003B

Design Analysis Report

for

Air Sparging/Soil Vapor Extraction System at Site 1 - Former Drum Marshalling Area

Naval Weapons Industrial Reserve Plant

Bethpage, New York

DEPARTMENT OF THE NAVY
UNITED STATES OF AMERICA

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0213

September 1997

C F BRAUN ENGINEERING CORPORATION

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C-49-09-7-148

September 19, 1997

Project Number 5253

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Reference:	Clean Contract No. N62472-90-D-1298, Contract Task Order Number 0213
Subject:	Final Design Analysis Report NWIRP Bethpage, New York

Dear Mr. Lehman:

Please find enclosed five copies of the subject report for your use. This report incorporates comments to us dated 09/10/97, (comment-response letter attached). As requested, one copy of the report (minus Appendix D -Cost Estimates) has been forwarded to Foster Wheeler.

If you have any questions or require additional information, please call me at (412) 921-8375.

Sincerely

David D Brayack

David D. Brayack, P.E.
Project Manager

/DDB

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DESIGN ANALYSIS REPORT
FOR
AIR SPARGING/SOIL VAPOR EXTRACTION SYSTEM
AT SITE 1 - FORMER DRUM MARSHALLING AREA

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Northern Division
Environmental Branch Code 18
Naval Facilities Engineering Command
10 Industrial Highway, Mall Stop #82
Lester, Pennsylvania 19113-2090

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CONTRACT NUMBER N62472-90-D-1298
CONTRACT TASK ORDER 0213

SEPTEMBER 1997

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1.0 INTRODUCTION

1.1 AUTHORIZATION

The Northern Division of the Naval Facilities Engineering Command has issued Contract Task Order (CTO) 0213 to CF Braun Engineering Corporation (CF Braun) under a master agreement with Brown & Root Environmental under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62472-90-D-1298. As part of CTO 213, CF Braun collected and tested soil samples to better define the extent of volatile organic compound (VOC) contamination, installed and operated a Pilot Scale Air Sparging/Soil Vapor Extraction System (AS/SVE) from March 1997 to July 1997, and is preparing this Design Analysis Report for implementation of a full scale AS/SVE system. This work is part of the Remedial Design, Phase II, for Site 1 - Former Drum Marshalling Area at the Naval Weapons Industrial Reserve Plant (NWIRP) located in Bethpage, New York.

1.2 PURPOSE OF REPORT

This report and drawings represent the Remedial Action Contract (RAC) design package, which will be used by the RAC contractor as a basis for designing, installing, and operating an AS/SVE System at the NWIRP Bethpage - Site 1. Cleanup of the soils and shallow underlying groundwater at that site is identified in the Record of Decision (ROD) dated May 1995. Specific remedial objectives and cleanup goals are provided in Section 1.3.

1.3 REMEDIAL OBJECTIVES AND CLEANUP GOALS

The remedial activities under the Navy's Installation Restoration Program at the NWIRP Bethpage have been divided into four general units, as follows.

- PCB- and metal-contaminated soils at Sites 1 and 2.
- Low-level VOC-, PCB-, and metal-contaminated soils at Sites 1, 2, and 3.
- Area-wide VOC-contaminated groundwater.
- VOC-contaminated soils and associated shallow groundwater at Site 1.

PCB-contaminated soils at Site 2 were remediated in 1995 via excavation and offsite disposal. PCB- and metal-contaminated soils and cesspool sludge at Site 1 will be remediated following the cleanup of VOC-contaminated soils at that site. The residual low-level contaminated soils at Sites 1, 2, and 3 will be addressed as required in the future based on land use.

Contaminated groundwater is being addressed under a regional groundwater feasibility study (RGFS), in cooperation with Northrop Grumman and Occidental. In addition, Northrop Grumman has installed a groundwater containment system at their southern border. The Northrop Grumman system is designed to capture contaminated groundwater migrating from both the NWIRP Bethpage and Northrop Grumman facilities.

This AS/SVE design specifically addresses the VOC-contaminated soils and associated shallow groundwater contamination at Site 1. The relevant remedial objective from the ROD for the remediation of the soils and shallow contaminated groundwater (10 to 20 feet) at Site 1 is as follows.

- Prevent leaching of contaminants in soils which would result in groundwater contamination in excess of groundwater remediation goals.

The Preliminary Remediation Goals (PRGs) for VOCs in soil to protect groundwater are as follows.

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Chemical of Concern	PRG (mg/kg)[1]
Trichloroethene	0.010 - 0.030
Tetrachloroethene	0.027 - 0.081
1,1,1-Trichloroethane	0.010 - 0.030

1. The ROD specifies a modified action level of three times the PRGs to be used to identify the areal extent of contamination. Therefore, the initial target for soil cleanup should be the low concentration within the range of PRGs. However, in the event that this concentration cannot be achieved within a reasonable time frame, then the high concentration within the range can be used.

1.4 BACKGROUND INFORMATION

Site 1 - Former Drum Marshalling Area occupies an area of approximately 4 acres, (See Drawing No. 1). It is surrounded on three sides by a fence and on the fourth side by Plant No. 3. The site is relatively flat, with the eastern portion covered with bare sandy soils, gravel, grass, and a concrete pad. The western portion of the site is predominantly covered with concrete. A vegetated wind row (pine) and fence are present along the eastern edge of the site to reduce community visibility.

The original basis for the environmental work conducted by the Navy at Site 1 resulted from public water supply wells being impacted by VOC contamination. In response to this impact, a regional groundwater quality study was conducted in the 1980s. The results of this study indicated that the Navy's Site 1 is one of several potential sources of a relatively large groundwater VOC plume originating near this area (and others) and extending for several thousand feet to the south (hydraulic downgradient direction).

Several sequential soil and groundwater investigations have been conducted to date, including a Remedial Investigation, pre-design testing investigation, and the AS/SVE pilot study.

The Navy conducted a Remedial Investigation in the early 1990s to investigate potential sources of the VOC contamination, (Halliburton NUS, May 1992 and Halliburton NUS July, 1993). Based on the results of this investigation, the source of the groundwater contamination at Site 1 was determined to originate near the former drum marshalling pads and in particular the northern pad. All shallow groundwater samples collected south of this pad (hydraulically downgradient), as well as a few shallow groundwater samples collected north of the pad, exhibited VOC contamination. However, this area of groundwater contamination also coincides with the location of cesspools at the site. These cesspools could also be a source of the VOC contamination.

Soil testing during the Remedial Investigation determined that Site 1 soils contained VOC, PCB, and arsenic contamination. Subsequent soil testing at the site confirmed the presence of PCB and VOC contamination; however, the arsenic contamination could not be confirmed. In addition, testing of the cesspool contents revealed even higher concentrations of VOCs and

PCBs than those found in the surrounding soils, and revealed the presence of cadmium contamination. Baseline soil and groundwater testing for the AS/SVE pilot study was conducted in March/April 1997. These tests confirmed the presence of VOC-contaminated soils and groundwater in this area.

A summary of available analytical data is presented in Table 1-1. The areal extent of known VOC contamination in soils and groundwater, and PCB contamination in soils is presented on Drawing No. 1. Please note that there are several areas within Site 1 where the exact extent of VOC contamination in soils and cesspool contents is uncertain. However, all of these areas overlay the location of contaminated groundwater. As a result, by addressing the area of groundwater contamination (through air sparging and associated soil vapor extraction), potential unidentified soil contamination in these areas will also be addressed.

A pilot-study air sparge/soil vapor extraction system was operated from April 1997 to July 1997. The preliminary results of this pilot study, and in particular, physical operating parameters, (e.g. radius of influence) were presented in an Interim Results Letter in July 1997. Complete documentation of the pilot study will be presented in a forthcoming report (November 1997).

The conclusions of the AS/SVE pilot study were as follows.

1. Stratification testing results indicate that dense vapor-phase VOCs do not preferentially accumulate near the bottom of an extraction well.

2. Testing of the soil vapor extraction radius of influence showed that the site soils are highly permeable, with extraction rates of 80 cubic feet per minute (cfm) per well achievable. Measured radii of influences ranged from 50 feet at 5 cfm to approximately 100 feet at 80 cfm. A reasonable correlation was developed between flow rate and radius of influence.

TABLE 1-1

SUMMARY OF SOIL AND GROUNDWATER DATA
AIR SPARGING/SOIL VAPOR EXTRACTION
SITE 1 - FORMER DRUM MARSHALLING AREA
NWIRP BETHPAGE, NEW YORK

Chemical of Concern	**Maximum Soil Concentration (mg/kg)**	**Soil PRG (mg/kg)**	**Maximum Groundwater Concentration (ug/l)**	**Groundwater PRG^1 (ug/l)**
Trichloroethene	158+^{3}	0.010	1,500^2	5
Tetrachloroethene	660^2	0.021	11,000^2	5
1,1-Dichloroethane	1.4^3	*	880	5
1,2-Dichloroethene	9^3	*	3,600	5
1,1-Dichloroethene	0.016^3	*	250	5
1,1,1-Trichloroethane	13^3	0.010	10,000	5

Note that PCBs, pesticides, semi-volatile organics, and metals were also detected in site soils.

1. Groundwater PRGs have not yet been finalized. Values presented are New York State Drinking Water Standards, and do not account for attenuation to the point of compliance. In addition, Northrop Grumman has installed a groundwater collection system, located approximately 4000 feet hydraulically downgradient, which is designed to intercept this contaminated groundwater.

2. Maximum concentration was detected in March/April or July 1997 sampling.

3. Maximum concentration was detected November 1995 to March 1996 testing by Foster Wheeler. Data includes samples collected from the cesspools. The "+" indicates that sample concentration was derived by multiplying TCLP leachate concentration by 20. Actual concentration is likely to be higher.

* No standard has yet been developed. Based on contaminant properties, a PRG similar to 1,1,1-trichloroethane would be expected.

MCL + ambient standard.

3. Soil vapor extraction at the water table resulted in flow through both the upper and lower unsaturated soil zones. Soil vapor extraction at the middle of the unsaturated zone resulted in flow through the middle of the unsaturated zone, but may have created stagnant flow conditions near the water table.

4. The cesspool structures do not appear to restrict air flow through them.

5. Air injection rates of as high as 60 cfm per well were achieved. However, rates greater than 20 cfm were difficult to consistently achieve and maintain.

6. The air sparging tests were partially successful. An estimated radius of influence of 10 to 40 feet was obtained. Based on the testing data, the radius of influence for air sparging is not a strong function of air flow rate. Chemical results from groundwater testing during the AS/SVE pilot study will be used to refine the radius of influence results.

7. The presence of a clay lens within approximately 5 feet above the water table at one site location requires special consideration for the design of air injection wells. To ensure capture of injected air, soil vapor extraction must be implemented between the clay lens and the point of air injection. Soil boring samples will be required during installation to confirm the location of clay lenses.

8. Based on the testing, soil vapor extraction rates need to be at least 2 to 3 times higher than air injection rates to ensure capture of all injected air.

1.5 REPORT FORMAT

This report is divided into four sections. Section 1.0 is this Introduction. A brief Remedial System Description and individual unit Equipment Design Analysis are provided in Section 2.0. Permitting requirements are presented in Section 3.0. Construction and preliminary operation schedules are provided Section 4.0, along with cost estimates.

2.0 REMEDIAL SYSTEM DESCRIPTION

2.1 SUMMARY

The air sparge/soil vapor extraction (AS/SVE) system will consist of:

- air injection wells;
- soil vapor extraction wells;
- an air injection blower;
- a soil vapor extraction blower;
- primary and secondary moisture separators; and
- offgas treatment.

The two blowers, the secondary moisture separator, and associated controls are existing at the facility, but will need to be relocated. Also, the blower speeds will need to be increased and one of the existing vacuum switches will need to be replaced with a more sensitive switch.

Other secondary features of the system will include: flow measurement ports; flow distribution control valves; pressure/vacuum relief valves; temperature and pressure cutoff switches; soil vapor sample ports; perimeter soil vapor pressure monitoring wells; and groundwater monitoring wells. The components of the system are discussed in Sections 2.2 through 2.5.

The air injection and soil vapor extraction blowers will be housed within the existing Transportation Building at Site 1. The design and cost estimate assumes that Northrop Grumman will remove all equipment from this building prior to use by the Navy. Also, the design assumes that Northrop Grumman, or the Navy under separate action will maintain electrical service to the building for the blowers and building heat and that Northrop Grumman or the Navy will maintain water service to the building. However, because of the potential split of the NWIRP Bethpage from Northrop Grumman operations, an alternative power supply may be required in the future and water service is not a requirement. In addition, a separate phone system will be required in the near future.

All piping will be located above ground to minimize disturbance of PCB-contaminated soils. Also, heat tracing and insulation will not be used on the piping, and therefore, cold weather is expected to prevent operation of the system for approximately 3 months each year.

Run SVE system through winter + shut down sparge

Site 1 is currently located within the fencing surrounding Plant No. 3. In addition, Plant No. 3 fencing forms the eastern and southern boundaries of Site 1. To limit vehicle and personnel access, additional fencing will be needed to the west and north of the Site 1 AS/SVE system. Two vehicle access gates will be required within this new fencing.

2.2 SOIL VAPOR EXTRACTION SYSTEM

Reference: Drawings No. 2 - Equipment and Piping Layout, No. 3 - Process Flow Schematic, and No. 6 - Well Installation Details. Appendix A - Pipe Size Calculations and Appendix B - Blower Information.

Design Basis

The soil vapor extraction system includes approximately 13 soil vapor extraction wells, (EW01 through EW13). The purpose of these extraction wells is to: induce a flow of air through the unsaturated soils and cesspools (vadose zone) and thereby volatilize VOCs; to collect these VOCs; and to collect air from the sparging process (which was injected to volatilize VOCs in the groundwater). The target flow rate for each extraction well is 20 to 30 cubic feet per minute (cfm). During startup and operation, flow to each extraction well will be controlled by a manual valve located at each well head. Flow measurements will be determined via portable velocity meters.

Based on the pilot scale test results, a vapor extraction rate of 30 cfm will result in a radius of influence of approximately 75 feet. To provide a 50% overlap between wells, an extraction well spacing of 100 feet will be used. The soil vapor wells will be connected to a common point through a series of laterals and headers.

The proposed location of soil vapor extraction wells is based on:

- The area of known VOC-contaminated soils, including cesspool contents (see Drawing Nos. 1 and 2), and

- The location of air injection wells to address groundwater contamination.

During the fall and early winter operation (when ambient air temperatures are lower than soil temperatures), condensate is expected to form within the soil vapor extraction system. This moisture will be collected in a new 1000-gallon moisture separator. Based on experience at other sites, approximately 20 to 30 gallons per week of condensate may be collected in this tank.

A second 50-gallon moisture separator is already present at the site (as part of the blower skid mount). This moisture separator has a working liquid capacity of approximately 25 gallons. A high moisture (water) level switch in this tank will shut-down the soil vapor extraction blower.

A single soil vapor extraction blower will be used to pull soil gases from all of the wells. The combined soil vapor extraction rate for the system will be approximately 330 cfm. This blower is existing at the site, and was used during the pilot-scale study. This blower will discharge to a vapor phase carbon unit (see Section 2.4).

330 ÷ 13 = 25 cfm
R = ?

Process Equipment List

Equipment	Quantity	Name/Description
Extraction Wells (EW01 to EW13)	13	Extraction Wells • 2-inch diameter, schedule 40 PVC well casing. • 0.020-inch well screen, 15 feet long extending from 10 feet above the water table to 5 feet below the water table. • Wells can also be used to monitor groundwater.
Extraction Blower (existing)	1	• 7.5 HP, 3-phase, 480 volt motor. • Roots Frame 36 Universal RAI Blower (rotary lobe), maximum vacuum rating of 14 inches Hg. • Control panel (on/off operation) with temperature, vacuum pressure, and high water level (secondary moisture separator) cutoff switches.

Equipment	Quantity	Name/Description
Vacuum Relief Valve (existing)	2	• One adjustable in the field, one preset at factory to protect blower.
Primary Moisture Separator	1	• 1000 gallon, with level indicator, and drain connection. • Operating pressure (4 to 6 inches mercury vacuum).
Secondary Moisture Separator (existing)	1	• 55-gallon, with level switch, and drain connection.
Controls (new and existing)	1	• Existing controls are panel mounted on blower skid. • System to operate with manual restart after automatic shutdown. • New telemetry system is required to alert designated individuals that system is not operating.
Piping	1400 feet	• 4-inch carbon steel on blower discharge. • 2-, 4-, and 6-inch, schedule 40 PVC (elsewhere). • 2- and 4-inch PVC ball valves.

Installation

The soil vapor extraction wells will be installed using 4.25 to 6.25 inch hollow stem augers. Split spoon samples will be collected every five feet from the ground surface to 10 feet above the water table (depth of approximately 45 feet below ground surface (bgs)). These samples will be used to identify the presence of significant clay lenses, which may impact the effectiveness of the soil vapor extraction wells. Based on previous soil testing at the site, clay lenses within the upper 45 feet of the vadose zone soils are not expected to be off significant concern. These samples may also be used to determine the presence of soil contamination (via head space field testing using a PID) and therefore identify potential soil sample locations for chemical testing.

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Continuous split spoon samples will be collected from a depth of 10 feet above the water table (approximately 45 feet bgs), to a depth of 5 feet below the water table. This interval represents the extraction well screen location. The presence of a clay lens from a depth of 5 feet above the water table to 5 feet below the water table is of significant concern because it could inhibit the capture of injected air from nearby air injection wells.

If clay is detected within the screened interval of the soil vapor extraction well, then the screen length or location will be modified according to the following considerations.

- The length of the well screen will be increased to allow vapor extraction from both above and below the clay layer.

- If the well screen above the water table exceeds 20 feet in length, then an additional soil vapor extraction well will be installed. The resulting well cluster at this location would have one well with a screened interval above the clay layer and one well with a screened interval below the clay layer.

- If the clay layer is less than one foot above the water table and extends to an air injection well, then this well may not be usable to capture injected air. Additional contingency plans for clay lenses affecting air injection wells are discussed in Section 2.3 - Air Injection System - Installation.

After augering to depth, extraction well installation consists of the following components (see Drawing No. 6).

- Place well at depth of boring.
- Install a sand pack (#2 silica sand) from bottom of well screen to one foot above top of screen.
- Install a 2-foot thick bentonite seal.
- Complete well with cement/bentonite grout.
- The well is to be developed by pumping/surging to obtain a final water turbidity of less than 50 NTU's.

Three soil vapor extraction wells were installed during the pilot study. One or more of these wells should be used for the full scale SVE system, if they are determined to be located in an acceptable area.

The soil vapor extraction wells should be completed with a Tee and removable cap approximately 6 inches above ground surface to allow access into the well for potential cleaning, water level measurements, and groundwater sampling. Each well should also have a sample port to allow collection of soil gas samples, and for measurement of gas velocity and pressure. This port should be located 2 feet away from valves and fittings which would interfere with velocity measurements.

The piping system is to be installed with expansion joints as needed to control temperature-related expansion and contraction. The piping should be sloped to facilitate condensate transport to either extraction wells or the primary moisture separator.

Operation and Controls

Except during the winter and maintenance down times, the soil vapor extraction system is intended to run continuously for the duration of the project. The existing blower operates with manual START and STOP buttons, and a RESET button for when the blower shuts down automatically. The blower will automatically shutdown in case of a high discharge temperature, a high suction vacuum pressure, or a high water level in the moisture separator.

The existing soil vapor extraction blower unit at the site was originally procured for the operation of the pilot study. To convert this blower from capacity of approximately 180 cfm (pilot scale) to 330 cfm (full scale), its pulley will have to be changed to speed it up to near its maximum rating. Operating the blower at this high speed is expected to shorten its normal life of several years and increase noise levels. The magnitude of this impact cannot be determined at this time. Normal maintenance on the blower consists of changing the oil and air filter, and greasing the bearings.

Soil vapor extraction rates from each well will be controlled by local manual valves. A portable velocity meter will be used to measure air flow while adjusting the control valves. The initial target flow rate for each well is 20 to 30 CFM. Exact flowrates will be determined during startup and operation based on the following criteria.

- Confirm capture of all injected air by maintaining a vacuum at all perimeter monitoring points. A soil vapor extraction of 2 to 3 times the air injection rate may be required to ensure capture.

- Extraction wells with higher contaminant concentrations (based on PID), should be operated at a higher flow rate.

- Extraction well flow rates should be pulsed periodically (i.e., cycled on/off or adjusted high/low) to prevent stagnant conditions from developing between adjacent extraction wells.

The AS/SVE system will not normally be manned. However, the system should be visually checked on a weekly basis and more thoroughly inspected on a monthly basis. The monthly inspections are also expected to coincide with other monitoring activities, (see Section 2.5).

Because of frequent disruptions in power noted during the pilot study (6 over three months), an alarm and telemetry system will be used to monitor operation of the system on a continuous basis. Upon blower failure or loss of power (once power is restored), the system will call up to five pre-determined numbers, to notify appropriate personnel.

2.3 AIR INJECTION SYSTEM

Reference: Drawings No. 2 - Equipment and Piping Layout, No. 3 - Process Flow Schematic, No. 4 - Location of Soil Boring/Monitoring Well Cross Sections, No. 5 - Cross Section - Soil Borings and Monitoring Wells, and No. 6 - Well Installation Details. Appendix A - Pipe Size Calculations and Appendix B - Blower Information.

Design Basis

The air injection system includes approximately 11 air injection wells, (IW01 through IW11). The purpose of these injection wells is to induce an air flow through the shallow groundwater, as well as the soils at the groundwater/soil interface. This flow will cause VOCs in these media

Within Cesspools?

to volatilize. The VOCs will then be collected by the soil vapor extraction system. The target flow rate for each injection well is 8 to 12 cubic feet per minute (cfm). The wells will be installed in three lines oriented perpendicular to natural groundwater flow. During startup and operation, flow to each injection well will be controlled by a manual valve located at each well head. Flow measurements will be via portable velocity meters.

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Based on the pilot scale results, an air injection rate of 10 cfm resulted in a measured radius of influence of between 10 and 40 feet. Because groundwater cleanup is a secondary objective for this project, the average measured radius of influence (25 feet) without overlap will be used for design purposes. Therefore, the air injection wells will be installed on 50-foot centers. The air injection wells will be connected to a common point through a series of laterals and headers. The location of air injection wells will be based on the area of known VOC-contaminated soils and groundwater.

Condensate is not expected to form within the air injection system. However, the piping will be sloped to the air injection wells to address potential condensate formation.

A single air injection blower will be used to inject air at each of the wells. The combined air injection rate for the system will be approximately 110 cfm. The air injection blower is existing at the site.

Process Equipment List

Equipment	Quantity	Name/Description
Injection Wells (IW01 to IW11)	11	Injection Wells • 2-inch diameter, schedule 40 PVC well casing. • 0.020-inch well screen, 2 feet long extending from 8 to 10 feet below the water table. • Wells can be used to monitor groundwater.
Injection Blower (existing)	1	• 7.5 HP, 3-phase, 480 volt motor. • Roots Frame 32 Universal RAI Blower (rotary lobe), with maximum pressure rating of 15 PSI. • Control panel (on/off operation) with temperature and two vacuum pressure cutoff switches.

Equipment	Quantity	Name/Description
Pressure Relief Valve (existing)	1	• One preset at factory to protect blower.
Pressure Relief Valve (new)	1	• Install new pressure relief valve to normally operate during blower startup.
Controls (new and existing)	1	• Existing controls are panel mounted on blower skid. • Existing system to operate with manual restart after automatic shutdown. • New system to alert designated individuals that system is not operating. • Replace one existing vacuum switch with a new more sensitive vacuum switch.
Piping	900 feet	• 4-inch carbon steel on blower discharge. • 2-, 4-, and 6-inch, schedule 40 PVC elsewhere. • 2- and 4-inch PVC ball valves.

Installation

The air injection wells will be installed using 4.25 to 6.25 inch hollow stem augers. Split spoon samples will be collected every five feet from the ground surface to 10 feet above the water table (depth of approximately 45 feet bgs). These samples will be used to identify the presence of significant clay lenses which may impact capture of injected air. These samples may also be used to determine the presence of soil contamination (via head space field testing using a PID) and therefore identify soil sample locations for chemical testing.

Continuous split spoon samples will be collected from a depth of 10 feet above the water table (approximately 45 feet bgs), to a depth of 10 feet below the water table. This interval represents the critical flow path for air from the air injection wells to the soil vapor extraction well screens. The presence of clay lenses from a depth of 5 feet above the water table to 10 feet below the water table is a significant concern with the successful operation of the air sparging system. If clay is detected in this zone, then an air injection well should not be installed at this depth unless the air flow pathway to a soil vapor extraction well can be confirmed. Examples of alternative placement would include installing the injection well at a higher elevation (e.g., just above the clay lens) and/or moving the injection well horizontally away from the clay.

After augering to depth, well installation will consist of the following components (see Drawing No. 6).

- Place well at depth of boring.
- Install a sand pack (#2 silica sand) from bottom of well screen to one foot above top of screen.
- Install a 2-foot thick bentonite seal.
- Complete well with cement/bentonite grout.
- The well is to be developed by pumping/surging to obtain a final water turbidity of less than 50 NTU's.

One air injection well was installed during the pilot study. If this well is located in an acceptable area, then it should be used for the full scale remediation.

The injection well heads should be completed with a Tee and removable cap approximately 6 inches above ground surface to allow access into the well for potential cleaning, water level measurements, and groundwater sampling. Each well head should also have a sample port to allow for air velocity and pressure measurements. This port should be located approximately 2 feet away from valves and fittings which would interfere with velocity measurements.

The piping system is to be installed with expansion joints as needed to control temperature-related expansion and contraction. The piping should be sloped to facilitate condensate transport to the injection wells.

Operation and Controls

Except during winter and maintenance periods, the air injection system is intended to run continuously for the duration of the project. The existing blower operates with START and STOP push buttons. The blower will automatically shutdown is case of high discharge temperature, high discharge pressure, or insufficient vacuum on the soil vapor extraction system.

The existing air injection blower unit at the site was originally procured for the operation of the pilot scale study. To convert this blower from approximately 35 cfm (pilot scale) to 110 cfm (full scale), its pulley will have to be changed to speed it up to near its maximum rating. Operating the blower at this speed is expected to shorten it's normal life of several years and increase noise levels. Normal maintenance on the blower consists of changing the oil and air filter, and greasing the bearings.

Air injection rates to each well will be controlled by local manual valves. A portable velocity meter will be used to measure flow rate while adjusting the control valves. The initial target flow rate for each well is 8 to 12 cfm. Exact flow rates are to be determined during startup and operation based on the following criteria.

- Confirm capture of all injected air by maintaining a vacuum at all perimeter monitoring points.

- The ability to inject the air at a given well without requiring excessive pressures relative to the rest of the system.

- Air injection rates should be periodically pulsed (i.e., cycled on/off or adjusted high/low) to prevent stagnant conditions from developing between adjacent wells.

The AS/SVE system will not normally be manned. The system should be visually checked on a weekly basis and more thoroughly inspected on a monthly basis. The monthly inspections are also expected to coincide with other monitoring activities, (see Section 2.5).

As a result of frequent power disruptions noted during the pilot study (6 over three months), a alarm and telemetry system will used to monitor operation of the system on a continuous basis. Upon blower failure or loss of power (once power is restored), this system will call up to five pre-determined numbers, to notify appropriate personnel.

2.4 VAPOR PHASE CARBON UNITS

Reference: Drawings No. 2 - Equipment and Piping Layout and No. 3 - Process Flow Schematic. Appendix C - Carbon Use Calculations.

Design Basis

Based on soil, groundwater, and soil gas testing, the soil vapors collected by the extraction system are expected to contain the VOCs listed in the following table. Other VOCs may also be present. Also provided in this table are vapor phase concentrations measured during the operation of the pilot scale study.

Pilot Values

VC?

Parameter	Average Concentration (ppm-v)	Concentration Range (ppm-v)
Freon-113	6.8	1.1 to 22
1,1-Dichloroethane	2.7	0.96 to 5.2
1,1-Dichloroethene	0.3	ND to 0.41
1,2-Dichloroethene	6.3	1.0 to 20
1,1,1-Trichloroethane	36.0	14 to 75
Trichloroethene	15.7	3.4 to 51
Tetrachloroethene	169.0	21 to 580
Total VOCs	236.8	44 to 750

During the pilot study, the concentration of VOCs in the extracted soil vapor was noted to decrease with time from an initial concentration of approximately 750 ppm-v to 95 ppm-v at the end of one month, 44 ppm-v at the end of two months, and 56 ppm-v at the end of three months of operation. The average concentration presented is the arithmetic average of the four data points.

236 79

~~Transition w/ pilot~~

OK

For purpose of this design, the average concentration of VOCs measured during the pilot scale study will be used to estimate the quantity of vapor phase granular activated carbon required for the first month of operation. Thereafter, the carbon usage will be assumed to be one third of the initial rate, for the duration of the project. Therefore, based on a flow rate of 330 cfm, the estimated average carbon usage rate will be approximately 150 pounds per day for the first month and 50 pounds per day for 24 months. The actual usage rate is expected to be higher during the initial operating period, and then decrease during the course of cleanup. Because these estimates are based on theoretical considerations, the relative accuracy of these estimates is plus or minus 50%. Actual use can be effected by other constituents in the extracted vapor, moisture content, and temperature.

A heater is typically employed prior to the vapor phase carbon units to reduce the relative humidity of the incoming vapor stream to 50% or less and thereby to optimize the use of carbon. To accomplish this, a temperature increase of 20 to 30 °F is required. However, the extraction blower is expected to heat the soil vapor by 10 to 20 °F. As a result, additional heating of the soil vapor cannot be justified on this system. The maximum temperature and pressure for the carbon units is anticipated to be 100 °F and 1 pound per square inch (psi), respectively.

The size of the vapor phase carbon units is based on both:

- The flow capacity of the carbon units, and
- The carbon change out frequency.

Process Equipment List

Equipment	Quantity	Name/Description
Carbon Units	3	Extraction Wells • Two 1800 pound vapor phase granular activated carbon units operating in series. • One 1800 pound carbon unit on standby. • Efficiency to be determined by sample ports before, between, and after carbon units.

Installation

The vapor phase units will be installed on grade, either within or outside the existing Transportation Building, based on available space. The treated soil vapor stack will discharge above the peak of the building roof.

Operation and Controls

The operation procedures for the carbon units consist of monitoring the soil vapor temperature and pressure entering these units and the VOC concentration before, in between, and after these units. Initial design parameters for the soil vapor entering the carbon units are a maximum temperature and pressure of 100 °F and 1 psi, respectively. Higher temperatures and pressures may be considered, based on the carbon vendor requirements and available capacity of the soil vapor extraction blower (total pressure change across the units).

Monitoring for contaminant breakthrough will be based on in-field PID readings and fixed-based VOC analysis. Preliminary criteria for changing out carbon is as follows.

1. PID reading reduction of less than 80% across the first carbon unit,
2. PID or VOC reduction of less than 95% across both carbon units, or
3. VOC concentrations in excess of Air Guide 1 Criteria in the exhaust stack.

specify

PID readings will be conducted weekly at first for at least one month. Based on operating data, and projected carbon changeout requirements, the frequency may be increased to monthly during the project.

VOC testing at a fixed base laboratory is expected to be monthly for the first six months, followed by quarterly for the balance of the project. Preliminary estimates indicate that the system may operate for approximately 2 years.

2.5 SOIL TESTING, GROUNDWATER WELLS, AND SOIL VAPOR PRESSURE MONITORS

Reference: Drawings No. 2 - Equipment and Piping Layout and No. 6 - Well Installation Details.

Design Basis

Soil and groundwater samples will be collected and analyzed to determine the concentration of VOCs at the beginning, during, and at the end of the remediation. Soil vapor pressure monitors will also be used to confirm air flow through the impacted soils and capture of all injected air.

Approximately 10 subsurface soil samples will be collected prior to the start of the remediation to establish baseline conditions. These samples will be distributed both horizontally and vertically throughout the VOC-contaminated soils. The sample locations will target locations with moderate (3 to 10 times the PRGs) and high (greater than 10 times PRGs) VOC concentrations. At least one sample location will be from within a cesspool of known VOC contamination.

Sample locations and depths will be determined based on lithology and PID screening results obtained during the installation of injection and extraction wells. Once a sample location is selected, the same location will be used throughout the course of the project. The soil testing will be used to monitor the effectiveness of the remediation and to determine when the soil remediation is complete.

Sample collection will be via split spoon through hollow stem augers. Sample frequency is anticipated to be every six months, through completion of the project. The samples will be analyzed for TCL VOCs.

Approximately 14 groundwater samples will be collected prior to the start of the remediation to establish baseline conditions. Groundwater from each of the 13 new extraction wells and the existing groundwater monitoring well near the center of the site (CFBMW01) will be sampled and analyzed for VOCs. This data will be used to confirm the location of groundwater contamination. Based on these results, up to four new monitoring wells will be installed at the southern edge of the site (hydraulic downgradient edge) to monitor the groundwater leaving the site. Existing monitoring wells at this location became dry when the use of the Navy recharge basins decreased significantly and the water table elevation decreased by approximately 10 feet.

Have they been abandoned?

Sample results from the four perimeter and one center-of-site shallow monitoring wells will be used to track the effectiveness of the air sparging component of the system. Groundwater testing of the wells is anticipated to be quarterly for the duration of the remediation. In addition, one round of groundwater samples should be collected approximately 6 months after the remediation is complete to document the final conditions.

Check figure

Six clusters of soil vapor pressure monitors will be installed on the eastern and western edges of the site. The location of each cluster will be in line with the air injection wells. These monitors will be used to confirm that all injected air is being captured by the soil vapor extraction system. A negative pressure (vacuum) at each of these locations will be considered confirmation of capture. If positive pressures are noted, then air injection and extraction rates will be adjusted accordingly. Each cluster will consist of two wells, one near the water table and one near the middle of the unsaturated zone.

Process Equipment List

Equipment	Quantity	Name/Description
Groundwater Monitoring Wells (BR101 to BR104 and CFBMW01)	5	Wells • 2-inch diameter, schedule 40 PVC well casing. • 0.020-inch well screen, 10 feet long extending from 2 feet above the water table to 8 feet below the water table. • Wells will be used to monitor groundwater quality.
Soil Vapor Pressure Monitors (SVPM 10 to SVPM 16)	12	Wells • 2-inch diameter, schedule 40 PVC well casing. • 0.020-inch well screen, 2 feet long extending from 23 to 25 feet below ground surface. • 0.020-inch well screen, 2 feet long extending from approximately 50 to 52 feet below ground surface, located just above water table. • Wells will be used to soil vapor pressure.

Installation

The groundwater monitoring wells and soil vapor pressure monitors will be installed using 4.25 to 6.25 inch hollow stem augers. Split spoon samples will collected every five feet from the ground surface to the water table (depth of approximately 55 feet bgs). These samples will be used to identify the presence of significant clay lenses which would impact the capture of injected air. Only one boring per cluster will be evaluated for lithology.

After augering to depth, well installation will consist of the following components (see Drawing No. 6).

- Place well at depth of boring.
- Install a sand pack (#2 silica sand) from bottom of well screen to one foot above top of screen.
- Install a 2-foot thick bentonite seal.
- Complete well with cement/bentonite grout.

Several soil vapor pressure monitors were installed during the pilot scale study. If acceptable, these wells should be used for the full scale remediation.

The well heads will be completed with a removable cap approximately 6 inches above ground surface to allow access into the well for soil vapor pressure readings, water level measurements, and/or groundwater sampling.

2.6 COMPLETION OF AS/SVE REMEDIAL ACTIONS

The remedy will be considered complete when the following site conditions are achieved.

Media	Proposed Remediation Goals	
	Average Concentration	Maximum Concentration
Soil	Average of all soil sample results less than PRGs.	Individual maximum soil sample results less than 3 times the PRGs.
Groundwater	Average of groundwater samples less than 10 times NYSDEC MCLs.	Individual maximum groundwater sample result less than 100 times the NYSDEC MCLs.

OK with NE

~~Nope~~ OK w/JB

If during the remediation, the VOC concentration in the soil vapor decreases to a point at which VOCs are no longer being effectively removed from the soils and/or groundwater, then the following options would be considered. The concentration at which VOC removal will be

Asymptotic concentration

Clarify that this is because gw is addressed elsewhere considered ineffective is 1 ppm, which is equivalent to approximately 0.1 pounds of VOCs per day.

1. Determine the need for additional air injection or soil vapor extraction wells in the area of concern.

2. Re-evaluate the PRGs, since the basis for the determining the goals is also based on chemical mobility and ability to migrate.

Shut off + monitor / Cycled operation

3.0 PERMITTING REQUIREMENTS

Permits or waste approval will be required for the onsite discharge of air and the off site transportation and disposal of condensate and drill cuttings.

Confirm per MOU

An air discharge permit will be required in accordance with 6 NYCRR Parts 200 through 257. Since the NWIRP Bethpage is a state Superfund site (Site No. 130003B), an actual permit may not be required. However, a permit application will need to be prepared and submitted for review to ensure state concurrence that the substantive requirements of a permit are met. NYSDEC Air Guide 1 provides relevant criteria for treatment and discharge requirements. Relevant criteria for annual guideline concentrations (AGC) and Short term Guideline Concentrations (SGC) for chemicals detected during the pilot scale study are summarized as follows.

Parameter	SGC (ug/m^3)	AGC (ug/m^3)
Freon 113	1,800,000	90,000
Vinyl chloride	1,300	0.02
1,1-Dichloroethane	190,000	500
1,2-Dichloroethene	190,000 (c)	360 (t) 1,900 (c)
1,1,1-Trichloroethane	450,000	1,000
Toluene	89,000	2,000
Trichloroethene	33,000	~~0.045~~ 0.45
Tetrachloroethene	81,000	~~0.075~~ 1.2

(t): trans
(c): cis

The listed concentrations apply to ground level concentrations at appropriate receptors. Air Guide 1 provides a range of air modeling procedures to correlate stack emissions with ground level concentrations. How to be addressed?

Condensate is expected to be generated on a periodic basis and captured within the primary moisture separator. This condensate will need to be tested and disposed off site, as either a RCRA characteristic hazardous waste or a non-hazardous waste. Permits are not required for this disposal, however, a waste acceptable application and approval from the receiving facility is required. As an option, if the volume of condensate collected is found to exceed several hundred gallons per month, then on site treatment of the condensate with granular activated carbon and disposal as a non-hazardous waste will be considered.

During the drilling operations, soil cuttings from areas of known PCB contamination must be containerized and tested. For cuttings which fail site-specific PCB or metal criteria, the cuttings are to be taken off site for appropriate disposal. As with the condensate, permits are not required for this disposal, however, a waste acceptance application and approval from the receiving facility is required.

4.0 COSTS AND SCHEDULE

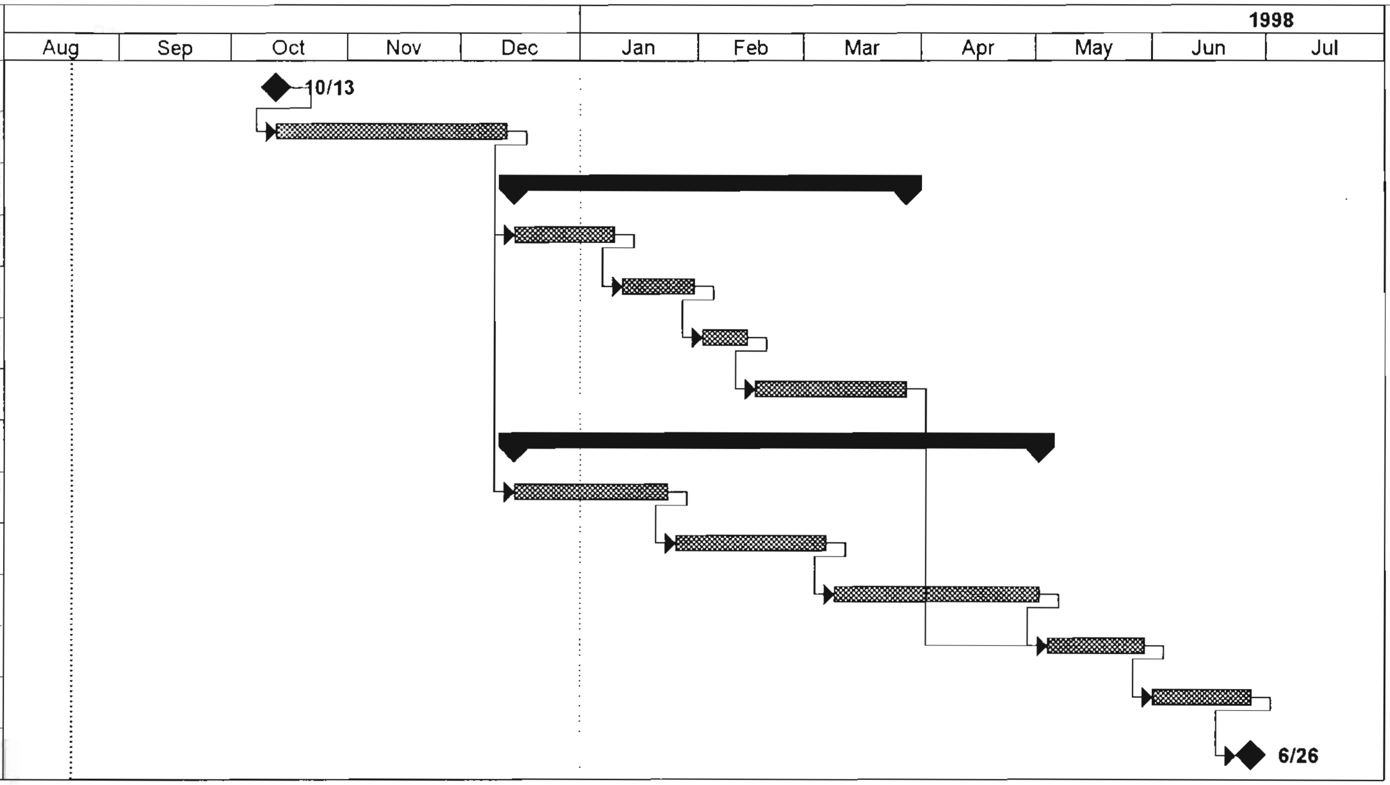
The cost estimates for the proposed system are provided in Appendix D. The cost estimate assumes that construction of the AS/SVE will occur over a three month period and that system startup and check out will require one month. Costs for the purchase of new blowers have not been included, although estimated costs for relocating and modifying the existing blowers are included.

Operation is assumed to occur over a 24 month period. Primary costs associated with operation consist of weekly visual checks, monthly inspections, carbon changeout, and sampling/analytical costs.

The estimated construction schedule is provided in Figure 4-1. This schedule assumes that the Navy will direct the RAC to proceed by October 13, 1997. Field activities would start in March 1998 and be completed in June 1998. Currently, a two year operation period is assumed. Actual operation may require more or less time to achieve the remedial goals.

FIGURE 4-1
CONSTRUCTION SCHEDULE
AIR SPARGING/SOIL VAPOR EXTRACTION

ID	Task Name	Duration
1	1.0 Notice to Proceed	0d
2	2.0 Design Engineering	45d
3	**3.0 Equipment Procuremen**	**75d**
4	Prepare bid packages	20d
5	Solicit bids	15d
6	Purchase equipment	10d
7	Receive equipment	30d
8	**4.0 Well Installation**	**100d**
9	Procure Driller	30d
10	Weather Hold	30d
11	Install Wells	40d
12	5.0 Equipment Installation	20d
13	6.0 Startup	20d
14	7.0 Remedy in Place	0d



Project:
Date: Tue 8/19/97

Task ▨
Progress ■
Milestone ◆
Summary
Rolled Up Task ▨
Rolled Up Milestone ◇
Rolled Up Progress ■

APPENDIX A

PIPE SIZE CALCULATIONS

1.0 VACUUM ON EXTRACTION BLOWER

1.1 PRESSURE DROP CALCULATIONS for EXTRACTION SYSTEM

The soil vapor extraction system was divided into 18 segments which are shown in Figure 1. Pressure changes corresponding to pipe length, size, and fittings were caculated for each segment. Pipe fittings included 90° elbows, ball valves (wide open), and standard tees (thru flow). Equivalent lengths for the fittings were obtained from the Cameron Hydraulic Data, Seventeenth Edition, Handbook. Calculations were performed to show pressure changes corresponding to the length and fittings in each pipe segment. The pressure changes are expressed in inches of water and are based on a soil vapor extraction flow rate of 30 cfm.

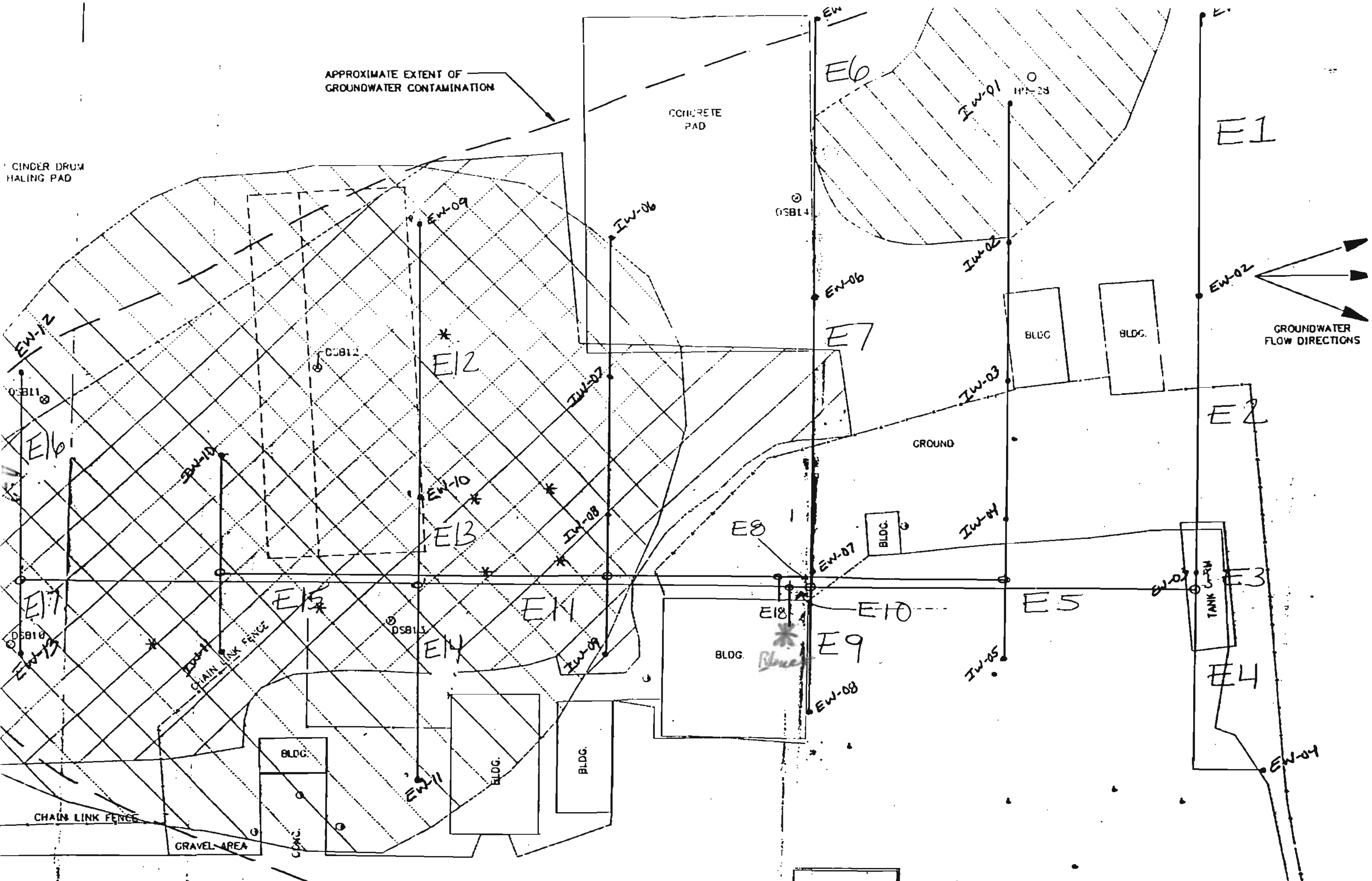


Figure 1. Extraction Segment Layout

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CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations — Extraction

BASED ON

DRAWING NUMBER

BY Patselas

CHECKED BY

APPROVED BY

DATE 7/29/97

Segment	Designated well	Pipe Size	Length	Pressure Drop
E1	01	2"	107 feet	0.19 inches of water
E2	02	2"	136	0.50
E3	03	2"	19	0.10
E4	04	2"	100	0.18
E5	—	4"	192	0.09
E6	05	2"	107	0.19
E7	06	2"	136	0.50
E8	07	2"	19	0.10
E9	08	2"	54	0.10
E10	—	4"	20	0.02
E11	—	4"	189	0.11
E12	09	2"	84	0.24
E13	10	2"	36	0.16
E14	11	2"	130	0.14
E15	—	4"	45	0.05
E16	12	2"	80	0.15
E17	13	2"	193	0.07
E18	—	4"	30	0.05

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Velocities through 2", 4", and 6" PVC with a flowrate (Q) of 30cfm from extraction wells

$Q = AV$ where A = area of pipe $\pi\left(\frac{d^2}{4}\right)$ or πr^2

V = velocity of flow

<u>for 2" pipe</u>

$$V = Q/A = 30\,ft^3/min \,/ (\pi)\,(0.00694\,ft^2)$$

$$= 1375.98\,ft/min = \underline{22.93}\,ft/s$$

<u>for 4" pipe</u>

$$V = Q/A = 30\,ft^3/min \,/ (\pi)(0.02778\,ft^2)$$

$$= 343.75\,ft/min = \underline{5.73\,ft/s}$$

<u>for 6" pipe</u>

$$V = Q/A = 30\,ft^3/min \,/ (\pi)(0.0625\,ft^2)$$

$$= 152.79\,ft/min = \underline{2.55\,ft/s}$$

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Calculation of Darcy-Weisbach friction factor

Reynolds number $(Re) = \frac{Dv}{\gamma}$

where

D = pipe inside diameter (ft)

v = velocity (ft/s)

γ = kinematic viscosity (ft^2/s) of air at 70°F $= 1.64 \times 10^4\ ft^2/s$

friction factor $(f) = 64/Re$

for 2" pipe

$$Re = \frac{(0.17225\ ft.)(22.93\ ft/s)}{1.64 \times 10^{-4}\ ft^2/s}$$

$$= 2.41 \times 10^4$$

$$f = 64/2.41 \times 10^4$$

$$= 0.0026 \cong \underline{0.003}$$

for 4" pipe

$$Re = \frac{(0.3355\ ft.)(5.73\ ft/s)}{1.64 \times 10^{-4}\ ft^2/s}$$

$$= 1.17 \times 10^4$$

$$f = 64/1.17 \times 10^4$$

$$= 0.0055 \cong \underline{0.006}$$

for 6" pipe

$$Re = \frac{(0.50541\ ft)(2.55\ ft/s)}{1.64 \times 10^{-4}\ ft^2/s}$$

$$= 7.85 \times 10^3$$

$$f = 64/7.85 \times 10^3$$

$$= \underline{0.008}$$

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Pressure drop equation

$$\Delta P\left(^{lb}/_{ft^2}\right) = f\rho \frac{v^2}{2g_c}\frac{L}{D}$$

where f = friction factor (dimensionless)

ρ = density of air at 70°F
= 0.075 lb/ft³

v = velocity (ft/s)

$$g_c = 32.174 \frac{lb_m \cdot ft}{lb_f \cdot s^2}$$

L = length (feet)

D = inside diameter of pipe (ft.)

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Pressure Drop from Segment E1

2" section

100' Horizontal — 100'
90° elbow — 5.17'
ball valve — 1.38'
106.55

Flow = 30cfm = 22.93 ft/s

ΔP = 0. 19" of water

Pressure Drop from Segment E2

2" section

100' Horizontal — 100'
90° elbow - 5.17'
ball valve - 1.38'
Tee, standard - 3.45'
expansion joint -
- 4 elbow — 20.68'
- 5' — 5'
135.68'

Flow = 60 cfm = 45.86 ft/s

ΔP = 0.50" of water

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Pressure Drop from Segment $\boxed{E3}$

2" section

5' H	—	5'
90° elbow	—	5.17'
ball valve	—	1.38'
Tee, standard	—	3.45'
2"-4" enlarge	—	3.25'
		18.25'

Flow = 90 cfm = 68.79 ft/s

ΔP = 0.10" of water

Pressure Drop from Segment $\boxed{E4}$

2" section

65' H	—	65'
25' V	—	25'
90° elbow	—	5.17'
ball valve	—	1.38'
2"-4" enlarge	-	3.25'
		99.8'

Flow = 30 cfm = 22.93 ft/s

ΔP = 0.18" of water

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Pressure Drop in Section $\boxed{E5}$

4" section

139' Horizontal	—	139'
Tee, standard	—	6.71'
expansion joint	—	[illegible]
—4 elbows		40.4'
– 5'		5'
		191.11'

Flow = 120cfm = 22.92 ft/s

ΔP = <u>0.09" of water</u>

Pressure Drop in Section $\boxed{E6}$

2" section

100' Horiz.	—	100
90° elbow	–	5.17'
ball valve	–	1.38'
		106.55

Flow = 30cfm = 22.93 ft/s

ΔP = <u>0.19" of water</u>

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Pressure drop in Segment $\boxed{E7}$

2" section

100' Horiz. — 100'

90° elbow — 5.17'

ball valve — 1.38'

Tee, standard — 3.45'

Expansion joint

-4 elbow — 20.68

-5' — 5'

135.68'

Flow = 60cfm = 45.86 ft/s

ΔP = 0.50" of water

Pressure drop in Segment $\boxed{E8}$

2" section

5' Horiz. — 5'

90° elbow - 5.17'

ball valve — 1.38'

Tee, standard - 3.45'

2"-4" enlarge - 3.25'

18.25'

Flow = 90 cfm = 68.79 ft/s

ΔP = 0.10" of water   0.10

Pressure drop in Segment $\boxed{E9}$

2" section

44' Horiz = 44'

90° elbow = 5.17'

ball valve = 1.38'

2"-4" enlarge = 3.25'

53.8'

Flow = 30cfm = 22.93 ft/s

ΔP = 0.10" of water

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Pressure Drop to Segment $\boxed{E10}$

4" section

8' horizontal — 8'
Tee, standard — 6.71'
4"-6" enlarge — 5.25'
19.96'

Flow = 240 cfm = 45.84 ft/s

ΔP = <u>0.02" of water</u>

Pressure Drop to Segment $\boxed{E11}$

4" section

131' horizontal — 131'
Tee, Standard — 6.71'
4"-6" enlarge — 5.25'
expansion joint
— 4 elbows — 40.4
— 5 feet — 5'
188.36

Flow = 150 cfm = 28.65 ft/s

ΔP = <u>0.11" of water</u>

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Pressure Drop from Segment $\boxed{E12}$

2" section

97' Horizontal — 97'
90° elbow — 5.17'
ball valve - 1.38'
expansion joint
— 4 elbow - 20.68'
— 5' - 5'
129.23'

Flow = 30cfm = 22.93 ft/s

ΔP = <u>0.24" of water</u>

Pressure Drop from Segment $\boxed{E13}$

2" section

31' Horiz. — 31'
90° elbow — 5.17'
ball valve — 1.38'
Tee, standard — 3.45'
2"-4" enlarge - 3.25'
44.25'

Flow = 60 cfm = 45.86 ft/s

ΔP = <u>0.16" of water</u>

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Pressure Drop from Segment $\boxed{E14}$

2" section

70' Horiz.	– 70'
90° elbow	– 5.17'
ball valve	– 1.38'
2"-4" enlarge	– 3.25'
	79.8'

Flow = 30 cfm = 22.93 ft/s

ΔP = <u>0.14" of water</u>

Pressure Drop From segment $\boxed{E15}$

4" section

140' horizontal –	140'
Tee, standard –	6.71'
expansion joint –	[illegible]
– 4 elbows	40.4'
– 5 feet	5'
	192.11

Flow = 60 cfm = 11.46 ft/s

ΔP = <u>0.05" of water</u>

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Pressure Drop from Segment $\boxed{E16}$

2" section

74' Horiz. — 74'

90° elbow — 5.17'

ball valve — 1.38'

2"-4" enlarge - 3.25'

83.8'

Flow = 30 cfm = 22.93 ft/s

ΔP = 0.15" of water

Pressure Drop from Segment $\boxed{E17}$

2" section

26' Horiz. — 26'

90° elbow - 5.17'

ball valve - 1.38'

2"-4" enlarge - 3.25'

35.8'

Flow = 30 cfm = 22.93 ft/s

ΔP = 0.07" of water

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Pressure drop from segment $\boxed{E18}$

6" section

15' horizontal —	15'
6" ball valve —	4.04'
6" T —	10.1'
	29.14'

ΔP = <u>0.05" of water</u>

1.2 WELL VACUUM DETERMINATION

Data from radius of influence testing performed in April 1997 was compiled for the extraction wells (EW-01, EW-02, and EW-03) screened at the water table. A range of vacuums were plotted versus corresponding flow rate to determine a design well point vacuum. Figure 2 shows the range of vacuums versus corresponding flow rate. Three vacuums obtained from the plot at 30 cfm were 4.7, 7.6, and 8.4 inches of water, respectively. The greatest vacuum, 8.4 inches of water, was used as the design vacuum at an extraction flow rate of 30 cfm.

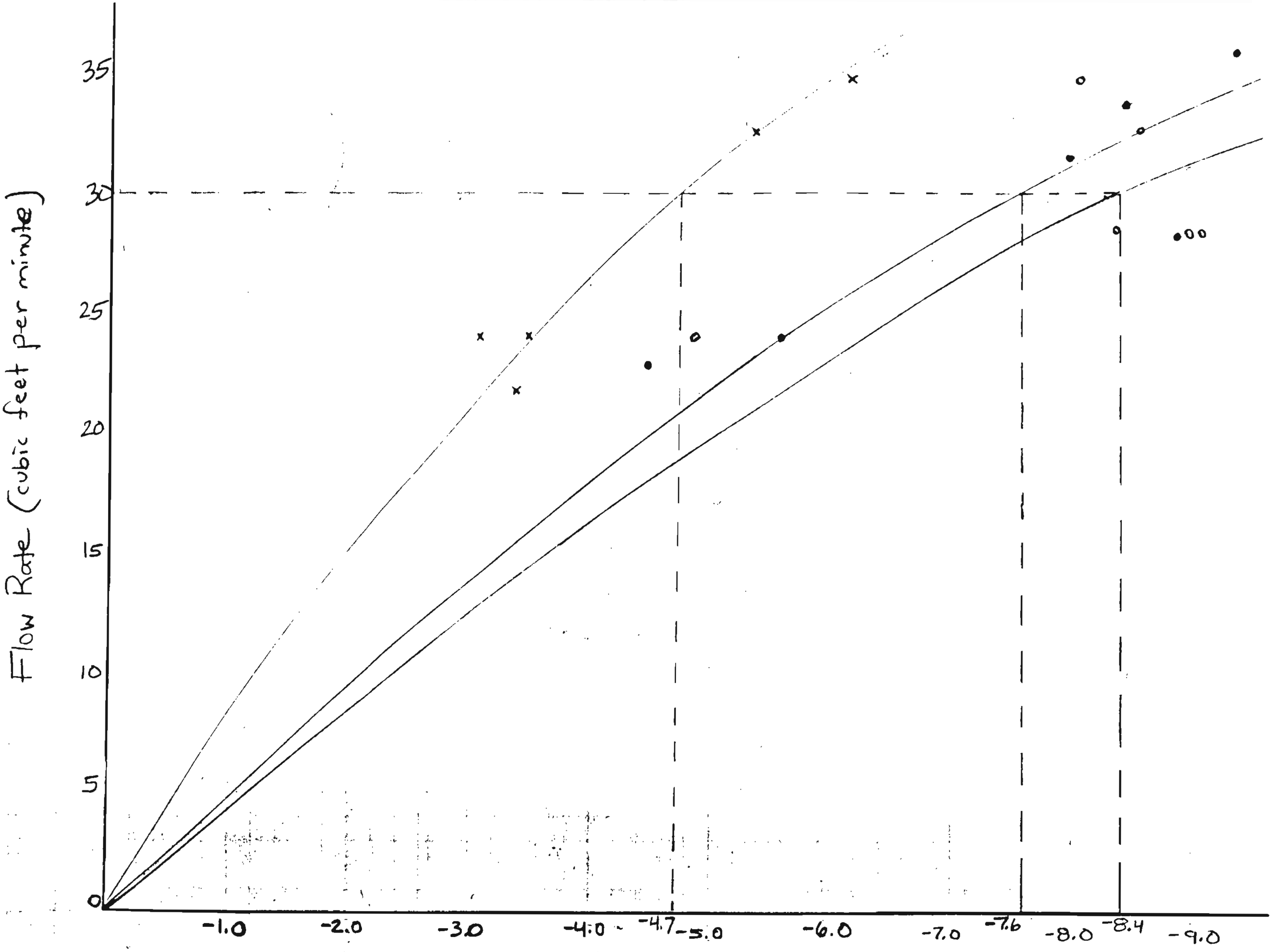


Figure 2. Flow Rate vs. Vacuum

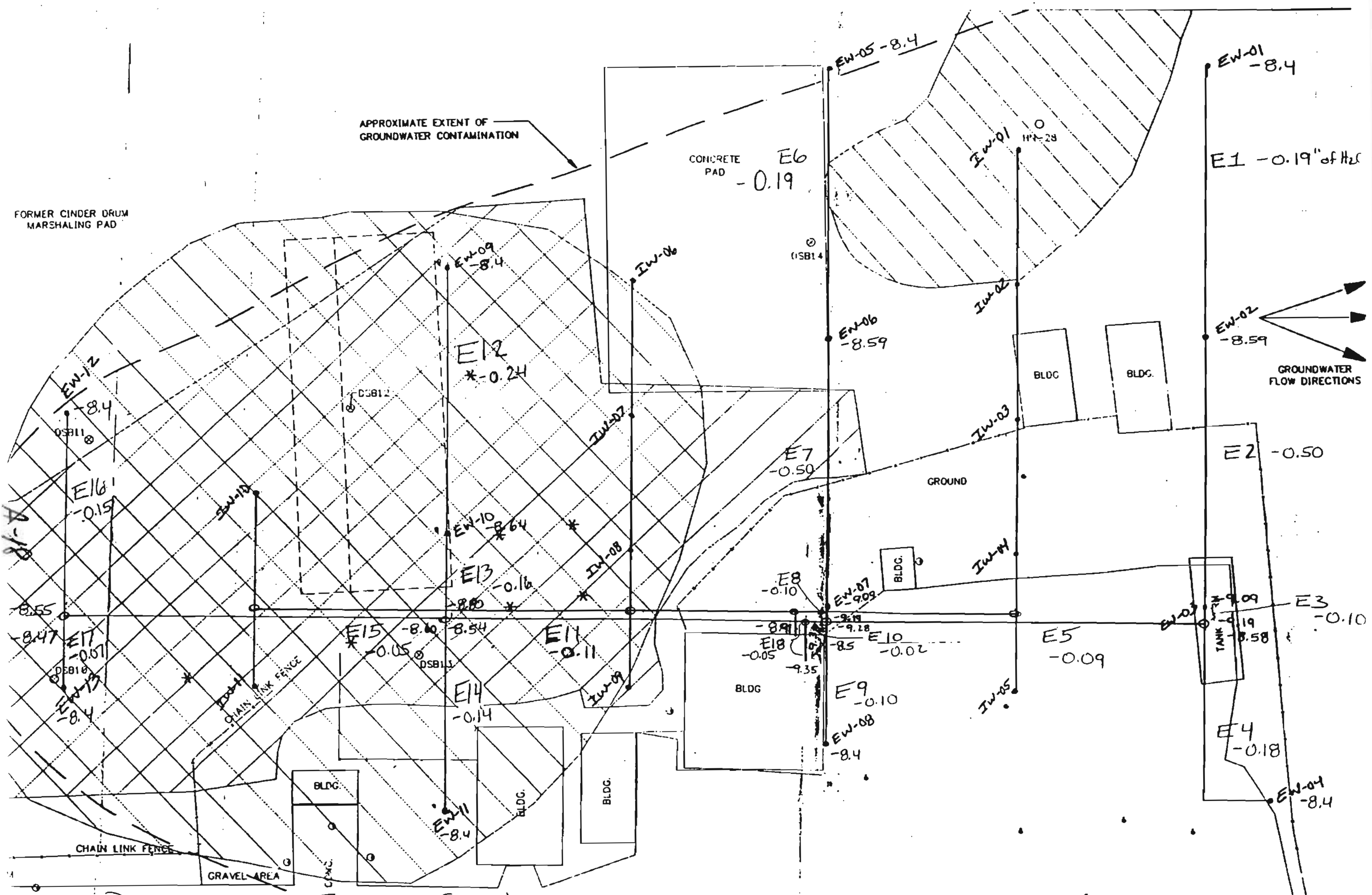


Figure 3 Pressure Changes at ~~E~~ Extraction Segments

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ______ OF ______

CLIENT NAVY	JOB NUMBER 5253
SUBJECT Pressure Drop thru Moisture Separators	
BASED ON	DRAWING NUMBER

BY Patzelw	CHECKED BY	APPROVED BY	DATE 9/15/97

Vacuum up to Moisture separator = 9.35" of water

9.35" of water + 8.4" of water + 5" of water = 22.75" of water
well point Vacuum

Add 5" of water for any fittings and lengths that are not part of the main pipe segments and as a correction factor for calculations based on water losses

Based on moisture separator specifications from Product Recovery Management (attached) a 4" of water column drop is measured in a 60 gallon size tank at 400 cfm.

∴ 8" of water column will be added for 2 moisture separation units.

Total vacuum at extraction blower = 30.75" of water

$$30.75\text{" of water}\left(\frac{\text{" of mercury}}{13.5\text{" of water}}\right) = 2.28\text{" of Hg}$$

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE ______ OF ______

CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations at Discharge

BASED ON

DRAWING NUMBER

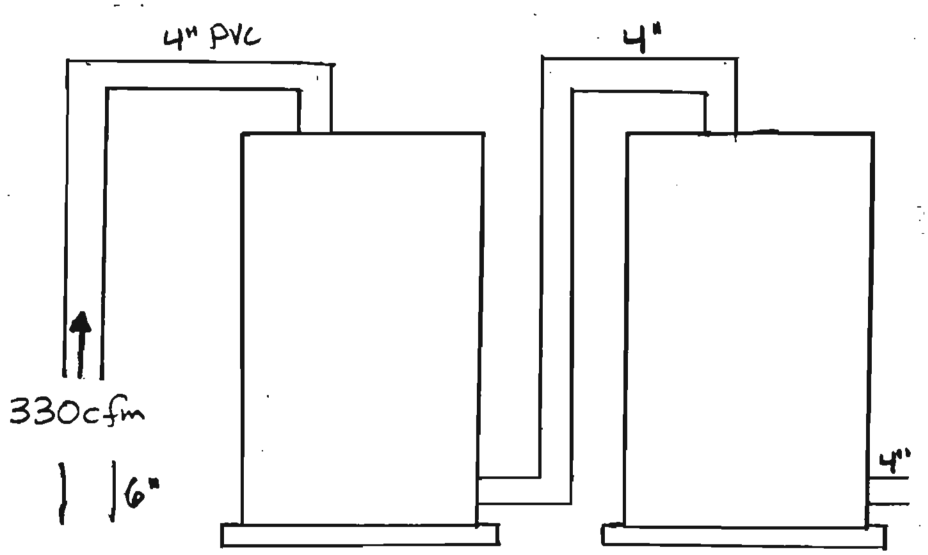
BY Patselas

CHECKED BY

APPROVED BY

DATE 8/4/97

Vessel Dimensions 44¼" x 44¼" x 89⅜"



Discharge of Extraction

3' - 6" carbon steel	=	3'	29' of 6" section
1 - 6" 90° elbow	=	15.2'	
10' - 6" carbon steel	=	10'	
1 - rubber coupling	=		
10' - 6" PVC	=	10'	
1 - 6"-4" reduce	=	5.25'	71' of 4" section
5' - 4" PVC	=	5'	
6 - 4" 90° elbows	=	60.6'	

For 6" pipe

$$Re = \frac{Dv}{\nu} = \frac{(0.50541')(28.05\,ft/s)}{1.64\times10^{-4}\,ft^2/s}$$

$$= 8.64\times10^4$$

$$\Rightarrow f = \frac{64}{Re} = \frac{64}{8.64\times10^4}$$

$$= 0.0007$$

ISSUE DATE

FILE NUMBER

TELEPHONE CONVERSATION REPORTING FORM

RECORDED BY Stavros Patselas

TELEPHONE NUMBER

CALL ☒ TO ☐ FROM

NAME Dick Anthony

TELEPHONE NUMBER 1888 TREAT IT

COMPANY Product Recovery Management

DATE OF CALL 8/6/97

ADDRESS

TIME 1420 ☐ A.M. ☒ P.M.

CONFERENCE CALL

☐ NO ☐ YES *(If **YES**, list conferees, conferees company, etc. in notes.)*

JOB NUMBER 5253-0144

CLIENT/PROJECT NAVY / Bethpage AS/SVE

SUBJECT Moisture Separator pressure drops

CONVERSATION NOTES:

No pressure drop curves available at this time, however, 400scfm has only 4" of water column drop in the 60 gal. sice tank. Will fax more info. (specifications) on moisture separator.

ACTION/RESPONSE

RESPONSIBLE PERSON	ACTION NEEDED	DUE DATE

COPIES TO:

RECORDER'S SIGNATURE

Order No. 11028 (12-90)

PRODUCT RECOVERY MANAGEMENT®

FAX from:

DICK ANTHONY
Northeast Brach Manager
PO. Box 352, Hummelstown, PA 17036
Phone 1-888-TREAT-IT(873-2848)
Fax 717-533-5577

DATE: 8-6-97
Total pages: 3

TO: Stavros Patseolas
Brown & Root Environmental

FAX NO: 610-491-9645

SUBJECT:
Moisture Separator Spec's.

COMMENTS:

Stavros,

Attached is the specifications for our moisture separator, as promised.

I don't have a pressure drop curve as I thought, just notes, but can tell you that at 400 scfm we had only 4" of water column drop in the 60 gal. size tank. At these flows the entire skid package with filter, relief valves, pipe etc. shouldn't be more than 12-15" drop.

I can help you with pipe losses in the rest of your system.

Sorry I couldn't spend more time on this, but I'm sure this will help.

I will call to follow up or answer any questions.

Sincerely,

D. A.

Product Recovery Management
Southeast: 205 Broadway Street • Durham, NC 27701 • (919) 682-2054 • Fax (919) 682-0066
Northeast: P.O. Box 352 • Hummelstown, PA 17036 • (717) 533-5577

A Division of Phillips Electric Co. of Durham, Inc.

SPECIFICATIONS

Moisture Separator Specifications

DUTY

The moisture separator shall be designed for use in a soil vapor extraction system capable of continuous operation with a pressure drop of less than six inches of water at the rated flow. The moisture separator must be capable of operation under various conditions ranging from a fine mist to slugs of water with an efficiency of ninety nine plus percent of water removal .

PRINCIPLE OF OPERATION

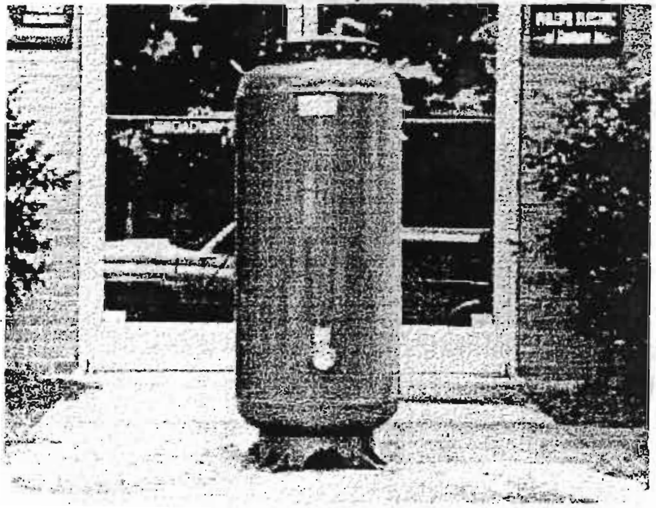
The moisture separator shall incorporate cyclonic separation to remove entrained water and particulates in the vapor stream.

CONSTRUCTION

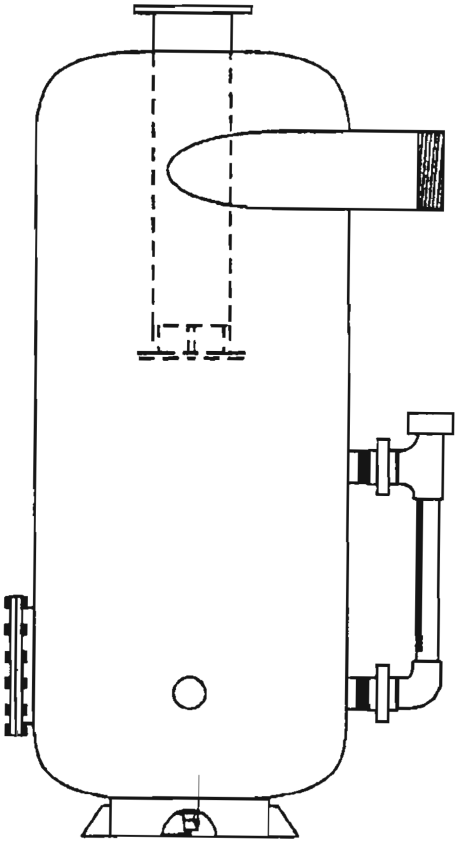
The body of the moisture separator shall be constructed of twelve gauge cold rolled steel designed to meet ASTM specifications for pressure vessels. The exterior shall be coated with an industrial grade primer and enamel paint for durability and chip resistance. The inlet and outlet ports shall be male NPT pipe threads. Additional ports for bottom drain, accessories, gauges, high level and clean-out shall be tank flange type with female NPT threads or male NPT threaded nipple type. Steel feet welded to bottom of tank for bolting tank to skid or floor. The inlet shall be tangentially located and welded to the body. The outlet to be vertical at top of tank with an NPT pipe connection or flange. The separator shall include a side mounted water sight tube assembly and also include an access or clean-out port.

PRODUCT RECOVERY MANAGEMENT

MS-30, 60 and 80, Moisture Separation Units



PRM Moisture Separators were designed exclusively for groundwater remediation using SVE technology. The are designed for your maximum blower protection and extended vapor phase carbon life while offering durability, service and flexibility of applications.



Shown with optional level control.

FEATURES

- High pressure construction with 12 gauge carbon steel
- Cyclonic separation of water (in liquid and vapor form) from the air stream
- Equipped with water level sight tube
- Low pressure drop
- Industrial enamel coating over primer
- Access port for cleaning
- Extra ports for gauges and sensors
- Optional sight tube / level control assembly

Note: Model no. indicates total volume of vessel, MS-30= 30gallon size tank, etc.

Unit	Max.H_2O Capacity	Maximum Airflow *	Inlet (NPT)	Outlet (NPT)	Weight
MS-30	15 Gal.	300 cfm	2"or 3"	4"	105#
MS-60	30 Gal.	700 cfm	4"	6"	150#
MS-80	40 Gal.	900 cfm	6"	8"	220#

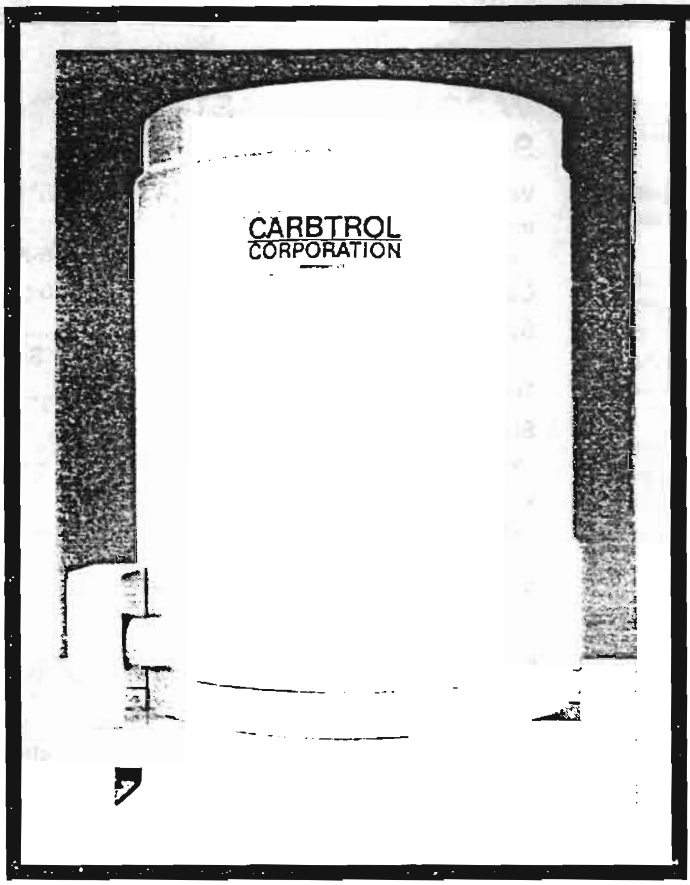
20" x 54
Dia.

* Airflow rated at less than 6 (iwg) inches of water gauge pressure drop

Product Recovery Management is a division of Phillips Electric Co. of Durham. Inc.
205 Broadway Street • Durham, NC 27701 • (919) 682-2054 • Fax (919) 682-0066
Toll Free: Southeast 1-888-PRM-Will Northeast 1-888-Treat-It

CARBTROL

AIR PURIFICATION ADSORBERS
1,000 LB. ACTIVATED CARBON G-4
1,800 LB. ACTIVATED CARBON G-6



FEATURES

- Low pressure drop at 400 CFM
  - G-4 9" water pressure
  - G-6 12" water pressure
- High activity carbon.
- Fork lift fittings for easy handling.
- 4" Ø perforated inlet distributor.
- DOT rated. Acceptable for transport of hazardous waste.

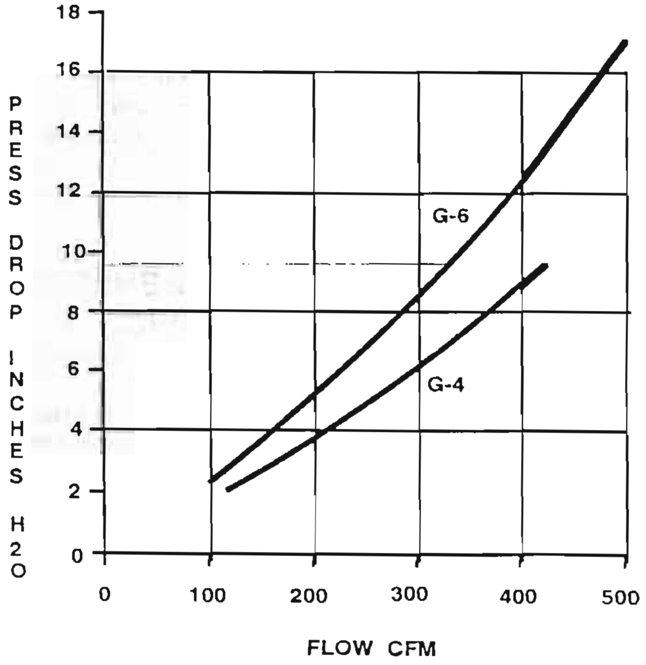
SPECIFICATIONS

G-4

CARBON: 1,000 lbs.
DIMENSIONS: 45-1/2" Ø x 66-1/2" height
SHIPPING WT: 1,500 lbs.

G-6

CARBON: 1,800 lbs.
DIMENSIONS: 45-1/2" Ø x 90" overall ht.
SHIPPING WT: 2,400 lbs.



CARBTROL®
CORPORATION

39 Riverside Avenue, Westport, CT 06880 • 1-800-242-1150 • (203) 226-5

AT-411/

CALGON
CALGON CARBON CORPORATION

SERVICE BULLET

VAPOR PAC

Calgon Carbon's Vapor Pac Service meets industrial needs for cost-effective removal of volatile organic compounds (VOCs) at air emission sources.

The Vapor Pac Service features a small, easily transportable adsorber which contains 1,800 pounds of activated carbon. The adsorber can handle air flows up to 1,000 cfm.

Designed to remove both toxic and non-toxic VOCs, the adsorption system is especially useful for short-term projects and for treatment of low volume flows that contain low to moderate VOC concentrations. Common applications include VOC removal from process vents, soil remediation vents, and air stripper off-gases.

To accommodate a wide variety of process conditions, Vapor Pac adsorbers are available in two basic designs: a polyethylene model that offers excellent corrosion-resistance, and a stainless steel model than can withstand higher temperatures, and slight pressure or vacuum conditions.

Calgon Carbon provides the adsorber, carbon, spent carbon handling and carbon reactivation (after the carbon meets the company's acceptance criteria) as part of the Vapor Pac Service. Ductwork and fans are the only equipment requiring a capital expenditure by the user.

When carbon becomes saturated with VOCs, the system is replaced with another adsorber containing fresh carbon.

By utilizing this unique service, users can generally achieve VOC removal and regulatory compliance objectives, minimize operating costs, and eliminate maintenance costs* (as the equipment is owned and maintained by Calgon Carbon). Furthermore, because organic compounds are safely destroyed through the carbon reactivation process, costs and regulations typically associated with waste disposal can be eliminated.

Please contact a Calgon Carbon Technical Sales Representative to learn more about the advantages of the Vapor Pac Service for your specific VOC control needs.

Damage to Vapor Pac Unit caused by negligence or misapplication is the responsibility of the user.

FEATURES AND BENEFITS OF VAPOR PAC SERVICE

- Adsorbers are specifically designed for ease of installation and operation.
- Adsorbers are available in plastic (polyethylene) and metal (stainless steel) construction to accommodate a wide variety of applications.
- System can be operated in series or parallel mode or a combination of both modes to handle a variety of flows and concentrations.
- System exchange eliminates on-site carbon handling.
- Recycling of spent carbon eliminates disposal problems.
- Capital expenditure is eliminated since Calgon Carbon Corporation owns and maintains equipment.

VAPOR PAC (PLASTIC) SPECIFICATIONS

Vessel dimensions: ....44¼" x 44¼" x 89¾
Inlet & discharge connections: ....6" PS 15-69 duct flang
Carbon volume: ....60 cu. ft. (1800 lb
System shipping weight: ....New - 2200 lbs
Spent - 4000 lb
Temperature rating: ....150°F ma
Static pressure rating above carbon level: ....20" W.C. ma
Vacuum pressure rating above carbon level: ....2" W.C. max

All units shipped F.O.B., Pittsburgh, Pennsylvania

MATERIALS OF CONSTRUCTION

Vessel: ....Polyethylen
Frame: ....Carbon steel coated with Sherwin Williams Tile Clad I
Inlet flanges, elbow, septum: ....PV
Discharge flange: ....Polyethylene
Fasteners & bottom valve support plate: ....Steel, plated
Sample fittings & sample canister: ....PV

VAPOR PAC (STAINLESS STEEL) SPECIFICATIONS

Vessel dimensions, diameter: ....5'
height: ....7'3
Inlet & discharge connections: ....8" PS 15-69 duct flanges
Carbon volume: ....60 cu. ft. approx. (1800 lbs)
System shipping weight: ....New - 2840 lbs
Spent - 4640 lbs
Static pressure rating above carbon level: ....15 psig
Vacuum pressure rating above carbon level: ....Full

All units shipped F.O.B., Pittsburgh, Pennsylvania

CALCULATION WORKSHEET Order No. 19116 (01-91)

PAGE ______ OF ______

CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculation at Discharge

BASED ON

DRAWING NUMBER

BY Patselus

CHECKED BY

APPROVED BY

DATE 8/4/97

$$\Delta P = f \rho \frac{v^2}{2g_c} \frac{L}{D}$$

$$= (0.0007)(0.075)\left(\frac{28.05^2}{64.35}\right)\left(\frac{29'}{0.5054}\right)$$

$$= 0.037 \text{ lb/ft}^2$$

$$= \underline{0.007\text{" of Water}}$$

<u>for 4" pipe</u>

$$Re = \frac{Dv}{\nu} = \frac{(0.3355')(63.03 \text{ ft/s})}{1.64 \times 10^{-4} \text{ ft}^2\text{/s}}$$

$$= 1.29 \times 10^5 \Longrightarrow f = \frac{64}{Re} = \frac{64}{1.29 \times 10^5}$$

$$= 0.0005$$

$$\Delta P = (0.0005)(0.075)\left(\frac{63.03^2}{64.35}\right)\left(\frac{71'}{0.3355}\right)$$

$$= 0.49 \text{ lb/ft}^2$$

$$= \underline{0.09\text{" of water}}$$

Calgon
1800 lb Vapor Pac ⟹ Pressure drop at 330 cfm = 4" of water
4" of water × 2 units = 8" of water

Carbtrol
1800 lb G-6 ⟹ Pressure drop at 330 cfm = 9.5" of H_2O
9.5" of water × 2 units = 19" of water

Use Carbtrol for design

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ______ OF ______

CLIENT NAVY		JOB NUMBER 5253	
SUBJECT Pressure Drop Calculations at Discharge			
BASED ON		DRAWING NUMBER	
BY Patselas	CHECKED BY	APPROVED BY	DATE 8/4/97

Total pressure drop from extraction outlet thru carbon units (2) to discharge

6" pipe ΔP = 0.007" of water

4" pipe ΔP = 0.09" of water

2 carbon units ΔP = 19" of water

Total = 19.097" of water

1.3 VACUUM at EXTRACTION BLOWER

The calculated pressure changes for the corresponding extraction segments are shown in Figure 3. The design well vacuum was added to the segment pressure changes to determine the vacuum on the inlet side of the extraction blower. Two-60 gallon moisture separators prior to the extraction blower have a total pressure drop of 8 inches of water. The total vacuum at the inlet side was calculated to be 30.75 inches of water, which includes the addition of 5 inches of water added to the total to account for any fittings and lengths that are not part of the main pipe segments.

1.4 EXTRACTION BLOWER SIZING

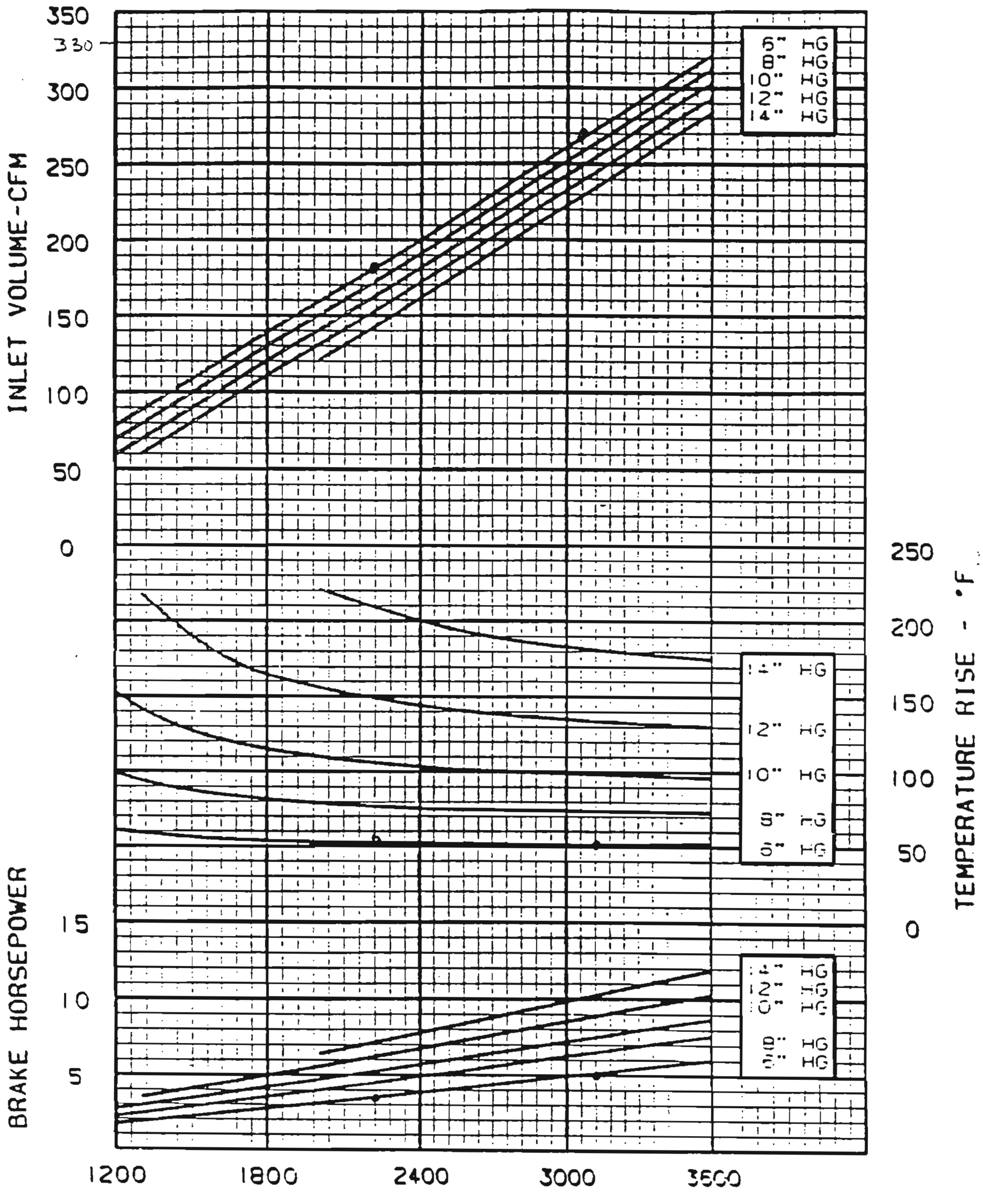
The existing Frame 36 Universal RAI Blower rated for 100 to 150 scfm at +1 psi/- 5 inches of mercury will be adequate for full phase system operations.

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE, INDIANA 47331
PRINTED IN U.S.A.

PERFORMANCE BASED ON
INLET AIR = 68 F
DISCHARGE PRESSURE = 30" HG ABS.
JULY, 1994

VACUUM PERFORMANCE
FRAME 36 UNIVERSAL RAI BLOWER
MAXIMUM VACUUM=15 IN. HG
MAXIMUM SPEED=3600 RPM

Existing Unit



2.0 PRESSURE ON DISCHARGE END OF INJECTION

2.1 PRESSURE DROP CALCULATIONS for AIR SPARGING SYSTEM

The air injection system was divided into 15 segments which are shown in Figure 4. Pressure changes corresponding to pipe length, size, and fittings were caculated for each segment. Pipe fittings included 90° elbows, ball valves (wide open), and standard tees (thru flow). Equivalent lengths for the fittings were obtained from the Cameron Hydraulic Data, Seventeenth Edition, Handbook. Calculations were performed to show pressure changes corresponding to the length and fittings in each pipe segment. The pressure changes are expressed in inches of water and are based on an air injection flow rate of 10 cfm.

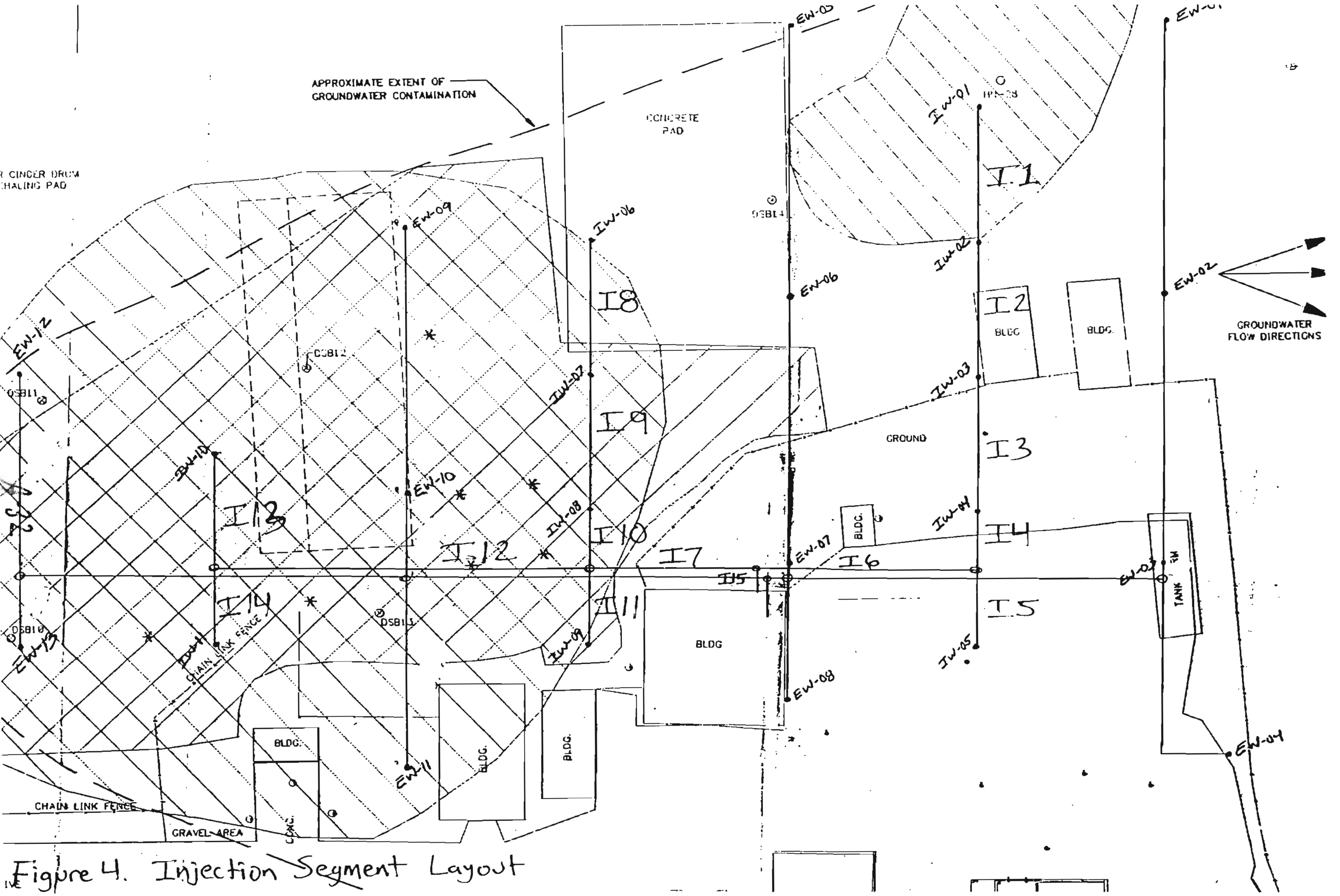


Figure 4. Injection Segment Layout

CALCULATION WORKSHEET Order No. 19118 (01-81)

PAGE ____ OF ____

CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations - Injection

BASED ON

DRAWING NUMBER

BY Patselas

CHECKED BY

APPROVED BY

DATE 8/1/97

Segment	Designated Well	Pipe Size	Length	Pressure Drop
I1	IW-01	2"	57'	0.03 inches of water
I2	IW-02	2"	60'	0.07
I3	IW-03	2"	86	0.16
I4	IW-04	2"	33'	0.08
I5	IW-05	2"	38'	0.02
I6	—	4"	88'	0.02
I7	—	4"	68'	0.02
I8	IW-06	2"	57'	0.04
I9	IW-07	2"	86'	0.10
I10	IW-08	2"	34'	0.06
I11	IW-09	2"	35'	0.02
I12	—	4"	190'	0.02
I13	IW-10	2"	52'	0.03
I14	IW-11	2"	37'	0.02
I15	—	4"	22'	0.02

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT NAVY		JOB NUMBER 5253	
SUBJECT Pressure Drop Calculations — Injection			
BASED ON		DRAWING NUMBER	
BY PATSELAS	CHECKED BY	APPROVED BY	DATE 8/1/93

Velocities through 2" and 4" PVC with at flowrate of 10cfm to each extraction well
Injection

for 2" pipe

$$V = Q/A = 10\ ft^3/min \Big/ (\pi)(0.00694\ ft^2)$$

$$= 458.66\ ft/min = \underline{7.64\ ft/s}$$

for 4" pipe

$$V = Q/A = 10\ ft^3/min. \Big/ (\pi)(0.02778\ ft^2)$$

$$= 114.58\ ft/min = \underline{1.91\ ft/s}$$

$$\Delta P\ (lb/ft^2) = f \rho \frac{v^2}{2g_c} \frac{L}{D}$$

(pressure drop)

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT NAVY	JOB NUMBER 5253
SUBJECT Pressure Drop Calculations — Injection	
BASED ON	DRAWING NUMBER

BY Patselas	CHECKED BY	APPROVED BY	DATE 8/1/97

Pressure Drop from Segment $\boxed{I1}$

2" section

50' → 2" Horizontal	=	50'
1 → 2" ball valve	=	1.38'
1 → 90° elbow	=	5.17'
		56.55'

Flow = 10cfm = 7.64 ft/s

ΔP = 0.03" of water

Pressure Drop From Segment $\boxed{I2}$

2" section

50' → 2" horizontal	50'
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
1 → 2" T, standard	3.45'
	60'

Flow = 20cfm = 15.28 ft/s

ΔP = 0.07" of water

Pressure Drop from Segment $\boxed{I3}$

2" section

50' → 2" horizontal	50'
1 → 2" ball valve	1.38'
1 → 90° elbow	5.17'
1 → 2" T, standard	3.45'
expansion joint	
4 → 2" elbows	20.68'
5' → 2" horiz	5
	85.68'

Flow = 30cfm
= 22.92 ft/s

ΔP = 0.16" of water

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CLIENT NAVY	JOB NUMBER 5253
SUBJECT Pressure Drop Calculations — Injection	
BASED ON	DRAWING NUMBER

BY Patselas	CHECKED BY	APPROVED BY	DATE 8/1/97

Pressure Drop from segment I4

2" section

20' →	2" horizontal	20'
1 →	2" ball	1.38'
1 →	90° elbow	5.17'
1 →	2" T, standard	3.45'
1 →	2" – 4" enlarge	3.25'
		33.25

Flow = 40 cfm = 30.56 ft/s

ΔP = 0.08" of water

Pressure Drop from Segment I5

2" section

Same as segment I4 + 8' - 3.45' (2" T) = 37.8'

Flow = 10 cfm = 7.64 ft/s

ΔP = 0.02" of water

Pressure Drop from Segment I6

4" section

81' →	4" Vertical	81'
1 →	4" T, standard	6.71
		87.71'

Flow = 50 cfm = 9.55 ft/s

OK to use 2"

ΔP = 0.02" of water

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations — Injection

BASED ON

DRAWING NUMBER

BY Patselas

CHECKED BY

APPROVED BY

DATE 8/1/97

Pressure Drop from Segment $\boxed{I7}$

4" section

61' → 4" Vertical	61'
1 → 4" T, standard	6.71'
	67.71'

Flow = 60 cfm = 11.46 ft/s

ΔP = 0.02" of water

Pressure Drop from Segment $\boxed{I8}$

2" section

50' → 2" H	50'
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
	56.55'

Flow = 10 cfm = 7.64 ft/s

ΔP = 0.04" of water

Pressure Drop from Segment $\boxed{I9}$

2" section

50' - 2" H	50'
1 - 2" ball	1.38'
1 - 90° elbow	5.17'
1 - 2" T, standard	3.45'
1 expansion joint	
— 4 2" elbows	(4x 5.17) = 20.68'
— 5' of length	5'
	85.68'

Flow = 20 cfm = 15.28 ft/s

ΔP = 0.10" of water

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ______ OF ______

CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations — Injection

BASED ON

DRAWING NUMBER

BY Patselas

CHECKED BY

APPROVED BY

DATE 8/1/97

Pressure Drop from Segment $\boxed{I10}$

2" section

20' → 2" H	20'
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
1 → 2" T, standard	3.45'
1 - 2"-4" enlarge	3.25'
	33.25'

Flow = 30cfm = 22.92 ft/s

ΔP = 0.06" of water

Pressure Drop from Segment $\boxed{I11}$

2" section

29' → 2" H	28
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
	34.55'

Flow = 10cfm = 7.64 ft/s

ΔP = 0.02" of water

Pressure Drop from Segment $\boxed{I12}$

4" section

137' → 4" ✓	137'
1 → 4" T, standard	6.71'
1 expansion joint	
— 5' length	5'
— 4 - 4" elbows	40.4'
	189.1

OK to use 2"

Flow = 20cfm = 3.82 ft/s

ΔP = 0.02" of water

CALCULATION WORKSHEET Order No. 19116 (01-91) PAGE ______ OF ______

CLIENT NAVY		JOB NUMBER 5253	
SUBJECT Pressure Drop Calculations Injection			
BASED ON		DRAWING NUMBER	
BY Patselas	CHECKED BY	APPROVED BY	DATE 8/1/97

Pressure Drop from Segment $\boxed{\text{I13}}$

2" section

42' → 2" H	42'
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
1" → 2"-4" enlarge	3.25'
	51.8'

Flow = 10 cfm = 7.64 ft/s

ΔP = 0.03" of water

Pressure Drop from Segment $\boxed{\text{I14}}$

2" section

27' → 2" H	27'
1 → 2" ball	1.38'
1 → 90° elbow	5.17'
1 → 2"-4" enlarge	3.25'
	36.8'

Flow = 10 cfm = 7.64 ft/s

ΔP = 0.02" of water

Pressure Drop from Segment $\boxed{\text{I15}}$

4" section

10' → 4" PVC	10'
1" → 4" PVC ball	2.68'
23' → 4" carbon steel pipe	23'
1 → C.S. 90° elbow	10.1'
	45.78'

Flow = 110 cfm → 21.01 ft/s

ΔP = 0.02" of water

2.2 WELL VACUUM CALCULATION

A well point pressure of 8.4 inches of water was used to calculate the pressure on the discharge end of the injection unit.

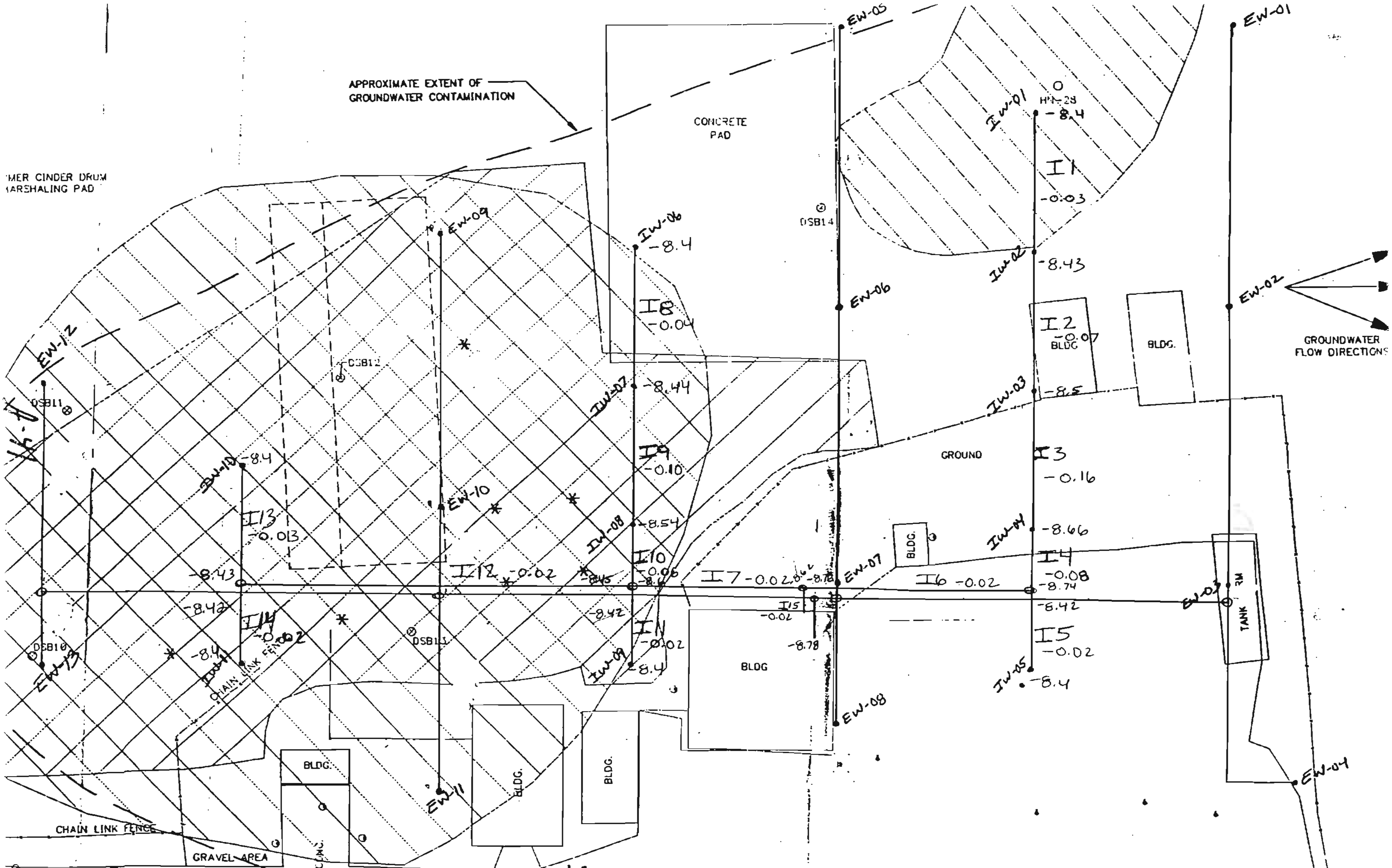
2.3 PRESSURE at EXTRACTION BLOWER

The calculated pressure changes for the corresponding extraction segments are shown in Figure 5. The design well pressure was added to the segment pressure changes to determine the vacuum on the inlet side of the extraction blower. The total pressure at the outlet side was calculated to be 4.8 psi, which includes the addition of 5 inches of water added to the total to account for any fittings and lengths that are not part of the main pipe segments and static head loss.

2.4 INJECTION BLOWER SIZING

110?

The existing Frame 32 Universal RAI Blower rated for 35 TO 60 SCFM at a pressure of 6 psi will be adequate to



igure 5. Pressure Changes at Injection Segments

CALCULATION WORKSHEET Order No. 19116 (01-91)

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CLIENT NAVY

JOB NUMBER 5253

SUBJECT Pressure Drop Calculations - Injection

BASED ON

DRAWING NUMBER

BY Putselus

CHECKED BY

APPROVED BY

DATE 8/1/97

Pressure at Injection Outlet is:

8.78" of water ⇒ 0.32 psi

5" of water ⇒ 0.18 psi

13.78" 0.50 psi

Note: 2.3 feet of water equals one psi.

Static Head Loss

Minimum is 8 feet : 8/2.3 ⇒ 3.5 psi

Maximum is 10 feet : 10/2.3 ⇒ 4.3 psi

Total pressure drop = 4.8 psi

DRESSER INDUSTRIES, INC.
ROOTS DIVISION
900 WEST MOUNT STREET
CONNERSVILLE,INDIANA 4733[illegible]
PRINTED IN U.S.A.

PERFORMANCE BASED ON
INLET AIR AT 14.7 PSIA & 68°F
JULY, 1994

PRESSURE PERFORMANCE
FRAME 32 UNIVERSAL RAI BLOWER
MAXIMUM PRESSURE RISE=15 PSI
MAXIMUM SPEED=3600 RPM