FT.)	31. HEIGHT ABOVE STRUCTURES (FT.)	32. STACK HEIGHT (FT.)	33. INSIDE DIMENSIONS (IN.)	34. EXIT TEMP.(°F)	35. EXIT VELOCITY (FT./SEC.)	36. EXIT FLOW RATE (ACFM)
N D 8 - 1	215	3	28 *	4	50	134	700

37. SOURCE CODE	38. HRS / DAY	39. DAYS / YR	40. % OPERATION BY SEASON Winter	Spring	Summer	Fall
	24	365	25	25	25	25

SEC. C

41. DESCRIBE PROCESS OR UNIT

1. Air Stripper for Groundwater Treatment
2. Soil Vapor Extraction for Soil Treatment
3.
4.
5.
6.
7.
8.

SEC. D

EMISSION CONTROL EQUIPMENT I.D.	CONTROL TYPE	MANUFACTURER'S NAME AND MODEL NUMBER	DISPOSAL METHOD	DATE INSTALLED MONTH / YEAR	USEFUL LIFE
42.	43.	44.	45.	46. /	47.
48.	49.	50.	51.	52. /	53.

SECTION

CALCULATIONS

See Attached Pages

* Stack Height Estimated Based on Assumed 25 ft Building Height

E

SECTION F

CONTAMINANT NAME	CAS NUMBER	INPUT OR PRODUCTION	UNIT	ENV. RATING	EMISSIONS ACTUAL	EMISSIONS UNIT	EMISSIONS HOW DET.	EMISSIONS PERMISSIBLE	% CONTROL EFFIC'CY	HOURLY EMISSIONS (LBS/HR) ERP	HOURLY EMISSIONS (LBS/HR) ACTUAL	ANNUAL EMISSIONS (LBS/YR) ACTUAL	ANNUAL EMISSIONS (LBS/YR) 10^x	ANNUAL EMISSIONS (LBS/YR) PERMISSIBLE
54. See Attached	55. – –	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.	68.
69.	70. – –	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.
84.	85. – –	86.	87.	88.	89.	90.	91.	92.	93.	94.	95.	96.	97.	98.
99.	100. – –	101.	102.	103.	104.	105.	106.	107.	108.	109.	110.	111.	112.	113.
114.	115. – –	116.	117.	118.	119.	120.	121.	122.	123.	124.	125.	126.	127.	128.
129.	130. – –	131.	132.	133.	134.	135.	136.	137.	138.	139.	140.	141.	142.	143.

SEC. G

SOLID FUEL TYPE	SOLID FUEL TONS / YR	SOLID FUEL % S	LIQUID FUEL TYPE	LIQUID FUEL THOUSANDS OF GALLONS/YR	LIQUID FUEL % S	GAS TYPE	GAS THOUSANDS OF CF/YR	BTU/CF
144	145	146	147.	148.	149.	150.	151.	152.

APPLICABLE RULE	APPLICABLE RULE
153.	154.

Upon completion of construction sign the statement listed below and forward to the appropriate field representative

THE PROCESS, EXHAUST OR VENTILATION SYSTEM HAS BEEN CONSTRUCTED AND WILL BE OPERATED IN ACCORDANCE WITH STATED SPECIFICATIONS AND IN CONFORMANCE WITH ALL PROVISIONS OF EXISTING REGULATIONS.

155. SIGNATURE OF AUTHORIZED REPRESENTATIVE OR AGENT	DATE

AGENCY USE ONLY

156. LOCATION CODE	157. FACILITY ID. NO.	158. U.T.M. (E)	159. U.T.M. (N)	160. SIC NUMBER	161. DATE APPL. RECEIVED	162. DATE APPL. REVIEWED	163. REVIEWED BY:
		.	.		/ /	/ /	

PERMIT TO CONSTRUCT

164. DATE ISSUED	165. EXPIRATION DATE	166. SIGNATURE OF APPROVAL	167. FEE
/ /	/ /		

168.
1. DEVIATION FROM APPROVED APPLICATION SHALL VOID THIS PERMIT
2. THIS IS NOT A CERTIFICATE TO OPERATE
3. TESTS AND/OR ADDITIONAL EMISSION CONTROL EQUIPMENT MAY BE REQUIRED PRIOR TO THE ISSUANCE OF A CERTIFICATE TO OPERATE

CERTIFICATE TO OPERATE

169. DATE ISSUED	170. EXPIRATION DATE	171. SIGNATURE OF APPROVAL	172. FEE
/ /	/ /		

173.
1. ☐ INSPECTED BY ______________________ DATE ____________
2. ☐ INSPECTION DISCLOSED DIFFERENCES AS BUILT VS. PERMIT, CHANGES INDICATED ON FORM
3. ☐ ISSUE CERTIFICATE TO OPERATE FOR SOURCE AS BUILT
4. ☐ APPLICATION FOR C.O. DENIED ____________ DATE ____________ INITIALED

174. SPECIAL CONDITIONS

1.	2.
3.	4.
5.	6.
7.	8.

AGENCY USE ONLY

APPENDIX B-2
AIR EMISSIONS INFORMATION

PROJECT: PLATTSBURGH SS-016 MADE BY: D. McCall DATE: 03/01/95
SUBJECT: Soil Vapor Extraction Emissions CHKD BY: DATE: 03/01/95

Problem: Estimate the contaminant emissions from the proposed Soil Vapor Extraction system.

Assumptions:

1. The soil vapor extraction is assumed to discharge the soil vapor to the atmosphere at a rate of 400 cfm.
2. The system is assumed to operate 24 hours per day and 365 days per year.

References:

1. Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) Air Emissions Models, EPA-450/3-87-026, December 1987.
2. *Basic Principles and Calculations in Chemical Engineering, 4th ed.*; David M. Himmelblau; Prentice-Hall, Inc., Engelwood Cliffs, NJ; 1982.
3. Estimating Air Emissions from Petroleum UST Cleanups, USEPA, Office of Underground Storage Tanks, June 1989.

The following is an explanation of the calculations and assumptions made in Section F of the Permit Application. An example calculation for trichloroethene is provided.

Groundwater Conc. Design Value (μg/L)

The concentration of the contaminants in the air stream from the vapor extraction system is estimated based on the level on contamination present in the groundwater. The level of contamination in the groundwater is assumed to be either the maximum detected value, or 4 times the average of the detected values, whichever is less. The groundwater contamination influent design values are presented in Table 1. These are the same values that were used for the calculation of emissions from the air stripper.

Trichloroethene = 79 μg/L

JOB NO. 05.35291.23

PROJECT: PLATTSBURGH SS-016 MADE BY: D. McCall DATE: 03/01/95
SUBJECT: Soil Vapor Extraction Emissions CHKD BY: DATE: 03/01/95

Groundwater Conc. Design Value (g/m^3)

This value is converted from the previous number:

$$79\frac{\mu g}{L} \times \frac{1\ g}{1x10^6\ \mu g} \times \frac{1000\ L}{m^3} = 0.079\frac{g}{m^3}$$

Henry's Law Constant (atm•m^3/mol)
These values were taken from Reference 1. Trichlorothene = $9.1x10^{-3}$

Molecular Weight (g/mol)
These values were taken from Reference 1. Trichloroethene = 131.39

C_{gas} (atm)
Based on equation C-4 presented in Reference 3, the concentration of the contaminants in the soil gas is estimated:

$$C_{gas} = \frac{C_{moisture} \times H}{MW}$$

Where: $C_{moisture}$ (g/m^3) is the concentration of the contaminant in the moisture. It is assumed that the concentration of the contaminant in the moisture is the same as the concentration of the contaminant in the groundwater.

H is Henry's Law Constant (atm•m^3/mol)

MW is the Molecular Weight (g/mol) of the contaminant

$$C_{gas} = 0.079\frac{g}{m^3} \times 9.1x10^{-3}\frac{atm \bullet m^3}{mol} \;/\; 131.39\frac{g}{mol}$$

C_{gas} = $5.49x10^{-6}$ atm, This is essentially the partial pressure of trichlorothene in the soil vapor in the contaminated area of the site.

JOB NO. 05.35291.23

PROJECT: PLATTSBURGH SS-016 MADE BY: D. McCall DATE: 03/01/95
SUBJECT: Soil Vapor Extraction Emissions CHKD BY: DATE: 03/01/95

C_{gas} (ppmv)

Based on Dalton's Law of partial pressure (Reference 2) the partial pressure of the contaminant is directly related to the volume of the contaminant in the vapor phase. Assuming that the total pressure is 1 atm:

C_{gas} = 5.49 ppmv

Actual Contaminant Emissions (lb/h)

Based on equation B-11 of Reference 3, the emission rate of the contaminants are determined:

$$ER = Q \times C_{gas} \times MW \times 1.581x10^{-7}$$

Where:	ER	is the emission rate (lb/hr)
	Q	is the soil vapor extraction rate (cfm) = 400 cfm
	C_{gas}	is the soil gas concentration (ppmv)
	MW	is the molecular weight (lb/lb mol)
	$1.581x10^{-7}$	is a constant with units of (lb mol · min/ft^3 · ppmv · hr)

$$ER = 400\ cfm \times 5.49\ ppmv \times 131.39 \frac{lb}{lb\ mol} \times 1.581x10^{-7}$$

ER = $4.97x10^{-2}$ lb/hr

Hourly Emissions (lbs/h), ERP and Actual

Because there is no control on the emissions from the soil vapor extraction system, the ERP and the Actual emissions are the same as calculated above.

Contaminant Emissions (lb/yr)

Assuming that the SVE system operates 24 hours per day and 365 days per year:

ER = $4.97x10^{-2}$ lb/hr x 24hr/day x 365day/yr = 435 lb/yr of trichloroethene emissions

SECTION E - Table 1

Design Values for the Estimation of Emissions from the Soil Vapor Extraction System

CHEMICAL	CAS Registry Number	Arithmetic Mean (µg/l)	4x Arith. Mean (µg/l)	Maximum Detected Conc. (µg/l)	Groundwater Conc. Design Value (µg/l)	Groundwater Conc. Design Value - Cm (g/m³)	Henry's Law Constants (atm·m³/mol)	Molecular Weight (g/mol)	Cgas (atm)	Cgas (ppmv)
Acetone	67-64-1	11	44	29	29	0.029	2.50E-05	58.08	1.25E-08	1.25E-02
Carbon Disulfide	75-15-0	4	15	2	2	0.002	1.68E-02	76.14	4.41E-07	4.41E-01
1,1-Dichloroethane	75-34-3	4	15	3	3	0.003	5.54E-03	99	1.68E-07	1.68E-01
1,2-Dichloroethene (total)	540-59-0	8	33	40	33	0.033	3.19E-02	96.95	1.09E-05	1.09E+01
Chloroform	67-66-3	6	23	28	23	0.023	3.39E-03	119.4	6.53E-07	6.53E-01
1,2-Dichloroethane	107-06-2	4	15	4	4	0.004	1.20E-03	98.76	4.86E-08	4.86E-02
2-Butanone	78-93-3	5	21	16	16	0.016	4.35E-05	72.12	9.65E-09	9.65E-03
1,2-Dichloropropane	78-87-5	4	17	10	10	0.010	2.30E-03	112.99	2.04E-07	2.04E-01
Trichloroethene	79-01-6	20	79	105	79	0.079	9.10E-03	131.39	5.47E-06	5.47E+00
Toluene	108-88-3	17	67	86	67	0.067	6.68E-03	92	4.86E-06	4.86E+00
Ethylbenzene	100-41-4	9	35	37	35	0.035	6.44E-03	106.16	2.12E-06	2.12E+00
Xylene (total)	1330-20-7	42	167	245	167	0.167	5.25E-03	106.2	8.26E-06	8.26E+00
1,2-Dichlorobenzene	95-50-1	4	18	2	2	0.002	1.94E-03	147	2.64E-08	2.64E-02
2-Methylphenol	95-48-7	5	20	3	3	0.003	2.60E-06	108.13	7.21E-11	7.21E-05
4-Methylphenol	106-44-5	17	68	79	68	0.068	4.43E-07	108.13	2.79E-10	2.79E-04
Naphthalene	91-20-3	25	101	170	101	0.101	1.18E-03	128.2	9.30E-07	9.30E-01
2-Methylnaphthalene	91-57-6	14	56	69	56	0.056	5.80E-05	142.19	2.28E-08	2.28E-02
Diethylphthalate	84-66-2	5	21	5	5	0.005	1.11E-02	222	2.50E-07	2.50E-01
bis(2-Ethylhexyl)phthalate	117-81-7	5	19	2	2	0.002	3.00E-07	390.68	1.54E-12	1.54E-06

1. Arithmetic Mean - When an analyte was not detected, one-half the sample quantitation limit was used to calculate the arithmetic mean.
2. Groundwater Concentration Design Value - The level of contaminant assumed to be in the influent water stream to the air stripper
   This number is either the maximum detected value, or 4 times the average of the detected values, whichever is less.
3. Source of Henry's Law and Molecular Weight - Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF) Air Emissions Models, EPA-450/3-87-026, December 1987.

PROJECT: PLATTSBURGH SS-016 MADE BY: D. McCall DATE: 06/25/96
SUBJECT: Air Stripper Emissions CHKD BY: DATE: 06/26/96

Problem: Estimate the contaminant emissions from the proposed groundwater treatment system

Assumptions:

1. Groundwater treatment system consists of an air stripper and carbon adsorption. The only source of contaminant emissions from the groundwater treatment system will be the air stripper.

2. The air stripper operates at a rate of 50 gpm groundwater treatment and 300 cfm of air.

3. The system is assumed to operate 24 hours per day and 365 days per year.

References:

1. Plattsburgh Air Force Base Installation Restoration Program - Nose Dock 8 (SS-016) Remedial Investigation Report, December 1995.

The following is an explanation of the calculations and assumptions made in Section F of the Permit Application. An example calculation for trichloroethene is provided.

Air Stripper Influent Design Value (μg/L)

The concentration of the contaminants in the off-gas from the air stripper is estimated based on the level on contamination present in the groundwater. The level of contamination in the groundwater is assumed to be either the maximum detected value, or 4 times the average of the detected values, whichever is less. The groundwater contamination influent design values are presented in Table 1.

The results of the groundwater sampling are summarized in Reference 1.

Trichloroethene = 79 μg/L

PROJECT: PLATTSBURGH SS-016	MADE BY: D. McCall	DATE: 06/25/96
SUBJECT: Air Stripper Emissions	CHKD BY:	DATE: 06/26/96

Actual Contaminant Emissions (lb/h)

To be conservative in the estimation of concentrations of the contaminants in the air stripper off-gas, it is assumed that 100% of the contamination is removed from the water and emitted to the atmosphere. Based on the water and air flow rates, a material balance is performed:

$$79\,\frac{\mu g}{L} \times \frac{1\,g}{1x10^{6}\,\mu g} \times \frac{1\,lb}{454\,g} \times \frac{3.785\,L}{gal} \times \frac{50\,gal}{min} \times \frac{60\,min}{hr} = 1.98x10^{-3}\,\frac{lb\ trichloroethene}{hr}$$

Hourly Emissions (lbs/h), ERP and Actual

Because the air stripper was conservatively assumed to be able to remove 100% of the contaminants from the groundwater, the ERP and the actual emissions are the same as calculated above.

Annual Emissions (lb/yr)

Assuming that the groundwater treatment system operates 24 hours per day and 365 days per year:

Emission Rate = $1.98x10^{-3}$ lb/hr x 24hr/day x 365day/yr = 17.3 lb/yr of trichloroethene

SECTION E - Table 1

Estimate of Groundwater Contamination into the Air Stripper

CHEMICAL	CAS Registry Number	Arithmetic Mean (µg/l)	4x Arith. Mean (µg/l)	Maximum Detected Conc. (µg/l)	Air Stripper Influent Design Value (µg/l)
Acetone	67-64-1	11	46	29	29
Carbon Disulfide	75-15-0	4	15	2	2
1,1-Dichloroethane	75-34-3	4	15	3	3
1,2-Dichloroethene (total)	540-59-0	8	33	40	33
Chloroform	67-66-3	6	23	28	23
1,2-Dichloroethane	107-06-2	4	15	4	4
2-Butanone	78-93-3	5	21	16	16
1,2-Dichloropropane	78-87-5	4	17	10	10
Trichloroethene	79-01-6	20	79	105	79
Toluene	108-88-3	17	67	86	67
Ethylbenzene	100-41-4	9	35	37	35
Xylene (total)	1330-20-7	42	167	245	167
1,2-Dichlorobenzene	95-50-1	4	18	2	2
2-Methylphenol	95-48-7	5	20	3	3
4-Methylphenol	106-44-5	17	68	79	68
Naphthalene	91-20-3	25	101	170	101
2-Methylnaphthalene	91-57-6	14	56	69	56
Diethylphthalate	84-66-2	5	21	5	5
bis(2-Ethylhexyl)phthalate	117-81-7	5	19	2	2

1. Arithmetic Mean - When an analyte was not detected, one-half the sample quantitation limit was used to calculate the arithmetic mean.
2. Air Stripper Influent Design Value - The level of contaminant assumed to be in the influent water stream to the air stripper
   This number is either the maximum detected value, or 4 times the average of the detected values, whichever is less.

SECTION F
Soil Vapor Extraction Emissions Estimates

CONTAMINANT		INPUT OR		ENV.	EMISSIONS				% CONTROL	HOURLY EMISSIONS (LBS/HR)		ANNUAL EMISSIONS (LBS/YR)		
NAME	CAS NUMBER	PRODUCTION	UNIT	RATING	ACTUAL	UNIT	DET.	PERMISSIBLE	EFFCNCY	ERP	ACTUAL	ACTUAL	10^x	PERMISSIBLE
Acetone	67-64-1	NA	NA		50.0	3	6		0	5.00E-05	5.00E-05	0.44	0	
Carbon Disulfide	75-15-0	NA	NA		2,318.5	3	6		0	2.32E-03	2.32E-03	20.31	0	
1,1-Dichloroethane	75-34-3	NA	NA		1,146.8	3	6		0	1.15E-03	1.15E-03	10.05	0	
1,2-Dichloroethene (total)	540-59-0	NA	NA		73,189.0	3	6		0	7.32E-02	7.32E-02	641.14	0	
Chloroform	67-66-3	NA	NA		5,360.6	3	6		0	5.36E-03	5.36E-03	46.96	0	
1,2-Dichloroethane	107-06-2	NA	NA		331.2	3	6		0	3.31E-04	3.31E-04	2.90	0	
2-Butanone	78-93-3	NA	NA		48.0	3	6		0	4.80E-05	4.80E-05	0.42	0	
1,2-Dichloropropane	78-87-5	NA	NA		1,507.7	3	6		0	1.51E-03	1.51E-03	13.21	0	
Trichloroethene	79-01-6	NA	NA		49,731.1	3	6		0	4.97E-02	4.97E-02	435.64	0	
Toluene	108-88-3	NA	NA		30,690.4	3	6		0	3.07E-02	3.07E-02	268.85	0	
Ethylbenzene	100-41-4	NA	NA		15,664.1	3	6		0	1.57E-02	1.57E-02	137.22	0	
Xylene (total)	1330-20-7	NA	NA		60,467.4	3	6		0	6.05E-02	6.05E-02	529.69	0	
1,2-Dichlorobenzene	95-50-1	NA	NA		267.7	3	6		0	2.68E-04	2.68E-04	2.35	0	
2-Methylphenol	95-48-7	NA	NA		0.538	3	6		0	5.38E-07	5.38E-07	0.0047	0	
4-Methylphenol	106-44-5	NA	NA		2.089	3	6		0	2.09E-06	2.09E-06	0.0183	0	
Naphthalene	91-20-3	NA	NA		8,212.8	3	6		0	8.21E-03	8.21E-03	71.94	0	
2-Methylnaphthalene	91-57-6	NA	NA		225.5	3	6		0	2.25E-04	2.25E-04	1.97	0	
Diethylphthalate	84-66-2	NA	NA		3,829.6	3	6		0	3.83E-03	3.83E-03	33.55	0	
bis(2-Ethylhexyl)phthalate	117-81-7	NA	NA		0.041	3	6		0	4.14E-08	4.14E-08	0.0004	0	

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SECTION F
Air Stripper (Groundwater Treatment) Emissions Estimates

CONTAMINANT		INPUT OR		ENV.	EMISSIONS				% CONTROL	HOURLY EMISSIONS (LBS/HR)		ANNUAL EMISSIONS (LBS/YR)		
NAME	CAS NUMBER	PRODUCTION	UNIT	RATING	ACTUAL	UNIT	DET.	PERMISSIBLE	EFFCNCY	ERP	ACTUAL	ACTUAL	10^x	PERMISSIBLE
Acetone	67-64-1	NA	NA		725.3	3	6		0	7.25E-04	7.25E-04	6.35	0	
Carbon Disulfide	75-15-0	NA	NA		50.0	3	6		0	5.00E-05	5.00E-05	0.44	0	
1,1-Dichloroethane	75-34-3	NA	NA		75.0	3	6		0	7.50E-05	7.50E-05	0.66	0	
1,2-Dichloroethene (total)	540-59-0	NA	NA		831.6	3	6		0	8.32E-04	8.32E-04	7.28	0	
Chloroform	67-66-3	NA	NA		573.2	3	6		0	5.73E-04	5.73E-04	5.02	0	
1,2-Dichloroethane	107-06-2	NA	NA		100.0	3	6		0	1.00E-04	1.00E-04	0.88	0	
2-Butanone	78-93-3	NA	NA		400.2	3	6		0	4.00E-04	4.00E-04	3.51	0	
1,2-Dichloropropane	78-87-5	NA	NA		237.6	3	6		0	2.38E-04	2.38E-04	2.08	0	
Trichloroethene	79-01-6	NA	NA		1,980.9	3	6		0	1.98E-03	1.98E-03	17.35	0	
Toluene	108-88-3	NA	NA		1,665.3	3	6		0	1.67E-03	1.67E-03	14.59	0	
Ethylbenzene	100-41-4	NA	NA		881.6	3	6		0	8.82E-04	8.82E-04	7.72	0	
Xylene (total)	1330-20-7	NA	NA		4,174.8	3	6		0	4.17E-03	4.17E-03	36.57	0	
1,2-Dichlorobenzene	95-50-1	NA	NA		50.0	3	6		0	5.00E-05	5.00E-05	0.44	0	
2-Methylphenol	95-48-7	NA	NA		75.0	3	6		0	7.50E-05	7.50E-05	0.66	0	
4-Methylphenol	106-44-5	NA	NA		1,709.1	3	6		0	1.71E-03	1.71E-03	14.97	0	
Naphthalene	91-20-3	NA	NA		2,522.8	3	6		0	2.52E-03	2.52E-03	22.10	0	
2-Methylnaphthalene	91-57-6	NA	NA		1,409.0	3	6		0	1.41E-03	1.41E-03	12.34	0	
Diethylphthalate	84-66-2	NA	NA		125.1	3	6		0	1.25E-04	1.25E-04	1.10	0	
bis(2-Ethylhexyl)phthalate	117-81-7	NA	NA		50.0	3	6		0	5.00E-05	5.00E-05	0.44	0	

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SECTION F
Combined Soil Vapor Extraction & Air Stripper Emissions Estimates

CONTAMINANT		INPUT OR		ENV.	EMISSIONS				% CONTROL	HOURLY EMISSIONS (LBS/HR)		ANNUAL EMISSIONS (LBS/YR)		
NAME	CAS NUMBER	PRODUCTION	UNIT	RATING	ACTUAL	UNIT	DET.	PERMISSIBLE	EFFCNCY	ERP	ACTUAL	ACTUAL	10^x	PERMISSIBLE
Acetone	67-64-1	NA	NA		0.78	2	6		0	7.75E-04	7.75E-04	6.79	0	
Carbon Disulfide	75-15-0	NA	NA		2.37	2	6		0	2.37E-03	2.37E-03	20.75	0	
1,1-Dichloroethane	75-34-3	NA	NA		1.22	2	6		0	1.22E-03	1.22E-03	10.70	0	
1,2-Dichloroethene (total)	540-59-0	NA	NA		74.02	2	6		0	7.40E-02	7.40E-02	648.42	0	
Chloroform	67-66-3	NA	NA		5.93	2	6		0	5.93E-03	5.93E-03	51.98	0	
1,2-Dichloroethane	107-06-2	NA	NA		0.43	2	6		0	4.31E-04	4.31E-04	3.78	0	
2-Butanone	78-93-3	NA	NA		0.45	2	6		0	4.48E-04	4.48E-04	3.93	0	
1,2-Dichloropropane	78-87-5	NA	NA		1.75	2	6		0	1.75E-03	1.75E-03	15.29	0	
Trichloroethene	79-01-6	NA	NA		51.71	2	6		0	5.17E-02	5.17E-02	453.00	0	
Toluene	108-88-3	NA	NA		32.36	2	6		0	3.24E-02	3.24E-02	283.44	0	
Ethylbenzene	100-41-4	NA	NA		16.55	2	6		0	1.65E-02	1.65E-02	144.94	0	
Xylene (total)	1330-20-7	NA	NA		64.64	2	6		0	6.46E-02	6.46E-02	566.27	0	
1,2-Dichlorobenzene	95-50-1	NA	NA		0.32	2	6		0	3.18E-04	3.18E-04	2.78	0	
2-Methylphenol	95-48-7	NA	NA		0.08	2	6		0	7.56E-05	7.56E-05	0.66	0	
4-Methylphenol	106-44-5	NA	NA		1.71	2	6		0	1.71E-03	1.71E-03	14.99	0	
Naphthalene	91-20-3	NA	NA		10.74	2	6		0	1.07E-02	1.07E-02	94.04	0	
2-Methylnaphthalene	91-57-6	NA	NA		1.63	2	6		0	1.63E-03	1.63E-03	14.32	0	
Diethylphthalate	84-66-2	NA	NA		3.95	2	6		0	3.95E-03	3.95E-03	34.64	0	
bis(2-Ethylhexyl)phthalate	117-81-7	NA	NA		0.05	2	6		0	5.01E-05	5.01E-05	0.44	0	

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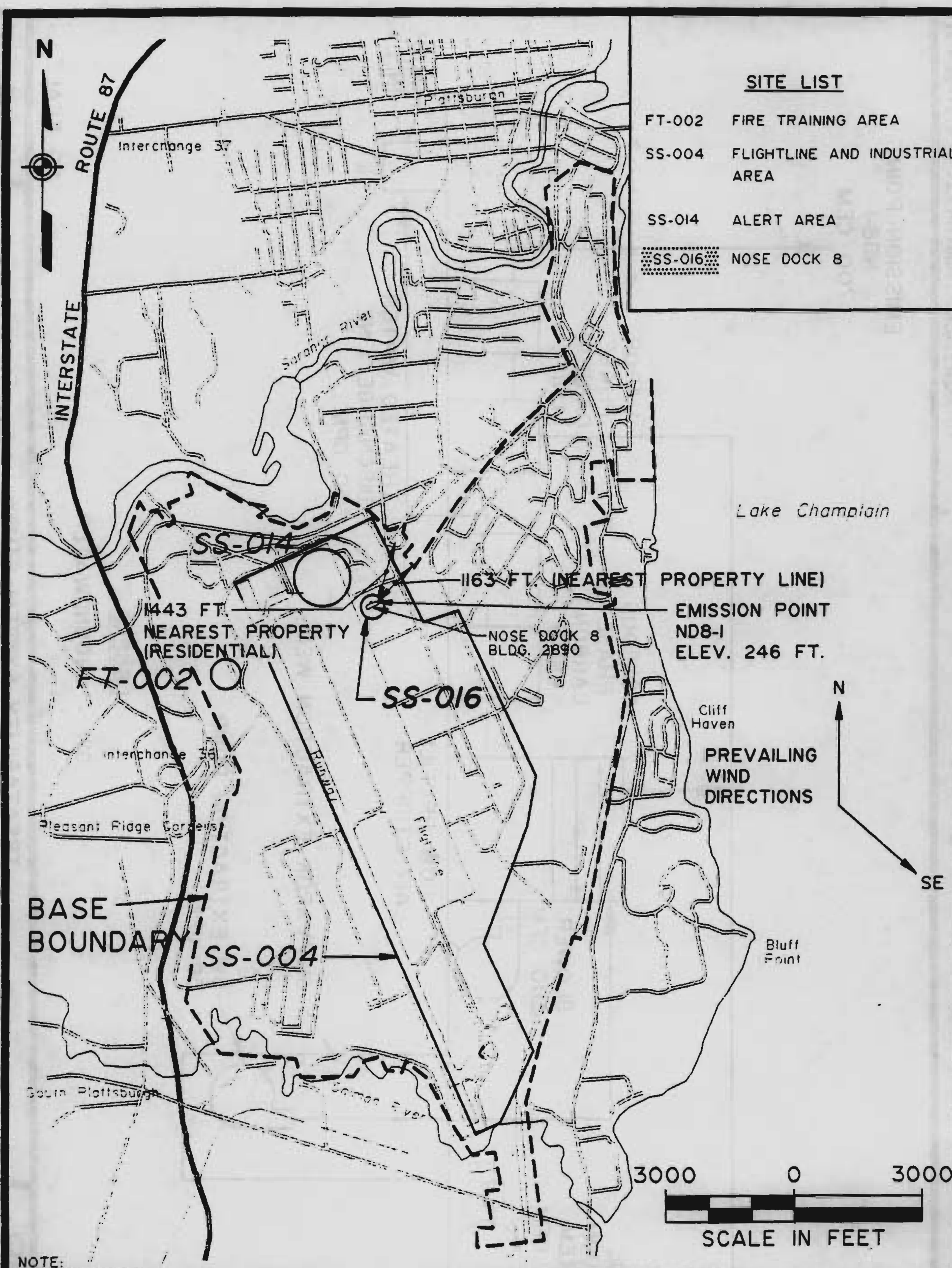
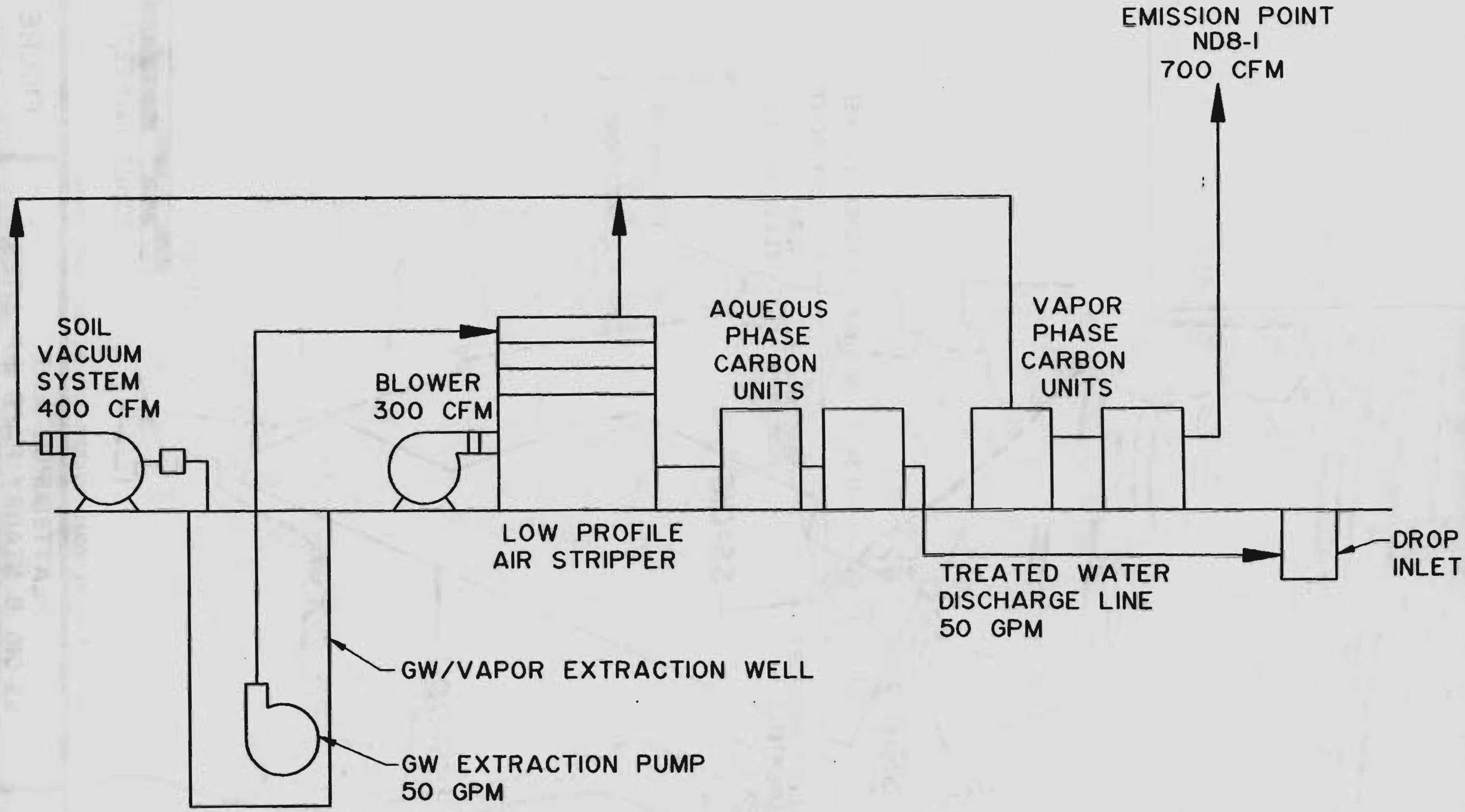


NOTE:
ORIGINALLY PRESENTED AS FIGURE 1-3 OF REMEDIAL INVESTIGATION REPORT (URS, 1994a)

URS CONSULTANTS, INC.	PLATTSBURGH A.F.B. SS-016 & NEARBY PAFB IRP SITES	FIGURE 1

AC-7567



LEGEND

GW - GROUNDWATER

NO SCALE

URS CONSULTANTS, INC.

TREATABILITY SYSTEM STUDY
SCHEMATIC

FIGURE 2

APPENDIX B-3
EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

August 21, 1996

Michael D. Zagata

Post-it® Fax Note 7671	Date 8/28/96 # of pages ▶ 3
To Chuck Dusel/Craig	From Brady Baker
Co./Dept. URS Pawlowski	Co. AFBCA
Phone # 716-856-5636	Phone # 518-563-2871
Fax # 2545	Fax # 3025

Mr. Michael Sorel, P.E.
AFBCA/DAE
426 U.S. Oval Suite 2210
Plattsburgh Air Force Base, NY 12903

Dear Mr. Sorel:

Re: Draft Work Plan Treatability Study at SS-016
Plattsburgh Air Force Base ID No. 510003

New York State has received and reviewed the draft Work Plan for the treatability study at SS-016. We offer the following comments at this time:

1. We have included a copy of effluent criteria if you opt for a groundwater discharge of the treated water.

2. As I have verbally related to Mr. Baker of your staff, if you opt for a surface water discharge of the treated water you need to contact our Region 5 office and request that a modification of your existing SPDES permit be processed.

3. We have reviewed your proposed air discharge and find it acceptable without the need for a vapor phase carbon filter.

Once you have decided on how you expect to discharge the treated water please let us know.

If you have any questions, please feel free to contact me at (518) 457-3976.

Sincerely,

James B. Lister

James B. Lister, P.E.
Bureau of Eastern Remedial Action
Division of Environmental Remediation

Enclosure

cc: R. Morse, USEPA-Region II

RECEIVED
URS CONSULTANTS
AUG 28 1996
JOB # 0535201.23(C-1)

CD

Rec'd 26 Aug

BEC

91-20-2a (1/89) DHWR Site No.: 5 - 10 - 003

Plattsburgh Air Force Base Nose Dock 8

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS EQUIVALENT TO A SPDES PERMIT

During the period beginning September 1, 1996

and lasting until September 1, 2001

the discharges from the treatment facility to groundwater shall be limited and monitored by the operator as specified below:

PARAMETERS	Limitations		Units	Minimum Monitoring Requirements	
	Daily Avg	Daily Max		Sample Type	Frequency
OUTFALL 001 - Treated Groundwater Remediation Discharge					
FLOW	Monitor	Monitor	GPD	Meter	Daily
pH (range)	6.0 to 9.0		SU	Weekly	Grab
Acetone	—	50	µg/l	Quarterly	Grab
2-Butanone	—	50	µg/l	Quarterly	Grab
Chloroform	—	7.0	µg/l	Monthly[1]	Grab
1,2-Dichlorobenzene	—	4.7	µg/l	Quarterly	Grab
1,1-Dichloroethane	—	5.0	µg/l	Quarterly	Grab
1,2-Dichloroethane	—	5.0	µg/l	Quarterly	Grab
cis 1,2-Dichloroethylene	—	5.0	µg/l	Quarterly	Grab
trans 1,2-Dichloroethylene	—	5.0	µg/l	Quarterly	Grab
1,2-Dichloropropane	—	5.0	µg/l	Quarterly	Grab
Ethylbenzene	—	5.0	µg/l	Monthly[1]	Grab
2-Methylphenol	—	10	µg/l	Quarterly	Grab
4-Methylphenol	—	10	µg/l	Monthly[1]	Grab
Napthalene	—	10	µg/l	Monthly[1]	Grab
Toluene	—	5.0	µg/l	Monthly[1]	Grab
Trichloroethylene	—	10	µg/l	Monthly[1]	Grab
1,2 Xylene	—	5.0	µg/l	Monthly[1]	Grab
Sum of 1,3 and 1,4-Xylenes	—	10	µg/l	Monthly[1]	Grab

Footnotes:

(1) The minimum measurement frequency for all the parameters (except flow) shall be monthly following a period of 24 consecutive weekly sampling events showing no exceedances of the stated discharge limitations.

91-20-2a (1/89) DHWR Site No.: 5 - 10 - 003

Plattsburgh Air Force Base Nose Dock 8

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS EQUIVALENT TO A SPDES PERMIT

During the period beginning September 1, 1996

and lasting until September 1, 2001

Special Conditions:

(A) Discharge is not authorized until such time as an engineering submission showing the method of treatment is approved by the Department. The discharge rate may not exceed the effective treatment system capacity. All monitoring data, engineering submissions and modification requests must be submitted to the following NYSDEC Division of Environmental Remediation contact person: Marsden Chen.

(B) Both concentration (mg/l or µg/l) and mass loadings (lbs/day) must be reported to the Department for all parameters except FLOW and pH.

(C) Only site generated wastewater is authorized for treatment and discharge.

(D) Authorization to discharge is valid only for the period noted above but may be renewed if appropriate. A request for renewal must be received 6 months prior to the expiration date to allow for a review of monitoring data and reassessment of monitoring requirements.

(E) Samples and measurements, to comply with the monitoring requirements specified above, shall be taken from treatment system effluent prior to discharge to groundwater.

(F) Discharge may not occur unless the ground is capable of accepting the treated effluent, i.e. the effluent may not be ponded on top of saturated or frozen ground. Also, a minimum separation distance of 100 feet must be maintained between the discharge location and any surface waters (including wetlands).

APPENDIX C
PERFORMANCE SPECIFICATION

PERFORMANCE SPECIFICATION
NOSE DOCK 8 (SS-016)
TREATABILITY STUDY SYSTEM

PART I - GENERAL

1.1 SCOPE

The Subcontractor shall provide a treatability study system to evaluate groundwater remediation at the Nose Dock 8 (SS-016) site located at the Plattsburgh Air Force Base, Plattsburgh, NY. The project includes installation of a groundwater/soil vapor extraction well, groundwater pump, air stripper, aqueous phase carbon adsorption units, vacuum system and infiltration galleries. A schematic of the treatability study system is shown in Sketch No. 1. The scope of services for the project shall include, but not be limited to:

A. All labor, materials, and services associated with fabrication, construction, installation and start-up of the treatability study system.

B. Rectification of construction and operating problems that prevent the system from functioning properly.

1.2 CONSTRUCTION DOCUMENTS

A. This specification for the treatability study system is to establish performance and quality requirements.

B. Work described or shown herein is not intended to be a complete representation of actual finished work. The work shall include all equipment and materials required for a complete and operating system, although some items are not specified or shown. Any work that is necessary or required to make the installation satisfactory and operable for its intended purpose, even though not specifically included, shall be performed as incidental work as if it were described.

1.3 SYSTEM PERFORMANCE

All equipment furnished and work performed shall be guaranteed against defects in materials and/or workmanship for a period of one (1) year from the completion of system start-up. Any failure of equipment or work due to defects in materials or workmanship shall be corrected by the Subcontractor.

1.4 HEALTH AND SAFETY

Subcontractor shall follow and implement the health and safety program in accordance with the URS Health and Safety Plan. Health and safety required for the work described herein shall be the responsibility of the Subcontractor.

PART 2 - PRODUCTS

2.1 GROUNDWATER/SOIL VAPOR EXTRACTION WELL

A. Furnish and install one (1) 8-inch diameter PVC groundwater/soil vapor extraction well as shown on Sketch No. 2.

B. Furnish and install three (3) 4-inch diameter PVC air pressure monitoring wells complete with pressure gauges. Material for the well riser pipe, screen, sand pack, and length of well shall be the same as shown in Sketch No. 2.

C. All PVC pipe shall comply with AWWA C-900.

D. The wells shall be installed at a location directed by the Engineer.

E. The Subcontractor shall record and document well construction and development, and submit records and documentation to the Engineer.

2.2 GROUNDWATER EXTRACTION PUMP

A. Furnish and install one (1) submersible pump as manufactured by Grundfos or approved equal.

B. Pump shall be sized to pump groundwater at a rate of 50 gpm at a total dynamic head equal to or greater than the static discharge head plus head losses in system piping connecting the pump to the air stripper.

C. Minimum efficiency at the design operating parameters shall be 55%.

2.3 AIR STRIPPER

A. Furnish and install one (1) air stripper - Model 2341-P as manufactured by North East

Environmental Products or approved equal. The air stripper shall be of the low profile, shallow tray type.

B. Air stripper sump tank, cover, and trays shall be polyethylene. Basic system components shall include a TEFC blower, blower inlet screen, and damper, a stainless-steel demister, a water inlet spray nozzle, a water level sight tube, and Schedule 80 PVC internal piping.

C. Additional features shall include:

1. Steel frame for skid mounting
2. Standard NEMA 3 R system control panel
3. High water level alarm switch(s)
4. TEFC discharge pump
5. Discharge pump level switch(s)
6. Influent and effluent sample ports

2.4 AQUEOUS PHASE CARBON UNITS

A. Furnish and install two (2) 1,800-lb. aqueous phase carbon units.

B. The aqueous phase carbon unit shall be installed with an initial charge of 1,800 lbs. of carbon.

2.5 INFILTRATION GALLERIES

A. Furnish and install three(3) infiltration galleries as shown in Sketch No. 3.

B. Each gallery shall have dimensions as follows:

1. Footprint - 35 by 35 feet
2. Depth - 7 feet

C. Excavations will be backfilled with 4.5 feet of No. 1 gravel and 2.5 feet of native soil excavated for each gallery. In addition, approximately 2 feet of native soil will be placed over the gallery above grade.

D. Water shall be introduced into each gallery by three 6-inch diameter perforated pipes running the entire length of the excavation. Pipes shall be placed below frost depth.

E. Furnish and install a layer of geotextile or liner material between the gravel and the native soil cover. Apparent opening size for geotextile shall be equivalent to US #100 sieve.

2.6 DISCHARGE LINES

A. Furnish and install PVC discharge lines to connect treatment system to infiltration galleries.

B. Pipe shall be 1.5-inch diameter Schedule 80 PVC.

C. Pipe shall be installed at a depth of approximately 5 feet below grade.

D. Area where trenching work has been performed shall be restored to condition existing prior to work.

2.7 VACUUM SYSTEM

A. Furnish and install one (1) vacuum system which includes the following: a blower, an air moisture separator, equipment for system air flow control, air flow monitoring, air pressure monitoring, and automatic timer cycling. System shall be capable of pumping water to water treatment system. Instrumentation shall be wired to the Programmable Logic Controller (PLC) as required to permit monitoring described in 2.9B.

B. Blower shall be sized to deliver a minimum 400 cfm at 0 inches H_2O vacuum and 150 cfm at 84 inches H_2O vacuum.

C. System shall be sized adequately to account for system pressure loss through piping.

2.8 CHLORINATION SYSTEM

A. Furnish and install a hypochlorite feed system including pump, static mixer, instrumentation, piping and all other required ancillary equipment to remove iron and prevent biofouling in the carbon adsorption units and infiltration gallery.

2.9 PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. Furnish and install one (1) PLC as manufactured by Allen Bradley or approved equal.

B. The PLC shall be capable of monitoring system operational parameters including air flow rate and air pressure from the vacuum system, treated water effluent flow rate, differential pressure across the aqueous phase carbon units, and water level in the groundwater/soil vacuum extraction well.

C. The PLC shall be capable of monitoring a minimum of three additional operational parameters.

D. The PLC shall be capable of remote interface via modem with a remote IBM or IBM compatible computer.

2.10 TRANSFER HOSE

Furnish and install a Flexwing petroleum hose as manufactured by Goodyear, or approved equal, for transfer of fluids between components of the treatability study system.

2.11 INSTRUMENTATION

A. Furnish and install the following:

1. One (1) treated water effluent flow meter.

2. One (1) differential pressure transmitter to monitor pressure drop across the aqueous phase carbon unit.

3. Pressure gauges as required. Pressure gauges shall be placed at all pumps and blowers.

4. One (1) level (pressure) transmitter to monitor water level in the groundwater/soil vacuum extraction well.

B. Instrumentation shall be wired to the PLC as required to permit monitoring described in 2.9B.

2.12 UTILITIES

A. General:

Subcontractor shall be responsible for utility clearances for all work.

B. Electrical Service:

1. The Subcontractor shall be responsible for installing all electric service for the treatability study system.

2. It shall be the responsibility of the Subcontractor to coordinate electric service installation.

3. The Subcontractor shall be responsible for furnishing and installing all conduit and wiring for power, control, and instrumentation required for a fully-operable system.

4. The Subcontractor shall be responsible for determining power requirements, and shall include 50% spare capacity.

5. All materials and work shall comply with the National Electric Code, National Electric Safety Code, OSHA, and all other applicable federal, state, and local codes.

B. Heating:

The Subcontractor shall be responsible for furnishing and installing unit heaters or other approved heating devices as required to keep system components from freezing.

C. Telephone Service:

1. The Subcontractor shall provide telephone service for remote monitoring of the treatability study system.

2. The Subcontractor is responsible for coordinating telephone service installation.

2.13 SAMPLE PORTS

The Subcontractor shall furnish and install sampling ports before and after all treatment units. Sample ports shall be easily and safely accessible.

PART 3 - EXECUTION

A. Installation:

Installation of the treatability study system shall be in accordance with manufacturer's instructions and recommendations.

B. Testing:

1. Operating tests shall be carried out during start-up to assure that the system operates properly.

2. All equipment shall be tested to demonstrate that it provides the required function.

3. The system shall be tested for leaks. Any deficiencies revealed by testing shall be corrected.

C. Process Development:

The Subcontractor shall be responsible for system modifications needed during start-up to achieve the required removal standards set forth in Table 1.

TABLE 1
NOSE DOCK 8 (SS-016) - TREATABILITY STUDY WORK PLAN
GROUNDWATER TREATMENT SUMMARY

CHEMICAL	ESTIMATED INFLUENT CONCENTRATION (µg/L)	DISCHARGE LIMITATION (µg/L)	PERCENT REMOVAL REQUIRED
Acetone	20.9	50.0	0
Carbon Disulfide	0.3	NS	NC
1,1-Dichloroethane	0.4	5.0	0
1,2-Dichloroethene (total)	5.5	5.0 *	10
Chloroform	4.2	7.0	0
1,2-Dichloroethane	0.6	5.0	0
2-Butanone	2.4	50.0	0
1,2-Dichloropropane	1.5	5.0	0
Trichloroethylene	21.6	10.0	54
Toluene	12.6	5.0	60
Ethylbenzene	5.5	5.0	9
1,2 Xylene	ND	5.0	NC
Xylene (sum of 1,3 and 1,4)	36.2	10.0	72
1,2-Dichlorobenzene	0.3	4.7	0
2-Methylphenol	0.5	10.0	0
4-Methylphenol	16.5	10.0	39
Naphthalene	24.6	10.0	59
2-Methylnaphthalene	10.1	NS	0
Diethylphthalate	0.8	NS	NC
bis(2-Ethylhexyl)phthalate	0.3	NS	NC

NC - Value not calculated. Insufficient data.
ND - Concentration not determined. No data available.
NS - Water quality criteria has not been established by NYSDEC for this chemical.
* - Discharge limitations are 5.0 µg/L for cis and 5.0 µg/L for trans 1,2-Dichloroethene

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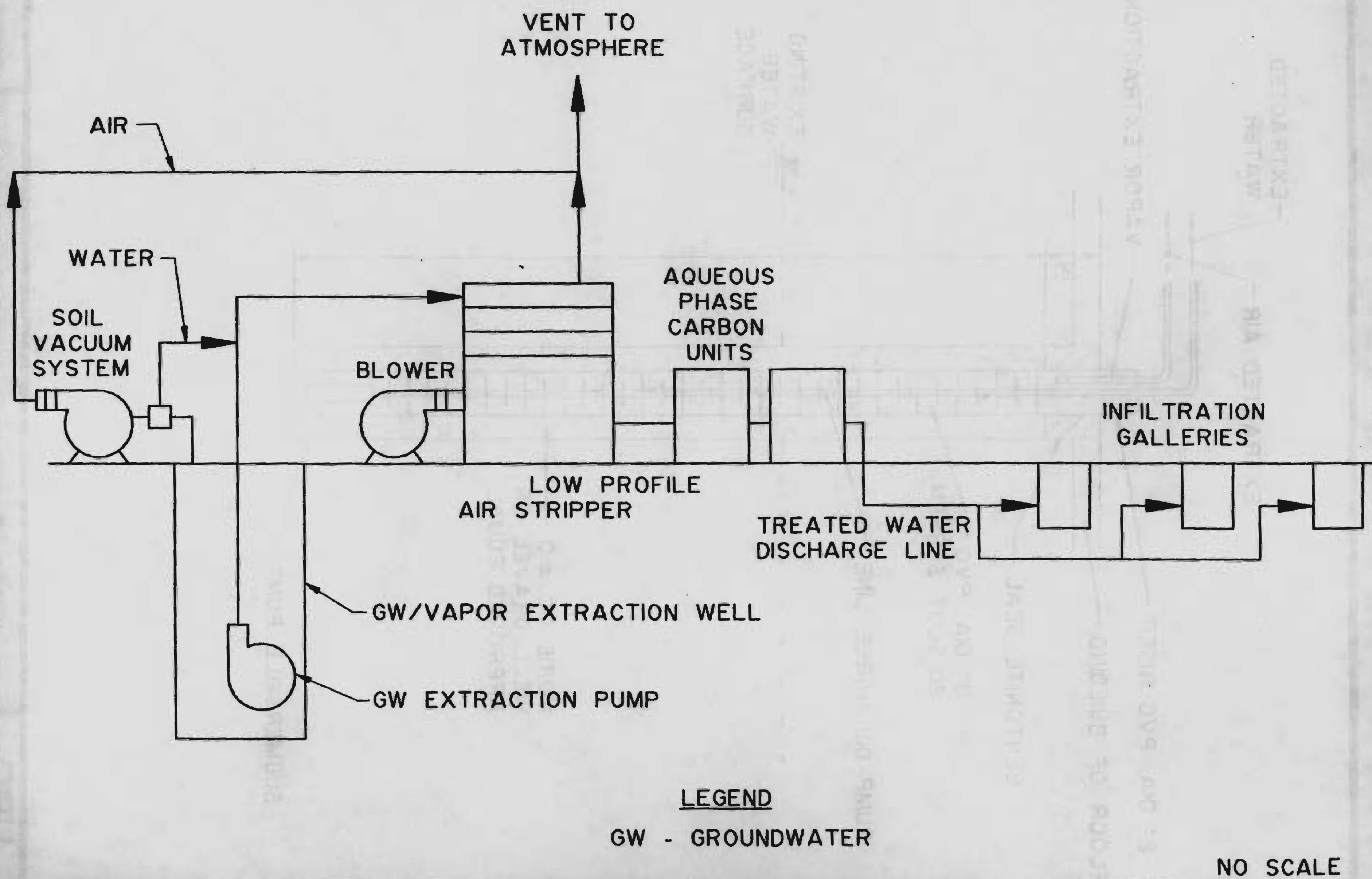
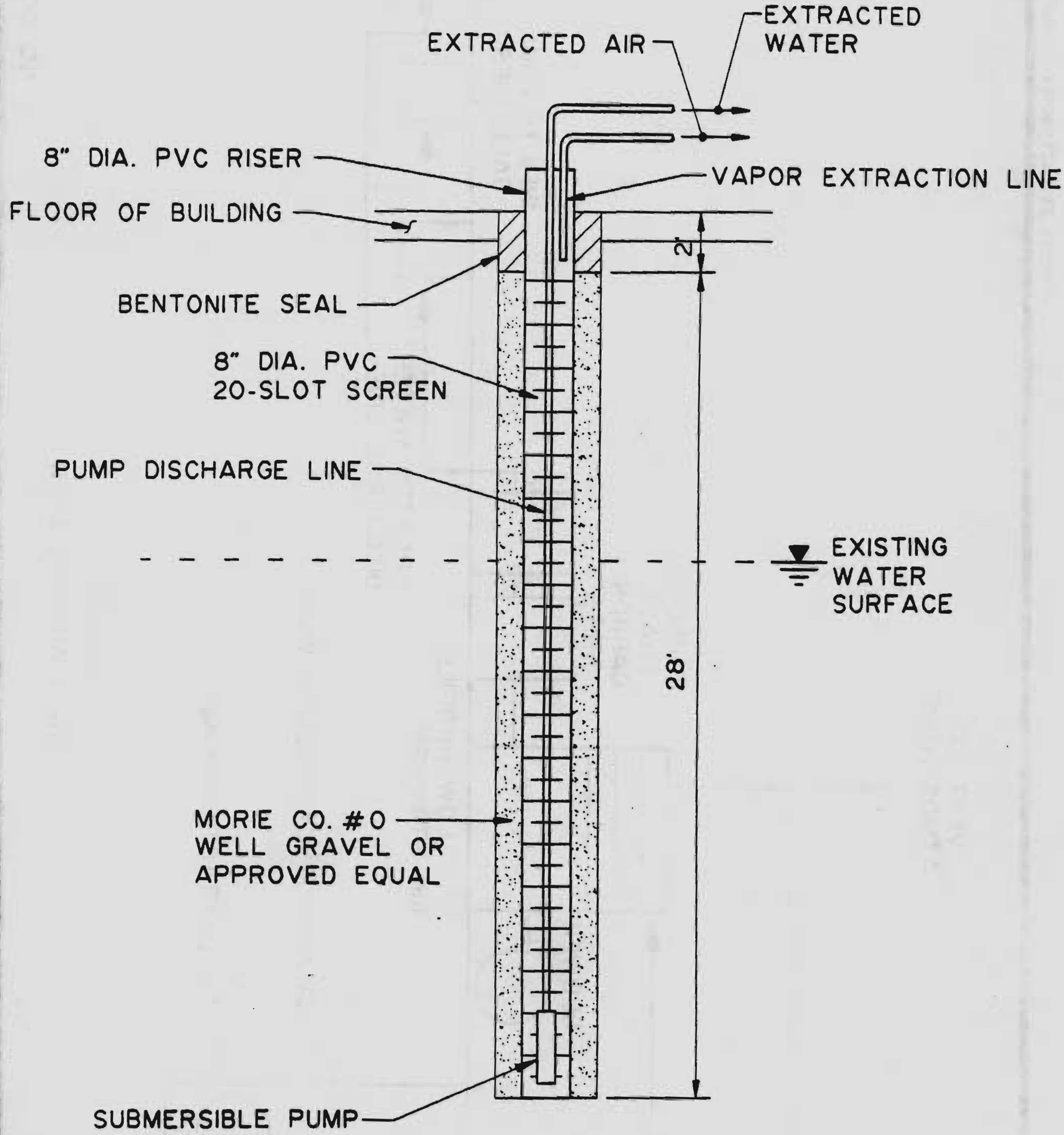


URS CONSULTANTS, INC.

TREATABILITY SYSTEM STUDY
SCHEMATIC

SKETCH 1



URS CONSULTANTS, INC.

GROUNDWATER/VAPOR EXTRACTION WELL

SKETCH 2

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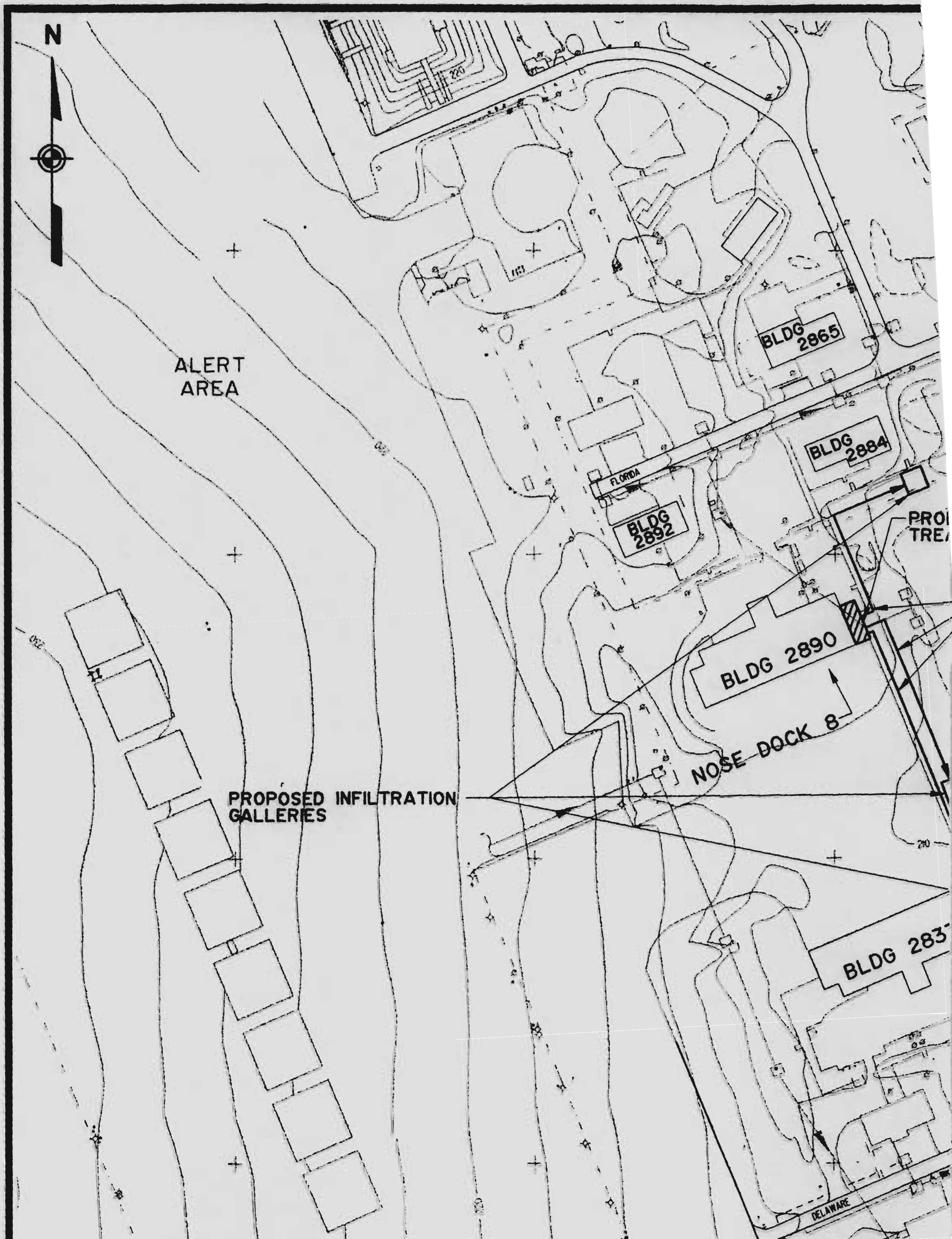

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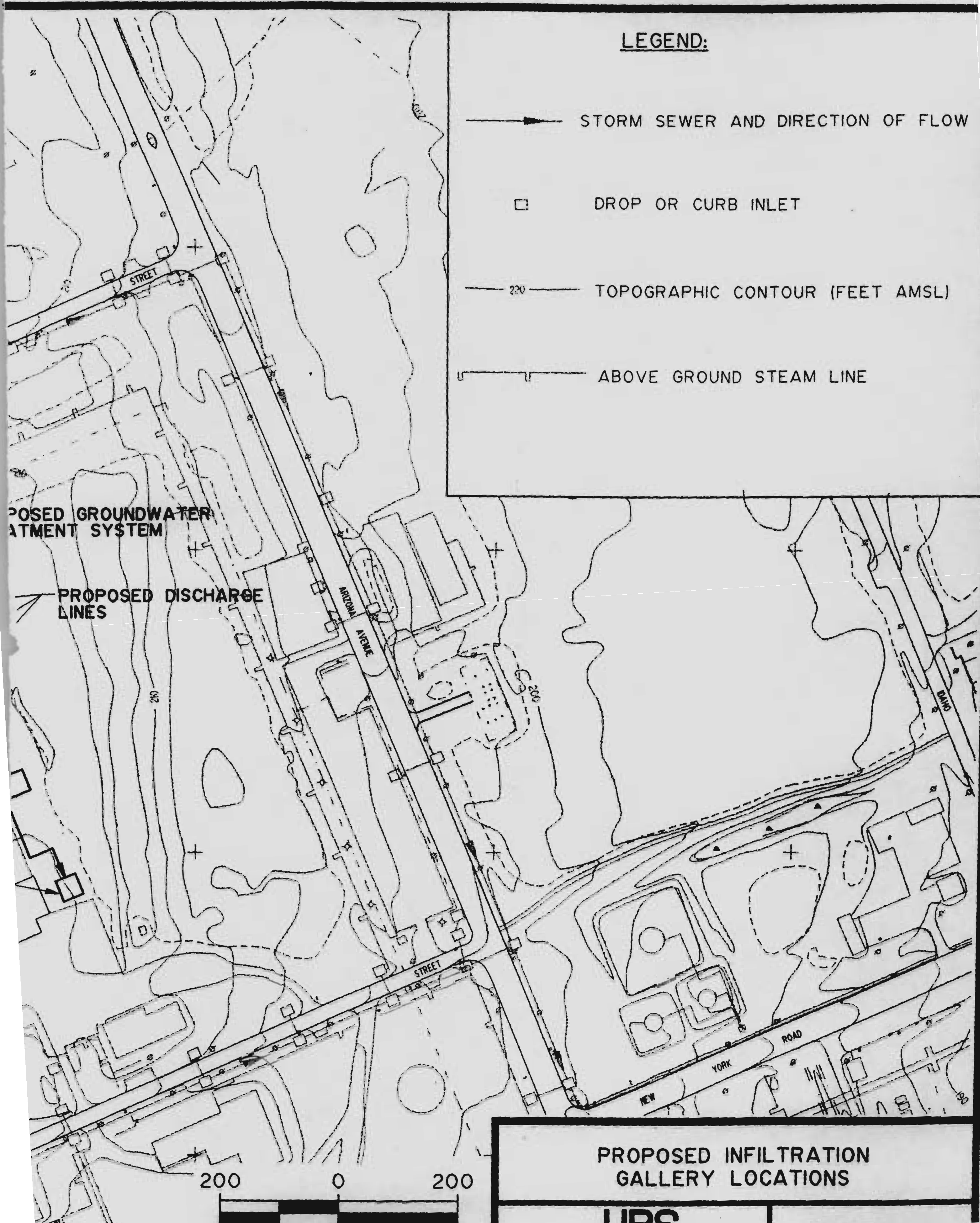
LEGEND:
STORM SEWER AND DIRECTION OF FLOW
DROP OR CURB INLET
220 TOPOGRAPHIC CONTOUR (FEET AMSL)
ABOVE GROUND STEAM LINE
POSED GROUNDWATER
ATMENT SYSTEM
PROPOSED DISCHARGE
LINES
STREET
ARIZONA AVENUE
STREET
NEW YORK ROAD
IDAHO
200
200
0
200
PROPOSED INFILTRATION
GALLERY LOCATIONS