In Situ Bioventing Treatability Study Work Plan for 3700 Fuel Yard Tinker AFB, Oklahoma Volume I

Department of the Air Force
Oklahoma City Air Logistics Center
Tinker Air Force Base, Oklahoma

December 1994

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Volume I

Appendix A:	*Project Management Plan*
Appendix B:	*Data Collection Quality Assurance Plan*
Appendix C:	*Data Management Plan*

Prepared for

Department of the Air Force

Oklahoma City Air Logistics Center

Tinker Air Force Base

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Department of the Air Force
Oklahoma City Air Logistics Center
Tinker Air Force Base

Prepared by

Engineering-Science, Inc.
Austin, Texas

October 1994

CONTENTS

APPENDICES

FIGURES

Page

SECTION 1.0
INTRODUCTION

This work plan presents the scope of an *in situ* bioventing treatability study for treatment of fuel-contaminated soils and a subsurface soils characterization at the 3700 Fuel Yard at Tinker Air Force Base (AFB), Oklahoma. This site is also referred to as petroleum, oil, and lubricant (POL) area C and site ST32. The study has four primary objectives: 1) to assess the potential for supplying oxygen throughout the contaminated soil interval; 2) to determine the rate at which indigenous microorganisms will degrade fuel when stimulated by oxygen-rich soil gas; 3) to evaluate the potential for sustaining these rates of biodegradation until fuel contamination is remediated to concentrations below regulatory limits; and 4) to evaluate four other fuel sites to determine the applicability of bioventing as a remediation alternative. Additional subsurface soils characterization will be done to further delineate the extent of the total petroleum hydrocarbon (TPH) contamination at the 3700 Fuel Yard.

1.1 PROJECT SCOPE OF WORK

The scope of work (SOW) for this project is oriented toward the collection of data to be used to evaluate bioventing as a remediation technology. The collection of data is focused primarily at the 3700 Fuel Yard, although treatability data will also be reviewed, along with available investigation data, to determine if bioventing is a potential remediation option at other fuel sites at Tinker AFB. Another key component of the SOW is the delineation of the subsurface total petroleum hydrocarbon (TPH) soil contamination at the site. A six vent well injection system will be constructed at the site and operated over a period of 1 year. Monitoring points and the blower operating parameters will be monitored periodically to determine the effectiveness of air injection over time and to adjust the operating parameters, as necessary, to optimize performance of the air delivery system (air injection). Final soil and soil gas samples will be collected and compared to initial sampling results to evaluate the overall efficiency of the system and to estimate the time required for site clean-up. The complete SOW is summarized in the project management plan (appendix A).

The pilot test will be conducted in three main phases. Vent wells (VWs) and monitoring points (MPs) will be installed during site characterization activities. The soils characterization will provide additional data on subsurface contamination to assist in delineation of contaminant plumes and to evaluate the remediation criteria of existing contamination. The initial stage will also include an *in situ* respiration test and an air permeability test. This initial testing is expected to take approximately 4 weeks. During the second phase, a bioventing system will be installed and operated over a 1-year period.

The final phase includes the final sampling of the soils and soil gas, and a 12-month in site respiration test.

Additional background information on the development and recent success of the bioventing technology is found in the *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Hinchee et al., 1992). This protocol development will also serve as the primary reference for pilot test well designs and detailed procedures which will be used during the test.

1.2 WORK PLAN ORGANIZATION

This work plan describes the data needs and methods of data collection to be used in the field to evaluate the use of bioventing to remediate contaminated soils at the 3700 Fuel Yard. It also describes the remedial design of the long-term, full scale bioventing system to be constructed for this treatability study.

This work plan is divided into eight sections including this introduction. Section 2 describes the site history, location, and environmental setting, and summarizes existing data on the extent of contamination at the 3700 Fuel Yard. Section 3 is a general description of bioventing as a remediation technology. Section 4 describes pilot test activities to be performed, including vapor monitoring point and vent well construction. Sampling strategy for the collection of data is also presented. The remedial design of the full scale bioventing system to be installed for the treatability study is provided in section 5. Section 6 describes the periodic system maintenance. Section 7 is the community relations plan prepared for this project. Section 8 contains the references used in preparing this document.

In addition to this work plan, there are four complementary plans prepared for this project, included as appendices to this plan.

- Appendix A: Project Management Plan. Project SOW, project organization, schedule, list of deliverables, and project budget.
- Appendix B: Data collection quality assurance plan. Descriptions of sampling procedures and other data collection protocols, analytical procedures and overall quality control of field and laboratory performance.
- Appendix C: Data management plan. Information on data records and formats for reporting and presenting the data.
- Appendix D: Health and safety plan. This plan includes health and safety information relative to planned activities and site characteristics.

A corrective action plan is also being prepared as a companion document to this work plan. The corrective action plan is a written proposal of the bioventing remedial action in response to the contaminated soils at the 3700 Fuel Yard, as required by the State of Oklahoma.

SECTION 2.0
SITE DESCRIPTION

2.1 SITE LOCATION AND HISTORY

The 3700 Fuel Yard, also referred to as POL storage area C and site ST32, is located midway along the eastern boundary of the base, between Warehouse Road and Douglas Boulevard. The location of POL storage area C with respect to the base is shown in Figure 2.1. The area of concern within this former jet fuel bulk storage area is located approximately 60 to 200 feet east of Building 3703.

Six underground storage tanks (USTs), each with a capacity of 25,000 gallons, were previously located in the 3700 Fuel Yard. Figure 2.2 depicts the site layout including locations of existing monitoring wells within and adjacent to the site. After serving in excess of 30 years as a fuel storage depot, the tanks were removed in 1991 along with approximately 1,500 cubic feet of fuel-contaminated backfill material. The excavated area has since been backfilled with clean sand, and the surface has been restored. Surface transportation and storage facilities have replaced the previous underground system. Jet fuel is now delivered by tanker truck to the site, where it is off-loaded into two aboveground storage tanks located at the southern boundary of the fuel yard.

The USTs, formerly located in the north portion of the fuel yard, had contained JP-4 jet fuel exclusively in recent years. Petroleum hydrocarbon contamination presumed to have leaked from these tanks or their pipelines is the target for bioventing treatment at this site (WSCI, 1992). A limited pilot test was initiated in 1992 to determine the feasibility of using bioventing to remediate TPH contaminated soils. One air injection vent well and three vapor monitoring points were installed at the site. Figure 2.3 indicates the location of the single blower bioventing pilot test initiated in 1992.

2.2 ENVIRONMENTAL SETTING

2.2.1 Climate

The climate at Tinker AFB is characterized by long, hot summers and mild winters. Droughts of varying duration in the summer and extremely cold and windy winter weather are not uncommon. Typically, summer temperatures range from approximately 66 to 94 degrees Fahrenheit, and winter temperatures range from 26 to 54 degrees Fahrenheit. The average annual rainfall is 40.45 inches, and the wettest month is typically May. The prevailing wind direction is from the south-southeast at an average windspeed of 12.4 miles per hour (mph). The wind direction is primarily from the north

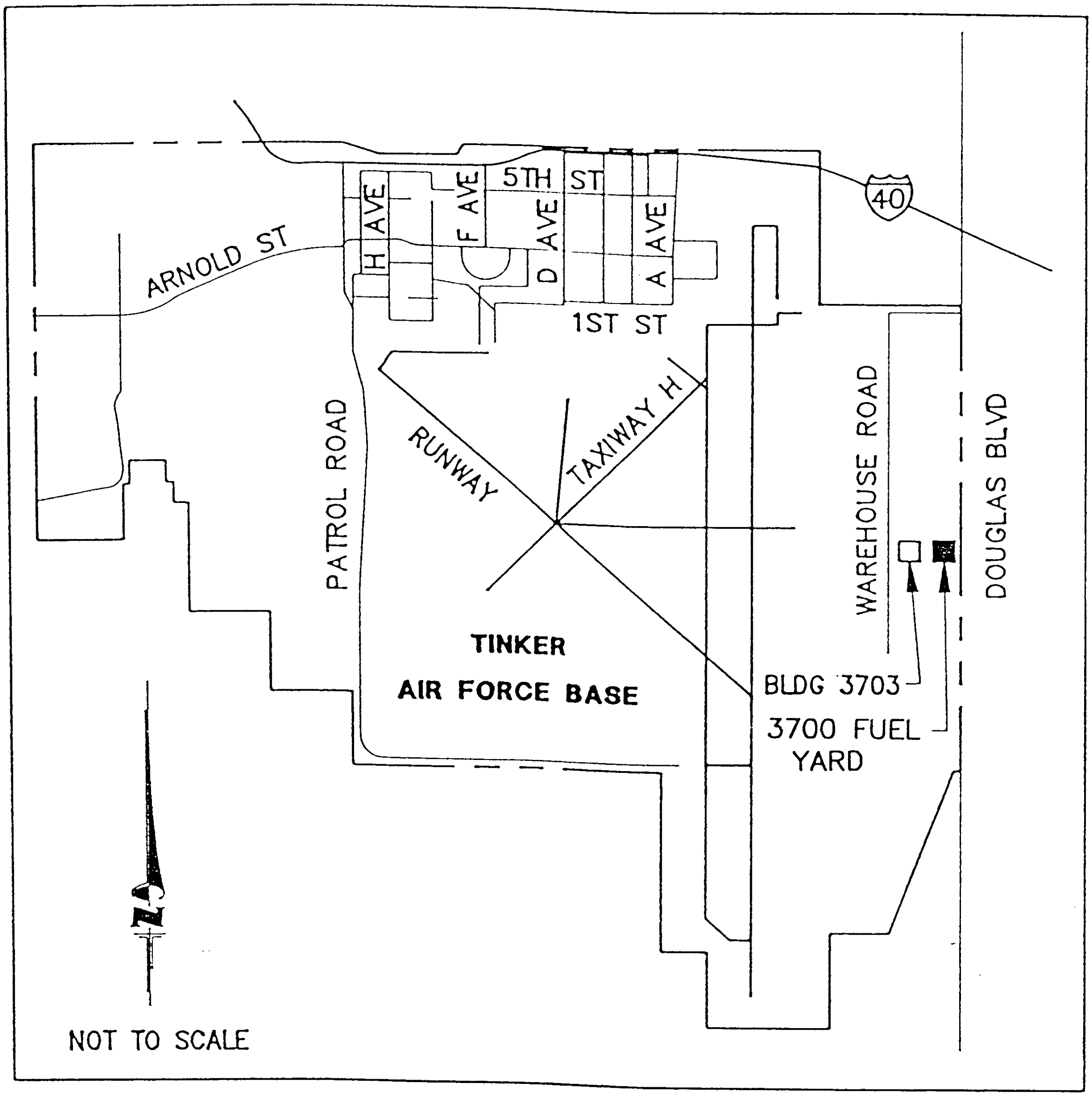

FIGURE 2.1
3700 FUEL YARD
LOCATION WITH RESPECT
TO BASE
TINKER AFB, OKLAHOMA

ENGINEERING–SCIENCE, INC.
AUSTIN, TEXAS

TKLOC 10/3/94

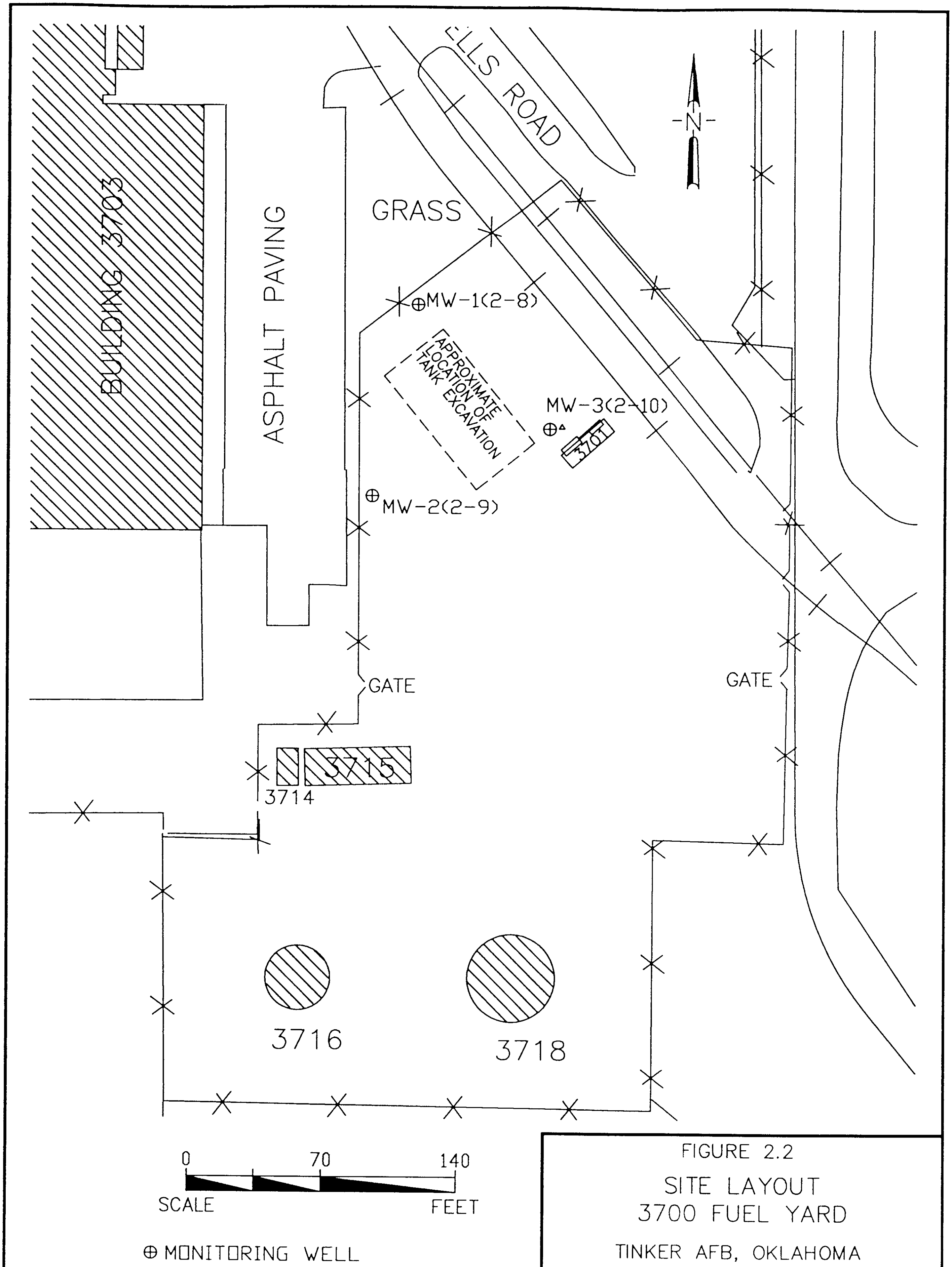

FIGURE 2.2

SITE LAYOUT
3700 FUEL YARD

TINKER AFB, OKLAHOMA

ENGINEERING-SCIENCE, INC.
AUSTIN, TEXAS

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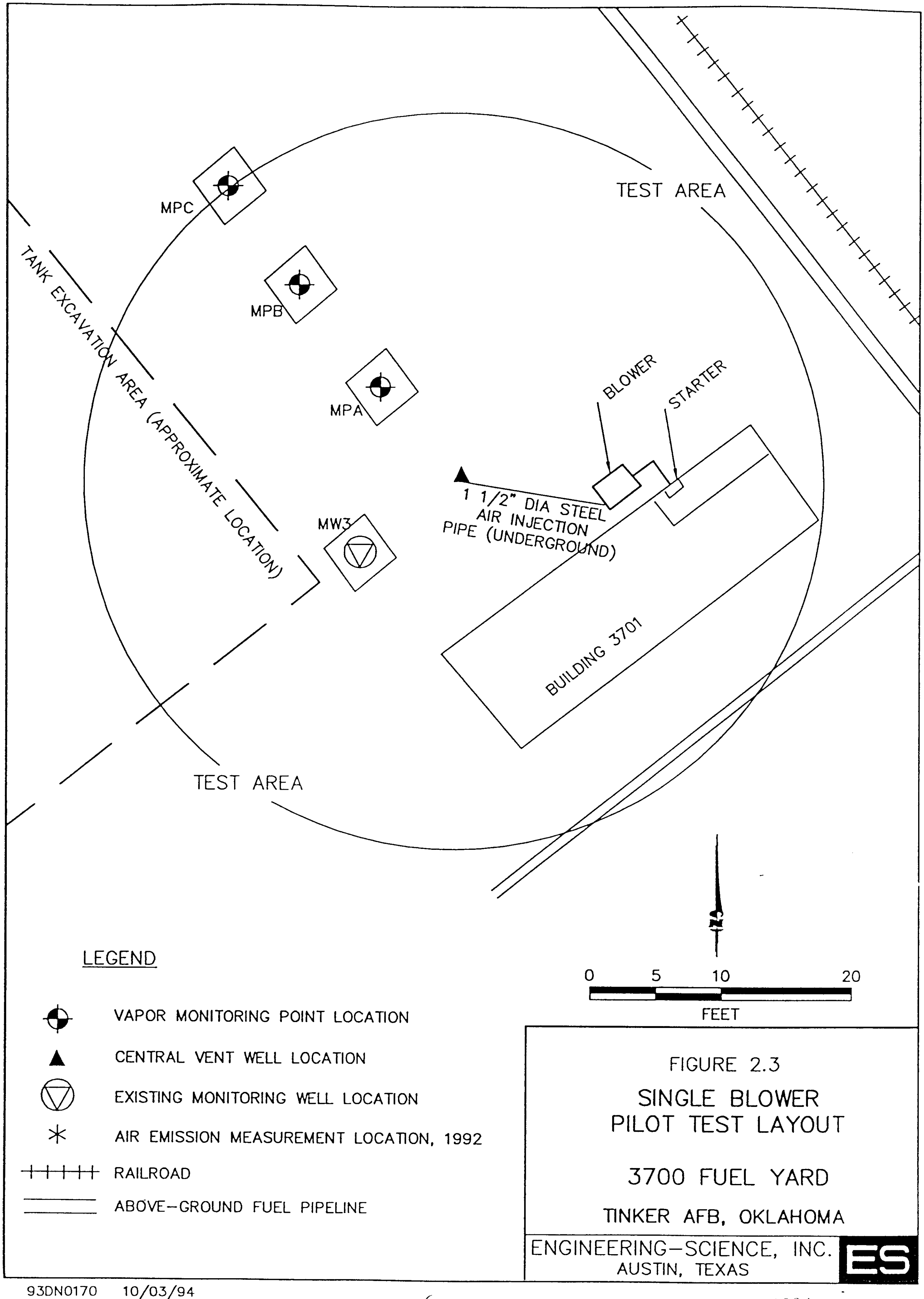
DECEMBER 21, 1994


TEST AREA
MPC
MPB
MPA
MW3
TANK EXCAVATION AREA (APPROXIMATE LOCATION)
BLOWER
STARTER
1 1/2" DIA STEEL
AIR INJECTION
PIPE (UNDERGROUND)
BUILDING 3701
TEST AREA
0
5
10
20
FEET
LEGEND
VAPOR MONITORING POINT LOCATION
CENTRAL VENT WELL LOCATION
EXISTING MONITORING WELL LOCATION
AIR EMISSION MEASUREMENT LOCATION, 1992
RAILROAD
ABOVE-GROUND FUEL PIPELINE
FIGURE 2.3
SINGLE BLOWER
PILOT TEST LAYOUT
3700 FUEL YARD
TINKER AFB, OKLAHOMA
ENGINEERING-SCIENCE, INC.
AUSTIN, TEXAS
ES
93DN0170 10/03/94

2.2.2 Physiography and Topography

Tinker AFB is located within the Central Redbed Plains section of the Central Lowland physiographic province. The area is characterized by nearly level to gently rolling hills, broad flat plains, and well-entrenched main streams. The valleys of secondary streams may exhibit a sag-and-swale appearance, indicative of the erosion of the somewhat cohesive residual soils (IT, 1993).

Local relief is primarily the result of dissection by erosional activity or stream channel development. At Tinker AFB, ground surface elevations vary from 1,190 feet above mean sea level (MSL) near the northwest corner where Crutcho Creek intersects the Tinker AFB boundary to approximately 1,320 feet MSL at area D, located on 59th Street, east of the main installation. The elevation of the 3700 Fuel Yard site is approximately 1,271 feet MSL (Soil and Water Consultants, 1992).

Drainage of Tinker AFB land areas occurs overland by flow of runoff to diversion structures and thence to area surface streams, which flow intermittently. The northeast portion of Tinker AFB is drained primarily by unnamed tributaries of Soldier Creek, which is a tributary of Crutcho Creek. The north and west sections of Tinker AFB, including the main runway, drain to Crutcho Creek, a tributary of the North Canadian River. Two small unnamed intermittent streams crossing installation boundaries south of the main instrument runway generally do not receive significant quantities of runoff from Tinker AFB because of site grading designed to preclude such drainage. These streams extend to Stanley Draper Lake, approximately 1/2 mile south of Tinker AFB (IT, 1993). The area in the vicinity of the site is generally flat with steep sloping relief located on the southern portion of the site and east of the railroad to the east.

2.2.3 Site Soils

Soils at this site consist of silty clay in the upper 2 to 4 feet overlying weathered sandstone. The weathered sandstone is generally very friable and consists of fine- to very fine-grained sand, with grain size increasing with depth (Parsons ES, 1992). During installation of the bioventing pilot test wells, a silty layer was encountered from 7 to 12 feet below ground surface (bgs), and the sandstone was slightly to moderately cemented below about 15 feet bgs. Groundwater occurred at depths between 16.5 and 17.0 feet bgs in the vent well installed and in nearby existing monitoring wells. Figure 2.4 is a hydrogeologic cross-section of the subsurface soils encountered during installation of the vent well and three monitoring points (Figure 2.3). This cross-section also depicts contaminant concentrations encountered during drilling activities.

2.2.4 Site Geology and Hydrogeology

At the 3700 Fuel Yard site, the top of the Garber Sandstone formation occurs at shallow depths, typically less than 4 feet. The sandstones are red-brown, fine to very fine grained, silty in part, and for the most part poorly cemented and friable. These

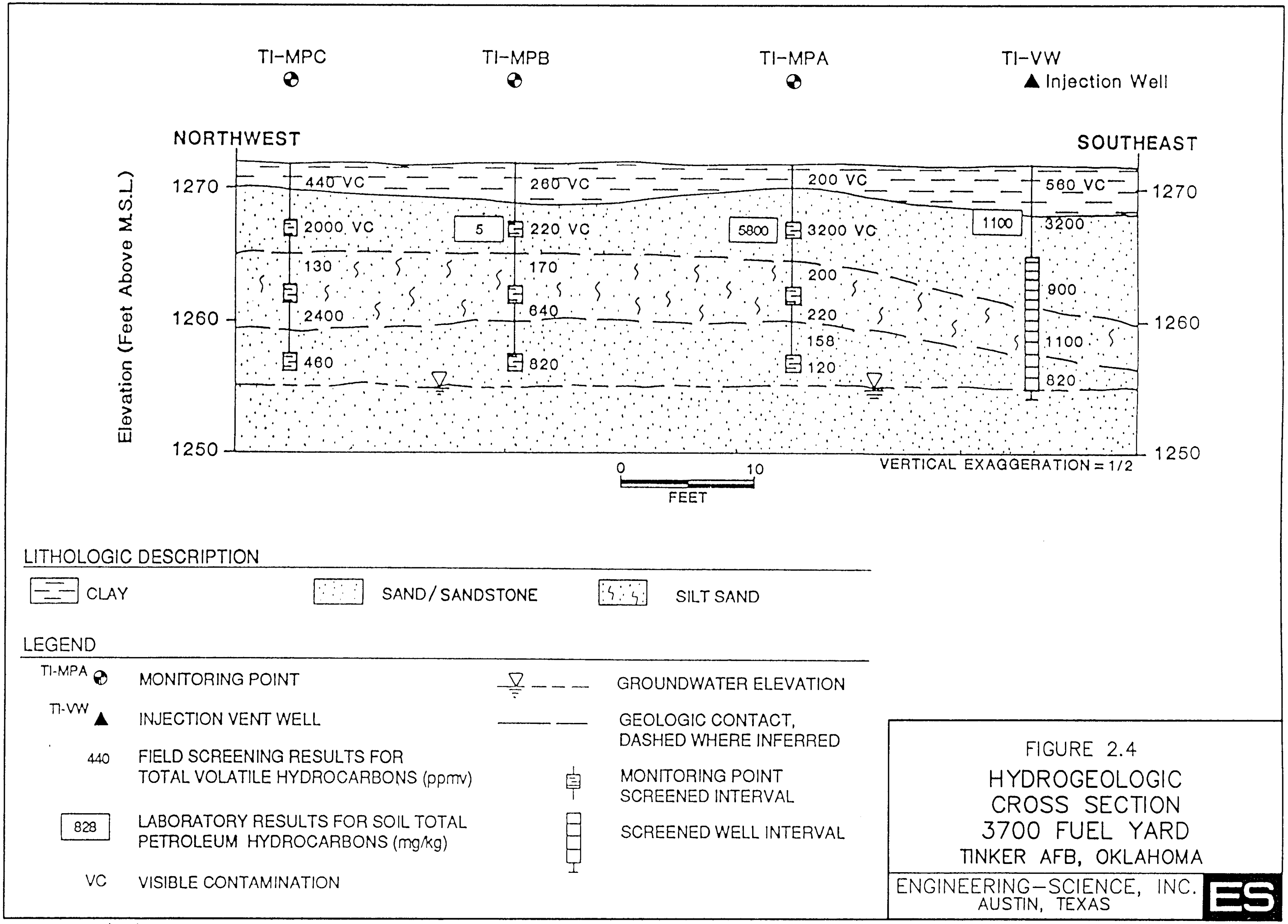


FIGURE 2.4
HYDROGEOLOGIC CROSS SECTION
3700 FUEL YARD
TINKER AFB, OKLAHOMA

TKXSEC 9/27/94

sandstones are overlain by clayey, fine-grained sands. A perched aquifer exists locally. This aquifer is encountered at a depth of approximately 17 feet below ground surface and generally flows eastward. Groundwater flow direction may be influenced locally by surface water and utility corridors. The perched water is separated from deeper producing zones of the Garber Sandstone formation by intervening, confining shales; thus, contamination of deeper zone water supplies is not considered an immediate threat (WSCI, 1992).

2.3 SITE CONTAMINANT DISTRIBUTION

Several investigations have been conducted to assess the contamination at the 3700 Fuel Yard site. The initial investigation was performed in 1990 and indicated significant soil contamination from petroleum products had occurred (ERI, 1990). The six 25,000-gallon underground storage tanks were removed in April 1991 after two USTs were determined to be leaking (WSCI, 1992).

A remedial investigation (RI) conducted in 1992 that concluded the bulk of petroleum-contaminated soils were confined to a depth of less than 10 feet and to the area immediately surrounding the former underground storage tank pit (WSCI, 1992). This RI was unable to fully delineate the extent of the petroleum contaminant plume.

Additional soil samples were also collected in 1992 during installation activities of a bioventing pilot test system at the site. Significant hydrocarbon contamination was encountered on the north side of the former storage tank pit and was confined primarily to the upper 15 feet of soil and weathered sandstone. Contamination decreased noticeably at approximately 15 feet bgs and below, where the sandstone appeared more structurally cementateous (Parsons ES, 1992).

The investigation to delineate the contaminant plume was continued for a RCRA facility investigation; however, only draft, unvalidated data were available for review. These data suggest that petroleum-contaminated soils are also present south of the former UST pit. A total petroleum hydrocarbon concentration of 4,700 ppm was detected in a soil sample collected from 16 to 17 bgs in a soil boring located approximately 40 feet from the former UST pit (IT, 1994, draft data).

Figure 2.5 depicts the extent of the 500 mg/kg TPH contamination plume, estimated from the previous investigation data. TPH contamination has been detected in soils and groundwater at depths ranging from 5 to 35 feet bgs. Concentrations of 4,700 mg/kg have been detected at 16 to 17 feet in one soil boring south of the former pit, and concentrations of up to 1,070 mg/kg were detected to the northeast of the pit. Several other borings have been drilled with no detectable contamination to enable determining partial delineation of the plume. The delineated TPH plume was drawn using the highest detected level of TPH in samples collected from each borehole regardless of the sampled depth. The majority of contamination is presumed to be between 5 and 17 feet bgs.

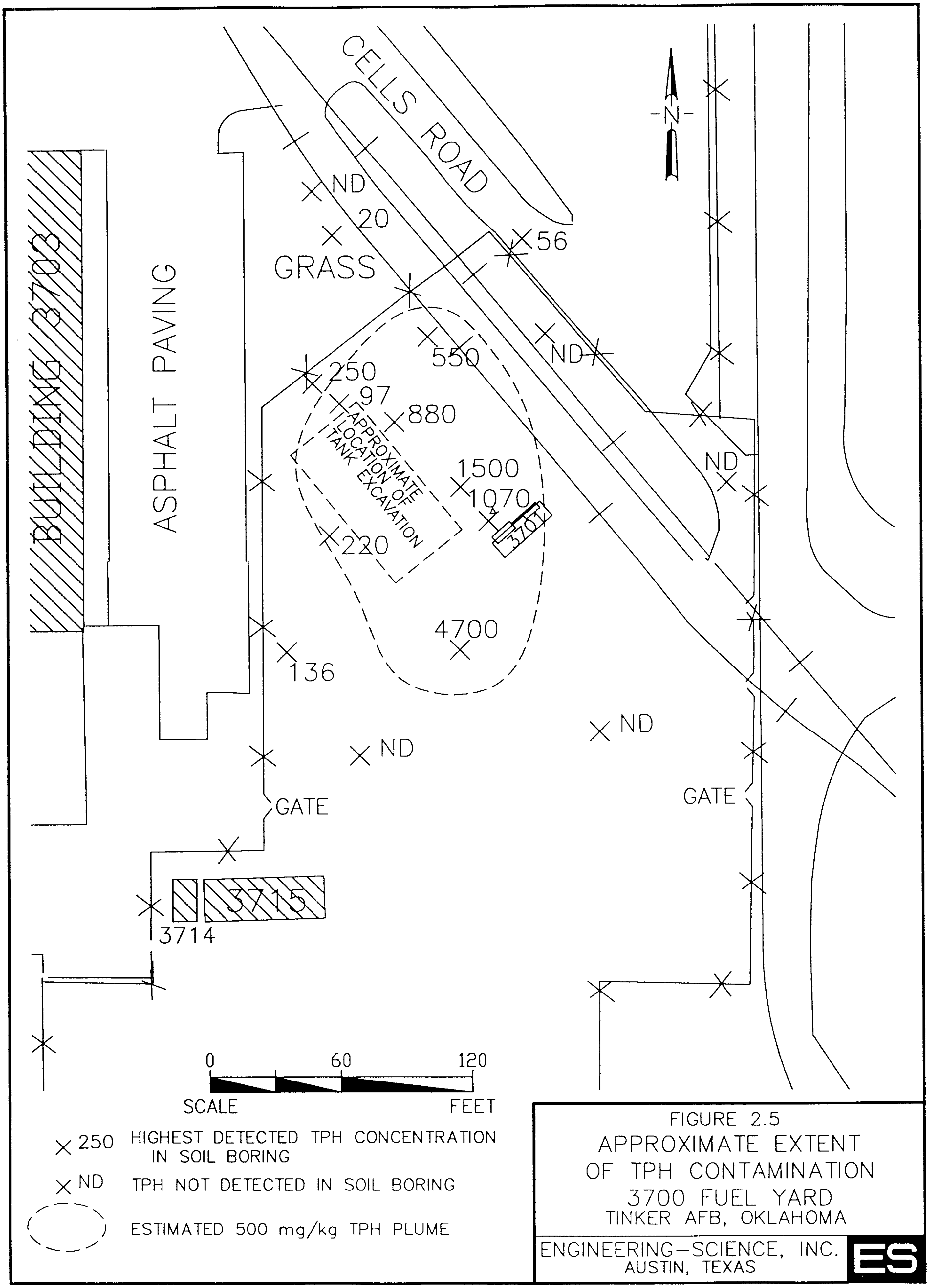


FIGURE 2.5
APPROXIMATE EXTENT OF TPH CONTAMINATION
3700 FUEL YARD
TINKER AFB, OKLAHOMA

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SECTION 3.0 REMEDIAL TECHNOLOGY DESCRIPTION

Bioventing is an innovative technology which uses low rates of air injection to supply oxygen to soil bacteria and enhance biodegradation of fuel hydrocarbons in vadose zone soils. The process provides oxygen to indigenous soil microorganisms promoting aerobic metabolism of the substrate compounds (typically fuel hydrocarbons). With careful control of airflow rates, volatile compounds can be biodegraded without being mobilized from soils.

The use of an air-based oxygen supply for enhancing biodegradation relies on the air flow injected from the blower system, and on a configuration of vent wells that will ensure adequate oxygenation for aerobic biodegradation while minimizing or eliminating volatilization of hydrocarbon contamination. A key feature of testing the effectiveness of a bioventing configuration is the use of discreet soil gas monitoring points to allow sampling of soil gas in short vertical sections of the soil to be sampled. These points are located at various distances from the vent wells and typically are screened at two or more depths. Sampling of these points can provide data on the ability of the vent well system to oxygenate the surrounding contaminated soil. The monitoring points can also be used to evaluate respiration rates (oxygen utilization) of microorganisms in different portions and depths of the contaminated soils, and to measure pressure responses from injection into the vent wells to determine air permeability of the soils.

The primary objectives of bioventing is to degrade most, if not all, of the contaminants in the vadose soils and to minimize volatilization of contaminants. The biodegradation of fuel produces only carbon dioxide and water as byproducts. Little or no transfer of contamination to the atmosphere takes place in a properly designed bioventing system. If a building or subsurface structure exists within the radius of influence of the air injection well, hydrocarbon vapors could be forced into that structure. In such a case, protection of subsurface structures would be required. No buildings or subsurface structures are anticipated to be affected by air emissions or vapor phase hydrocarbon intrusion in the vicinity of the 3700 Fuel Yard.

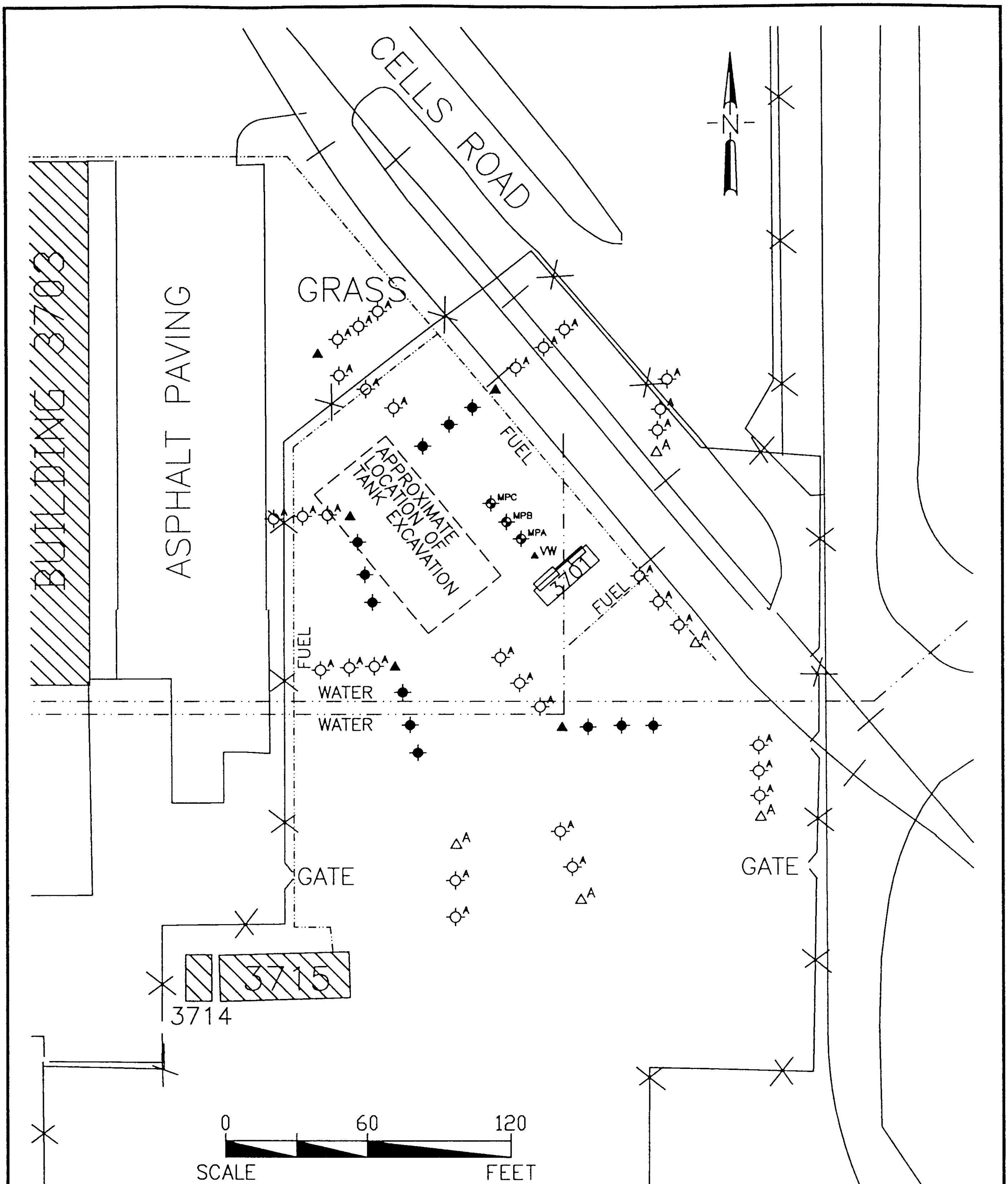
A bioventing pilot test was performed at the 3700 Fuel Yard site in November of 1992 to determine the feasibility of this technology for reducing levels of benzene, toulene, ethyl benzene, and xylene (BTEX) and TPH in contaminated soils (Parsons ES, 1992). One air injection vent well and three VMPs were installed near the limits of the former tank pit. The results demonstrated that between 420 and 900 milligrams of fuel per kilogram of soil can be degraded each year at the site. The radius of influence for oxygen dispersion from the vent well was at least 28 feet. These positive results led to upgrading to a full-scale bioventing system for site remediation.

SECTION 4.0
TREATABILITY STUDY ACTIVITIES

The purpose of this section is to describe the work that will be performed by Parsons Engineering-Science, Inc. (Parsons ES) at the 3700 Fuel Yard site (POL area C) during the bioventing treatability study. ES will perform siting and construction of an additional five vent wells and twelve monitoring points to complement the existing single blower pilot system. *In situ* respiration tests; air permeability tests; soil flux, soil gas, and groundwater sampling; and periodic monitoring and sampling of a long-term bioventing treatability test system will also be conducted. Soil borings drilled for installation of monitoring points and vent wells will also be sampled to more fully characterize and delineate the soil contamination of the vadose zone in the vicinity of the POL site. If significant fuel contamination is encountered outside the proposed vent well grid, then additional VWs may be constructed in the contaminated boreholes for use in this treatability study. Testing activities performed on any existing wells will be limited to field screening of soil gas samples. Soil, soil gas, soil flux (air emission), and groundwater sampling procedures; the vent well grid configuration; and the blower set up that will be used to inject air (oxygen) into contaminated soils are also discussed in this section. Treatability testing activities will be confined to unsaturated soils remediation. Groundwater monitoring wells which have a portion of their screened interval above the water table may be used as screening vapor MPs or to measure the composition of background soil gas.

4.1 SITE LAYOUT

Figure 4.1 illustrates the proposed locations of vent wells and monitoring points to be installed at the site. Also shown is the existing single blower system installed in 1992. Although five vent wells and twelve monitoring points are planned, the grid layout includes several alternate boring locations to be cleared for utilities in the event significant fuel contamination is not observed in the planned locations. The grid shown on figure 4.1 was developed using soil data collected from previous investigations to select the portions of the site that are expected to be most contaminated. The spacing between soil borings was determined based on existing radius-of-influence data generated from the bioventing pilot test previously performed at the 3700 Fuel Yard. Radius of influence at the site is estimated conservatively to be between 35 to 45 feet from the injection point. From review of boring logs drilled at the site, the soils are presumed to be relatively uniform. The planned distance between two injection vent wells is estimated at 80 feet to allow for a small degree of overlap. Over time, the entire area of influence from the injection system of six vent wells will probably extend beyond 45 feet,



▲VW EXISTING INJECTION VENT WELL

⊕MPC EXISTING MULTIDEPTH MONITORING POINT

▲ PROPOSED VENT WELL LOCATION*

◆ PROPOSED MONITORING POINT LOCATION*

△A ALTERNATE VENT WELL LOCATION

⊕A ALTERNATE MONITORING POINT LOCATION

*NOTE: ONLY 17 BOREHOLES ARE PLANNED. ADDITIONAL LOCATIONS ARE PROVIDED IN THIS FIGURE AS OPTIONAL, TO ALLOW FOR CONTINGENCIES BASED ON FIELD SCREENING RESULTS.

FIGURE 4.1

PROPOSED SOIL BORING GRID LAYOUT

3700 FUEL YARD

TINKER AFB, OKLAHOMA

ENGINEERING–SCIENCE, INC.
AUSTIN, TEXAS

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so this spacing should be sufficient to supply air and maintain oxygen levels for all of the contaminated subsurface soils at the site.

The soil borings will be drilled starting in the center of the contamination plume and moving toward the outside to delineate the TPH plume. At least one boring is planned outside the established grid in each direction. Initial determination of the plume limits will be based on field screening of the soil boring cores during drilling. Some soil borings drilled in uncontaminated soils may be abandoned if the twelve planned multi depth monitoring points have already been constructed.

4.2 VENT WELL

Five vent wells will be installed at the site at locations as discussed in Section 4.1. The VWs will be used for treatability testing purposes and will be constructed of 4-inch inside-diameter (ID), schedule 40 polyvinyl chloride (PVC) with a 10-foot interval of 0.04-inch slotted screen set at 5.5 to 18 feet bgl. Flush-threaded PVC casing and screen will be used with no organic solvents or glues. The filter pack of clean, well-rounded silica sand with a grain size of 6 to 9 and will be placed in the annular space of the screened interval. A 2-foot layer of bentonite pellets, hydrated in place with potable water, will be placed directly over the filter pack. This layer of pellets will prevent the addition of bentonite slurry from saturating the filter pack. A bentonite-cement grout will then be added into the remaining annular space above the bentonite pellets to produce an airtight seal above the screened interval. A complete seal is critical to prevent injected air from short-circuiting to the surface during the bioventing test. Figure 4.2 illustrates the proposed construction of a typical VW for this site. This figure also shows the proposed piping for underground connection to the vent well and its associated protective concrete vault.

Although contaminated soils may exist above 5.0 feet bgs, the 5.5-foot depth was chosen for the top of the screened interval to reduce the potential of short-circuiting of injected air to the surface. It is likely that oxygen can still be delivered to the shallow soils by vertical flow and diffusion. The bottom of the screened interval at 18 feet bgs will be set into the top of the perched water which is present at approximately 16.5 to 17.0 feet bgs. Placing the screened interval of the injection well into the water table will allow oxygenation of soils in this zone if the water table subsides during the life of the air injection system.

4.3 MONITORING POINTS

Figure 4.3 depicts a typical multi depth vapor MP construction for this site. Soil gas oxygen and carbon dioxide concentrations will be monitored at depths of 5 feet, 10 feet, and 15 feet at each location. Multi-depth monitoring will confirm that the entire soil profile is receiving oxygen, and will serve to measure fuel biodegradation rates at each depth. The spaces between monitoring intervals will be sealed with bentonite to isolate

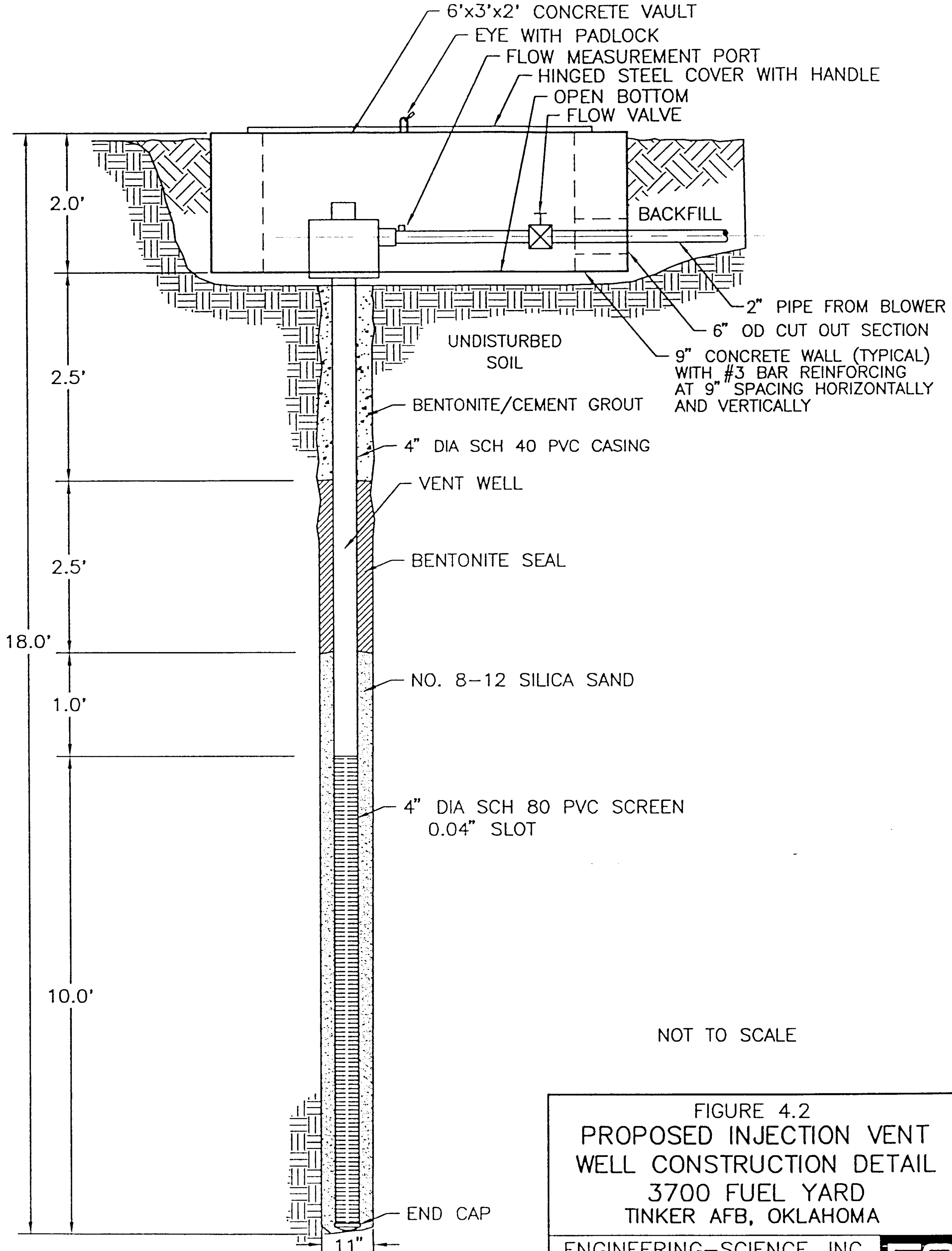

FIGURE 4.2
PROPOSED INJECTION VENT WELL CONSTRUCTION DETAIL
3700 FUEL YARD
TINKER AFB, OKLAHOMA

ENGINEERING-SCIENCE, INC.
Austin, Texas

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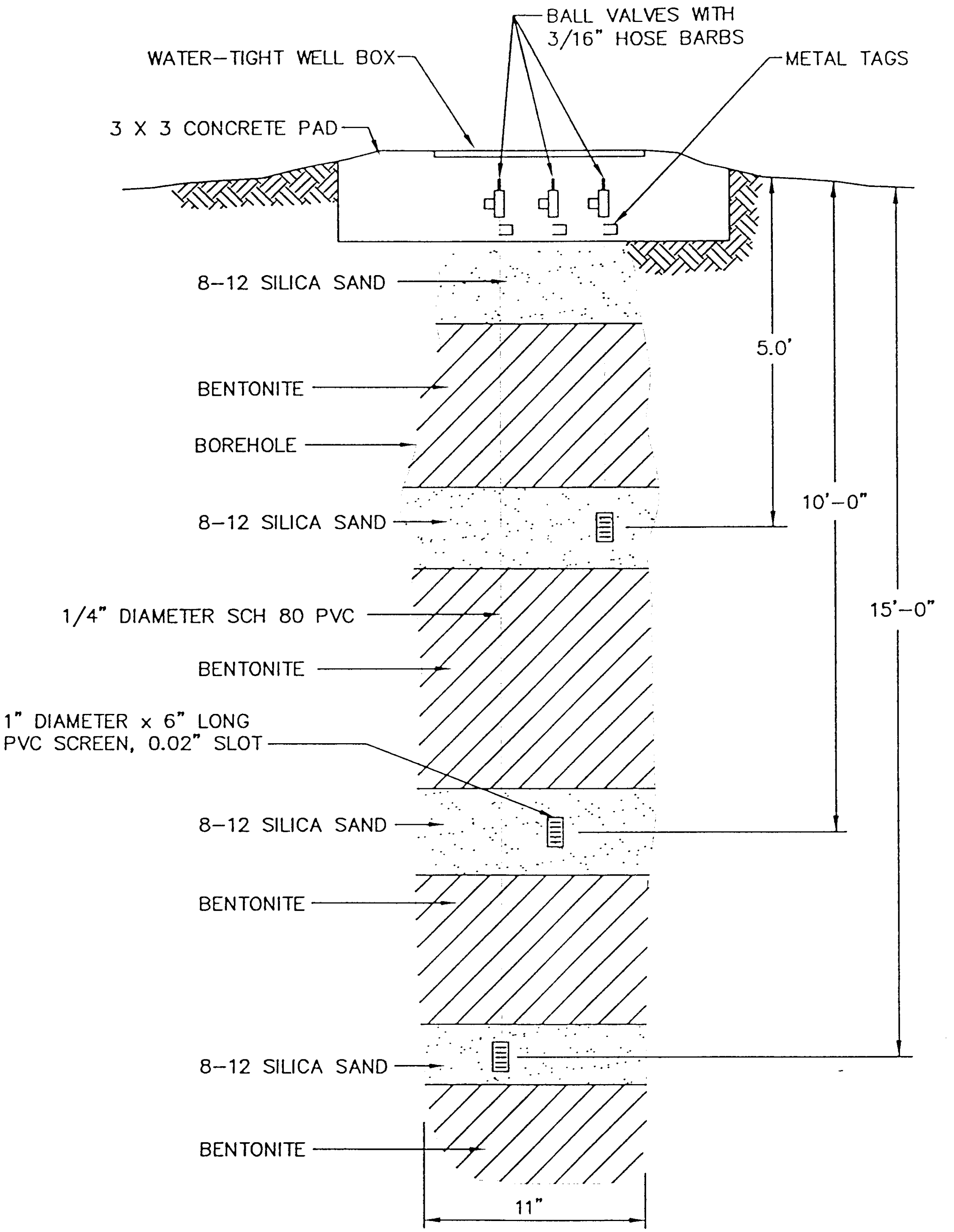

FIGURE 4.3

PROPOSED MONITORING POINT
CONSTRUCTION DETAIL
3700 FUEL YARD

TINKER AFB, OKLAHOMA

ENGINEERING-SCIENCE, INC.
AUSTIN, TEXAS

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the intervals. As with the VW construction, several inches of hydrated bentonite pellets will be used to shield the filter pack from rapid infiltration of bentonite slurry additions. Soil temperature will be monitored using thermocouples installed at depths of 5 feet and 15 feet bgs in the existing monitoring point closest to the single blower injection vent well (MPA). Additional details on VW and MP construction are found in section 4 of the protocol document (Hinchee et al., 1992).

4.4 HANDLING DRILL CUTTINGS

Investigation-derived waste from field activities consists of soil cuttings, decontamination water, monitoring well purge water, and investigation trash such as personal protective clothing and construction debris. All soil cuttings and wastewaters will be collected in US Department of Transportation approved containers. The containers will be labeled and stored inside the 3700 Fuel Yard in the general vicinity of the bioventing installation. All containers will be placed on pallets. Unless required, plastic sheeting, disposed protective clothing, and miscellaneous trash will be treated as a solid nonhazardous waste and will be placed in construction-type dumpsters for disposal.

Disposal of wastewaters will be coordinated through Tinker AFB. Disposal of water through the industrial wastewater treatment plant or the groundwater treatment plant requires a copy of the water analysis. The water must be nonhazardous. Up to five samples of soil cuttings contained in drums will be analyzed to characterize the waste cuttings for disposal. The cuttings will be handled and disposed of in accordance with the pertinent laws and regulations. Transport of any hazardous wastes generated at the site will be by a transporter registered with the State of Oklahoma and to a landfill, treatment facility, or storage facility approved and permitted by the State of Oklahoma and the federal government to handle the specific waste generated. All drums must be removed from the temporary storage in the 3700 Fuel Yard within 90 days after being generated.

4.5 SAMPLE DATA ACQUISITION ACTIVITIES

This section sets forth sampling and guidance for field work by describing the sampling and data gathering activities to be performed as part of this treatability study. Soil samples will be collected to determine the baseline conditions of contaminated soils in the TPH plume, and to delineate the actual extent of the plume. Groundwater samples will be collected in the three monitoring wells in the vicinity of the site to assess the current condition of the perched water underlying the soil contamination in the vadose soils. Soil flux (air emission) samples will be collected before and during operation of the bioventing system to determine if contaminant emissions occur from the soil under undisturbed conditions and during air injection. Finally, soil gas samples will be collected from each monitoring point (at three depths in each monitoring point) at 4 month intervals over a period of 12 months. This will provide data for assessing the relative contaminant levels over the operation time of the bioventing system.

A summary of the sampling activities follows. Details of the activities, including sampling procedures and quality assurance/quality control (QA/QC) methods, are presented in the data collection quality assurance plan (appendix B). The sample identification scheme is described in the data management plan (appendix C).

4.5.1 Soil Sampling

Soil drilling and sampling will be used to characterize the nature and extent of vadose zone soil contamination in the 3700 Fuel Yard. A total of seventeen soil borings will be drilled to a depth of approximately 18 feet using continuous-flight hollow-stem augers. The tentative locations of the borings are shown on Figure 4.1. This figure shows more than seventeen boreholes to allow changes to be made in the characterization and vent well configurations based on field screening observations during drilling of the initial borings at the site. Permanent bioventing wells or monitoring points will be installed at seventeen of these soil boring locations. A background vapor monitoring point (VMP) will also be installed in an uncontaminated area designated by Tinker AFB.

Soil cores will be collected continuously using a split-spoon or core-barrel sampler. The lithology of each core will be described on a soil boring logsheet. Soil cores will be carefully evaluated to determine the vertical depth and relative concentration of any visible contamination. The core samples will be screened with an organic vapor analyzer, and at least one sample per boring will be placed into a container for headspace analysis. Samples for chemical analysis will be collected in 5-to 6-foot intervals and will be handled in accordance with the data collection quality assurance plan (DCQAP). The analytical requirements for the soil samples are also described in the DCQAP, which is appendix B to this work plan.

After the bioventing treatability test operates for 12 months, five more soil borings will be drilled to evaluate the effectiveness of the 12-month bioventing study to remediate contaminated soils at the site. The five borings will be drilled approximately 5 feet from those initial soil borings which exhibited the greatest levels of contamination. Three samples will be collected from each soil boring at the same depths as those collected in the corresponding borehole 12 months earlier. The samples will be collected and handled in accordance with the DCQAP and analyzed for the same parameters as the initial soil samples.

4.5.2 Groundwater Sampling

Three monitoring wells were constructed at the site in 1992. Their locations relative to the excavation area are shown on Figure 2.2. One groundwater sample will be collected from well 2-8, well 2-9, and well 2-10. Groundwater samples each will be collected and analyzed as described in the DCQAP. These data will define current contaminant levels in the groundwater resulting from the migration of fuel contaminants from the TPH plume in the vadose soils.

4.5.3 Flux Soil Sampling (Air Emissions)

Soil flux sampling will be conducted at the locations shown on Figure 4.4. The purpose of the flux sampling in these areas will be to more accurately estimate any upward diffusion of volatile organic compounds from the soil into the atmosphere or potentially into buildings adjacent to the 3700 Fuel Yard contaminant source area. Flux samples will be collected using procedures outlined in EPA guidance document, "Measurement of Gaseous Emissions Rates from Land Surfaces Using an Emission Isolation Flux Chamber" (Radian, 1985). Soil flux samples will be collected in Summa™ canisters. Sample handling and analytical methods are more fully described in the DCQAP.

4.5.4 Soil Gas Sampling

Soil gas samples will be collected from fifteen vapor monitoring points. Three VMPs were installed with the initial bioventing pilot test, and twelve will be installed as part of this study. Each VMP is constructed with three distinct screened sample intervals. The forty-five discrete sampling intervals will be sampled initially after installing the twelve new VMPs and before beginning any other testing. Three corresponding depths of the background VMP will also be sampled and analyzed during the initial soil gas characterization. The samples will first be field screened, then the samples will be collected in Summa canisters. Sampling methodology, handling, and analytical requirements are described in the DCQAP.

The discrete MP intervals sampled during the initial testing will be resampled and analyzed after 4 months, 8 months, and 12 months of operating the bioventing treatability system. The system will be shut down 21 days before these periodic soil gas samples are collected so that the stagnant soil gas conditions will more closely reflect those from the initial sampling. This will enable a direct comparison of soil gas data with previously collected data to more accurately evaluate the progress or efficiency of the bioventing treatability system.

Soil gas screening will be performed to assist in the evaluation of bioventing as a remediation alternative at four other fuel sites: the 290 Fuel Farm, area A service station, BX service station, and the fuel purge facility. Soil gas samples will be collected using existing monitoring wells and a maximum of 5 manually driven soil gas points at each site. These samples will be screened using portable field instruments to measure percent oxygen, percent carbon dioxide, and total volatile hydrocarbon content. Soil gas screening at these four sites will be performed during the same mobilization as the pilot test activities during the system installation at the 3700 fuel yard.

4.6 *IN SITU* RESPIRATION TEST

The objective of the *in situ* respiration test is to determine the rate at which soil bacteria degrade petroleum hydrocarbons. Respiration tests will be performed at selected depth intervals in at least six MPs where bacteria biodegradation of hydrocarbons is

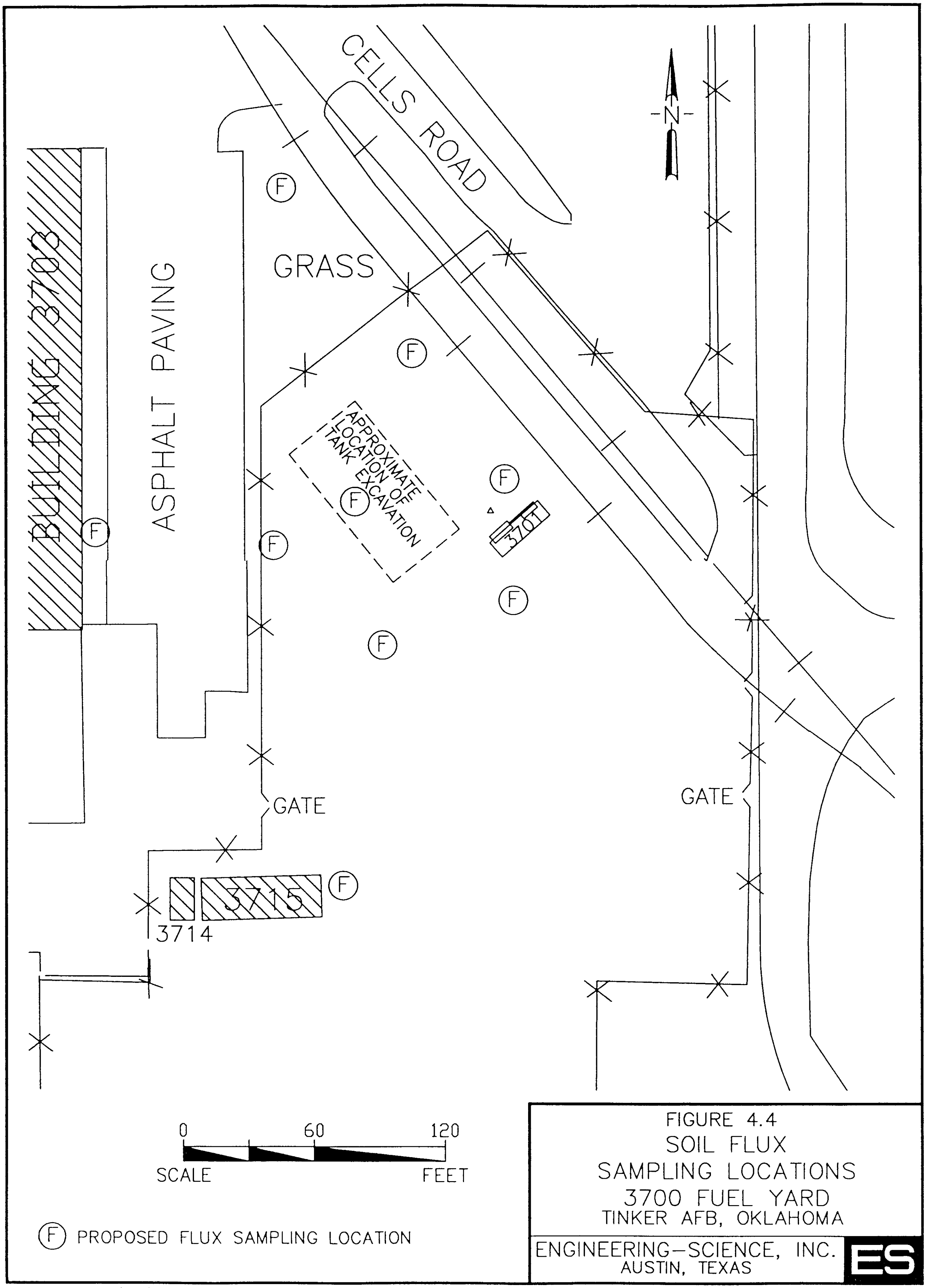

FIGURE 4.4
SOIL FLUX
SAMPLING LOCATIONS
3700 FUEL YARD
TINKER AFB, OKLAHOMA

TKFLUX 10/03/94

indicated by low oxygen levels and elevated carbon dioxide concentrations in the soil gas. A 1-cubic-foot-per-minute (cfm) pump will be used to inject air into the selected MP depth intervals containing low levels (<2 percent) of oxygen. A 20-hour air injection period will be used to oxygenate local contaminated soils. At the end of the 20-hour air injection period, the air supply will be cut off, and oxygen and carbon dioxide levels will be monitored for the following 48 to 72 hours. The decline in oxygen and increase in carbon dioxide concentrations over time will be used to estimate rates of bacterial degradation of fuel residuals. Helium will also be injected at each MP to account for oxygen loss to diffusion or leakage. In site respiration tests will be performed on four vapor monitoring points during the initial testing activities and after 12 months of air injection to compare the effect of contaminant reduction on oxygen utilization rates. Additional details on the *in situ* respiration test are found in Section 5.7 of the protocol document (Hinchee et al., 1992).

4.7 AIR PERMEABILITY/OXYGEN INFLUENCE TEST

The objective of the air permeability test is to determine the extent of the subsurface that can be oxygenated using one air injection VW. Three separate air permeability tests will be conducted at the site. Air will be injected into each tested 4-inch-diameter VW using a blower, and pressure response will be measured at each MP with differential pressure gauges to determine the region influenced by the unit. Oxygen will also be monitored in the MPs to verify that oxygen levels in the soil increase as the result of air injection. Three air permeability tests lasting approximately 4 to 8 hours each will be performed.

SECTION 5.0 BIOVENTING SYSTEM INSTALLATION AND DESIGN

A full-scale bioventing system will be installed to operate with minimal interruption for 1 full year. This section describes the design criteria and installation details for this bioventing system.

5.1 BASIS OF DESIGN

5.1.1 Siting Criteria

Identification of hydrocarbon contamination in the 3700 Fuel Yard is the governing site criteria in designing the bioventing system. Figure 2.5 details the approximate extent of TPH contamination known to exceed the 500 mg/kg clean up standard. Other site related design goals are to use existing wells and structures when feasible, to identify and avoid subsurface utility hazards, and locate components requiring power near existing utilities.

5.1.2 System Criteria

The primary objective of designing the bioventing system is to deliver air to the contaminated region at the appropriate flow rate and pressure as indicated from pilot testing. The Draft Interim Pilot Test Results Report (Parsons ES 1992) was used to determine the full-scale system size and configuration to provide oxygen to the contaminated soils. The radius of influence (ROI) around each vent well is another key parameter to consider when designing a bioventing grid pattern. The ROI is the radial distance from each injection well in which increased oxygen levels can be sustained over long periods of time to promote aerobic respiration in contaminated (oxygen depleted) soils. The ROI used to develop the conceptualized grid spacing for the vent wells is 35 to 45 feet. This is a conservative estimate based on the results of the pilot testing. Using figure 2.5, the contaminant delineation from the ROI, five VWs and twelve VMPs will be installed at the site. The existing single-blower bioventing system will be maintained as the sixth injection point in the six-well, full-scale system. Figure 5.1 details the tentative location of VWs and VMPs. The existing blower system with its single vent well and three VMPs is also shown as part of the vent well grid on figure 5.1. The VWs are located 80 feet apart to allow minimum overlap and achieve full coverage of the contaminated soil for air delivery. Figure 5.1 also identifies alternative locations for MP installation in the event field conditions encountered necessitate modifying the grid.

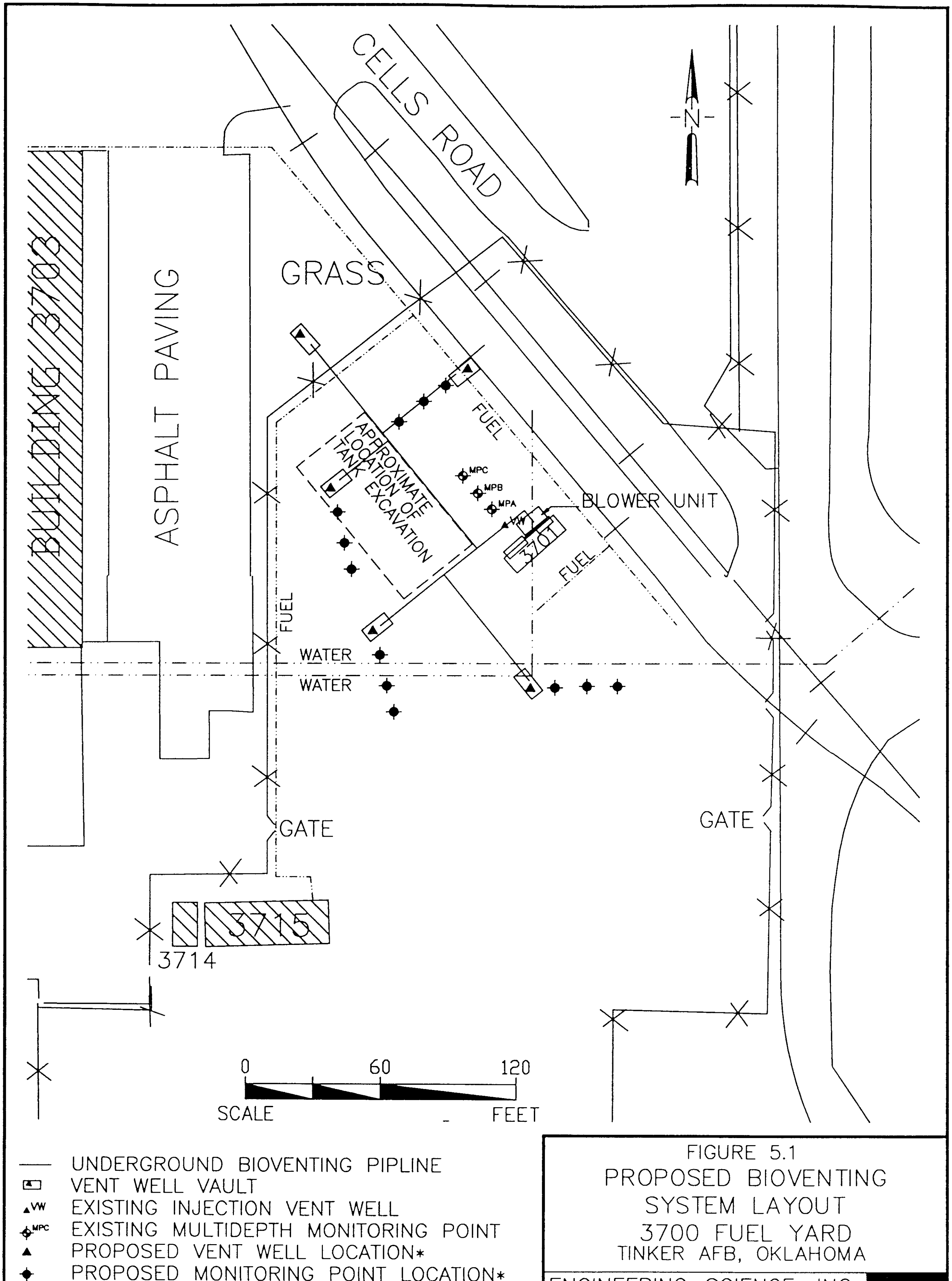

FIGURE 5.1
PROPOSED BIOVENTING SYSTEM LAYOUT
3700 FUEL YARD
TINKER AFB, OKLAHOMA

ENGINEERING–SCIENCE, INC.
AUSTIN, TEXAS
ES

In sizing the blower assembly, it is calculated that an air delivery rate of 25 standard cubic feet per minute (scfm) at a pressure of approximately 60 inches of water to each VW will provide sufficient ROI. A 2.5-horsepower regenerative blower with a capacity of up to 75 scfm at 60 inches of water has tentatively been selected for installation to provide low-maintenance, trouble-free operation to the five newly installed vent wells. The size of this blower may be upgraded based on the results of the pilot testing. The existing single-blower injection system currently at the site will continue to be maintained at the site as part of the full-scale system. The piping system for the full scale system will be installed underground. The piping scheme shown on Figure 5.1 minimizes trenching distance and avoids unnecessary crossing of utility lines.

5.2 INSTALLATION

Installation of the bioventing system will be performed with the assistance of base personnel, a drilling subcontractor, a trenching subcontractor, and Parsons ES field personnel. An electrical subcontractor may also be retained for installation of any additional electrical receptacles required and for the wiring of this system. Section 4 of this work plan provides installation details for vent wells and vapor monitoring points.

5.2.1 Base Support Requirements

The following base support is needed to install the bioventing system:

- Assistance in obtaining drilling, trenching, and digging permits.
- Identification of underground utility lines.
- Electric power supply consisting of 230-volt, 30 amp, single-phase service and a breaker box with one 230-volt receptacle and two 110-volt receptacles.

5.2.2 Subsurface Construction

In addition to the activities of section 4, the installation will require trenching to place 1.5 inch steel piping 18 inches below ground surface with a 2-inch layer of sand placed under the pipeline. A trenching subcontractor, supervised by Parsons ES, will perform the excavation required to install the piping after underground utility lines have been identified. Figure 5.1 depicts the proposed trenching layout. Approximately 360 feet of trenching will be required to install the piping. Alteration to this layout may be required if the contaminant plume is significantly different than anticipated.

At each VW, the trenching subcontractor will also install a concrete vault 6 feet long by 3 feet wide by 2 feet deep to allow access for system adjustments and measurements, and to protect system components. Each vault, detailed in figure 5.2 will have a hinged steel cover with a handle and a method of locking. Each vault will have a 6 inch diameter cut out section for pipe entry and exit, as relevant. The vaults are designed to minimize water penetration into the inside working portion of the vault.

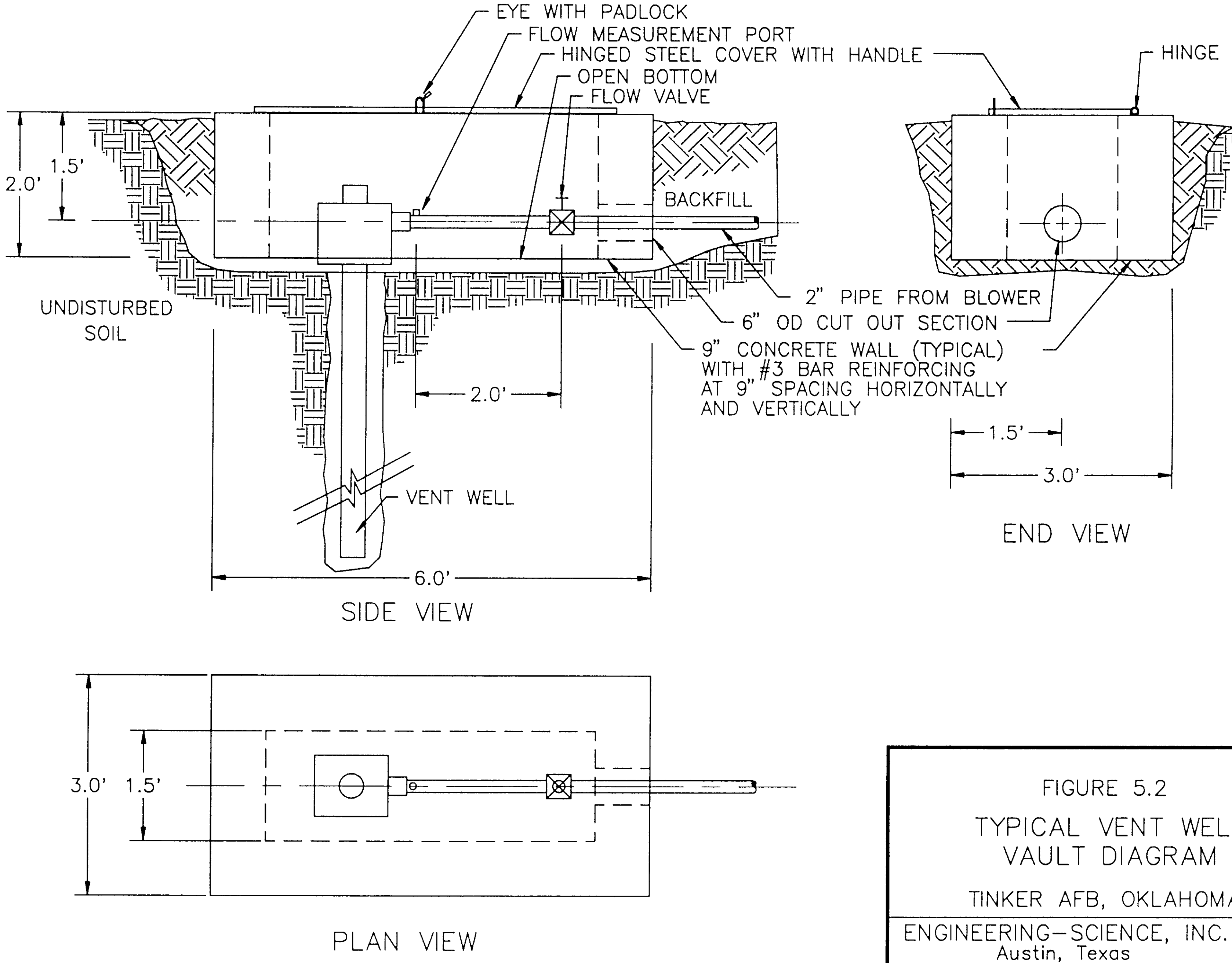

FIGURE 5.2

TYPICAL VENT WELL VAULT DIAGRAM

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Austin, Texas

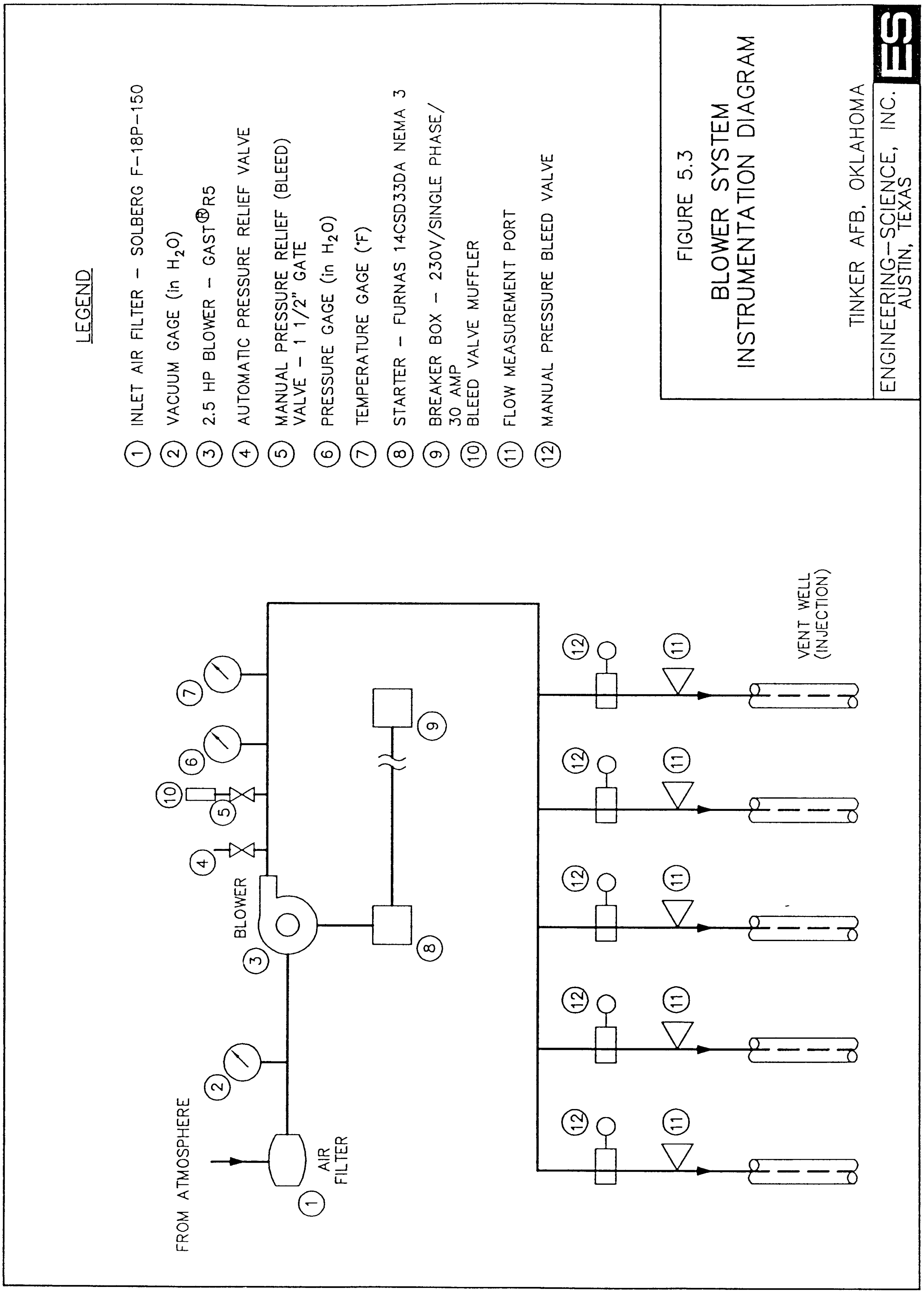
ES

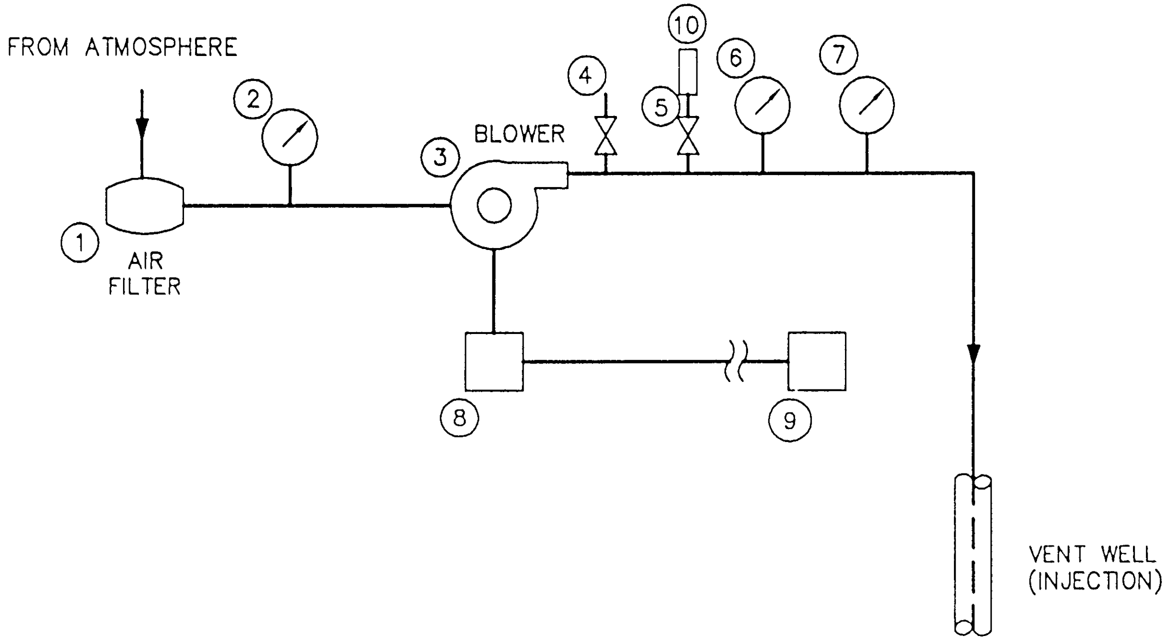
TKVW 10/03/94

Parsons ES personnel will install the pipe, fittings, and equipment for the system.

5.3 BLOWER HOUSING

The blower system will be housed in a small, prefabricated shed for protection from the weather. Figures 5.3 and 5.4 illustrate the instrumentation of the blower systems. Figure 5.3 is an instrumentation schematic or the proposed 5 vent well injection system, and Figure 5.4 is an as built instrumentation schematic of the existing single blower system operating at the site. The five well blower unit will be located near the existing blower unit to provide access to readily available electrical power.


LEGEND
1 INLET AIR FILTER - SOLBERG F-18P-150
2 VACUUM GAGE (in H_2O)
3 2.5 HP BLOWER - GAST® R5
4 AUTOMATIC PRESSURE RELIEF VALVE
5 MANUAL PRESSURE RELIEF (BLEED) VALVE - 1 1/2" GATE
6 PRESSURE GAGE (in H_2O)
7 TEMPERATURE GAGE (°F)
8 STARTER - FURNAS 14CSD33DA NEMA 3
9 BREAKER BOX - 230V/SINGLE PHASE/ 30 AMP
10 BLEED VALVE MUFFLER
11 FLOW MEASUREMENT PORT
12 MANUAL PRESSURE BLEED VALVE
FROM ATMOSPHERE
AIR FILTER
BLOWER
VENT WELL (INJECTION)
FIGURE 5.3
BLOWER SYSTEM INSTRUMENTATION DIAGRAM
TINKER AFB, OKLAHOMA
ES
ENGINEERING-SCIENCE, INC.
AUSTIN, TEXAS
BLOPID 10/03/94



LEGEND

1. INLET AIR FILTER – SOLBERG F-18P-150
2. VACUUM GAGE (in H_2O)
3. 1 HP BLOWER – GAST® R4110N-50
4. AUTOMATIC PRESSURE RELIEF VALVE
5. MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" GATE
6. PRESSURE GAGE (in H_2O)
7. TEMPERATURE GAGE (°F)
8. STARTER – FURNAS 14CSD33DA NEMA 3
9. BREAKER BOX – 230V/SINGLE PHASE/30 AMP
10. BLEED VALVE MUFFLER

FIGURE 5.4

AS BUILT EXISTING SINGLE BLOWER INSTRUMENTATION DIAGRAM 3700 FUEL YARD

TINKER AFB, OKLAHOMA

ENGINEERING-SCIENCE, INC.
AUSTIN, TEXAS

BLOWPID2 10/03/94

SECTION 6.0
PERIODIC SYSTEM MAINTENANCE

This operations and maintenance section has been created as a routine maintenance guide for monitoring the performance of the bioventing blower and vent well plumbing. After the first year of operations, basic maintenance of this system is the responsibility of the Air Force. An operation and maintenance (O & M) plan will be prepared describing any work requiring ongoing maintenance after installing and initiating air injection into the system vent wells. This section is a summary of the bioventing system components, maintenance procedures and schedules, and methods to forecast maintenance needs. Exhibit A to this work plan contains blower performance curves and relevant service information, and exhibit B is a data collection sheet.

6.1 CONFIGURATION SUMMARY

System type: Injection

Blower: Regenerative

Blower model: Gast R5

Motor: 2.5 horsepower

Inlet vacuum gauge (range): 0 - 60 inches of water

Inlet filter: Solberg part number F-18-150

Outlet temperature gauge : 0 - 250° Fahrenheit

Outlet pressure gauge (range): 0 - 100 inches of water

Pressure/vacuum relief valve set at 60 inches of water

6.2 SYSTEM OPERATION

Bioventing is the forced injection of fresh air, or withdrawal of soil gas, to enhance the supply of oxygen for *in situ* bioremediation. At this site, a pressure air injection blower unit is used to inject air into the soil, thereby supplying fresh air with 20.8 percent oxygen to the contaminated soils. Once oxygen is provided to the subsurface, existing bacteria will proceed with greater efficiency in the aerobic breakdown of fuel residuals.

6.3 SYSTEM DESCRIPTION

6.3.1 Blower System

A regenerative blower powered by a 2.5 horsepower (hp) direct-drive motor is the workhorse of the bioventing system. This blower will complement the 1.0 hp regenerative blower currently at the site. The newly installed blower will be rated at a flow rate of greater than 75 standard cubic feet per minute at a pressure of 60 inches of water; however, the actual performance of the blower will vary with changing site conditions. The system employs an air filter to remove any particulates which are entrained in the air stream as well as several valves and monitoring gauges which are described in the next section. Figure 5.3 is a schematic of the blower system for air injection into the five-vent-well system to be installed at Tinker AFB. Figure 5.4 is the as-built schematic for the existing blower system. Corresponding blower performance curves, and relevant service information are provided in exhibit A.

6.3.2 Monitoring Gauges

The bioventing system is equipped with gauges and ports to determine system performance. A vacuum gauge is located in the inlet piping and a pressure gauge in the outlet piping. A temperature gauge is located at the outlet of the blower system. Flow measurement ports are also located in the outlet piping at least 2 feet downstream of a flow control valve mounted in the protective vault constructed at each vent well. Figures 5.3 and 5.4 detail the locations of the gauges installed on the two blower systems at this site.

6.4 SYSTEM MAINTENANCE

Although the motor and blower are relatively maintenance free, periodic system maintenance is required for proper operation and long life. Recommended maintenance procedures and schedules are described in detail in the instruction manuals exhibit A in briefly summarized in this section.

6.4.1 Blower/Motor

The blower and motor are relatively maintenance free and should not require any periodic maintenance during the 1-year extended testing period. Both blower and motor have sealed bearings and do not require lubrication.

6.4.2 Air filter

To avoid damage caused by passing solids through the blower, an air filter has been installed in line before the blower. The filter element is paper and is accompanied by a polyurethane foam prefilter. The filter should be checked weekly for the first 2 months of operation. The best schedule for filter replacement will be determined during weekly field checks of the system throughout the first year of operation. The polyurethane prefilters can be washed with lukewarm water and a mild detergent. Paper filter elements should never be washed, but should be disposed of and replaced as necessary. When the pressure or vacuum drop across the filter is above 15 inches of water, a dirty filter element should be suspected, and the filter should be cleaned or replaced.

Filter inspection must be performed with the system turned off. To restart the motor, open the manual air dilution valve (red handle) to protect the motor from excessive strain, start motor, and slowly close dilution valve. If the handle has been removed from the manual air dilution valve, do not open the valve or otherwise change the setting (it has been pre-set for a specific flow rate) before restarting the blower.

To remove the filter, loosen the three clamps or the wing nut, lift the metal top off the air filter, and lift the air filter from the metal housing. Remove the polyurethane prefilter (if applicable) and wash before replacing. When replacing the filter, be careful that the rubber seals remain in place.

The filter element is manufactured by Solberg Manufacturing, Inc. in Itasca, Illinois. Their telephone number is (708) 773-1363. Additional filters will be installed by Parsons ES during the first year of operation, as needed. The filter model number is F-18P-150. It is recommended that Tinker AFB keep at least one spare air filter at the site. Four spare filters will be supplied with the blower system.

6.4.3 Maintenance Schedule

The following maintenance schedule is recommended for this system. During the initial months of operation more frequent monitoring is recommended to ensure that any startup problems are quickly corrected. A daily drive-by inspection is recommended during the initial week of operation to ensure that the blower system is still operating with no unusual sounds. Data collection sheets that can be used to record maintenance activities are in exhibit B.

6.4.4 Major Repairs

Blowers systems are very reliable when properly maintained. Occasionally, a motor or blower will develop a serious problem. If a blower system fails to start, and a qualified electrician verifies that power is available at the blower or starter, the Parsons ES site manager Brian Vanderglas should be called at (512) 719-6000. Parsons ES will promptly repair any damage to the blower system during the first year of operation.

6.5 SYSTEM MONITORING

6.5.1 Blower Performance Monitoring

To monitor the blower performance, vacuum, pressure, and temperature will be measured. These data should be recorded weekly on a data collection sheet (exhibit B). All measurements should be taken at the same time while the system is running. Because the system is loud, hearing protection should be worn at all times, when working next to the blower. Noise levels generated by the blower are rated at approximately 75 dBA during maximum injection pressure. This level can be further reduced to 71 dBA by installing a silencer/muffler. The blower will be installed in a blower shed for longterm eperation, which will also help to reduce the noise levels.

Air flow measurements should be taken weekly for the first month of operation and monthly after, or as needed. These measurements will be collected from air measurement ports located slightly upstream of each vent well in the piping. This will facilitate adjustments in the flow control valves to equilibrate air flow to each vent well.

6.5.2 Vacuum/Pressure

With hearing protection in place, open the blower enclosure and record all vacuum and pressure readings directly from the gauges (in inches of water or psi). Record the measurements on a data collection sheet.

6.5.3 Flow Rate

The flow rate through the vent well and soils can be calculated when the inlet vacuum and outlet pressure of the blower are known. This pressure change across the blower (vacuum plus pressure) can be compared to the performance curves for the blower (in exhibit A) to determine the approximate flow rate.

6.5.4 Temperature

With hearing protection in place, open the blower enclosure and record the temperature readings directly from the gauges in degrees Fahrenheit (°F). Record the measurements on a data collection. The temperature change can be converted to degrees Celsius (°C) using the formula °C= (°F - 32) x 5/9.

6.5.5 Monitoring Schedule

The following monitoring schedule is recommended for this system. During the initial months of operation, more frequent monitoring is recommended to ensure that any start up problems are quickly corrected. Data collection to assist your data collection and are in exhibit B.

Monitoring Item	Monitoring Frequency
Vacuum/Pressure	Daily during first week, then once per week.
Temperature	Daily during first week, then once per week.
Air Flow	Weekly during first month, then once per month.
Noise	Daily during the first week, then once every 4 months, or whenever increases in volume are suspected during weekly inspections.

SECTION 7.0
COMMUNITY RELATIONS PLAN

7.1 OVERVIEW

The State of Oklahoma requires that, for all confirmed releases requiring a corrective action plan, owners provide notice to the public by means designed to reach those individuals directly affected by the release and the planned corrective action (rule 1308.A). In addition, RCRA and CERCLA have specific requirements for community relations planning and implementation. Tinker Air Force Base is committed to ensuring that individuals who may be effected by contamination at the 3700 Fuel Yard or by corrective actions planned for this area are adequately notified and informed of current conditions and planned activities. The community relations effort for the 3700 Fuel Yard corrective action will be conducted as a part of, and consistent with, the base community relations plan. This section presents community relations information and activities specifically relevant to the corrective action described in this work plan.

7.2 IMPLEMENTATION

A spokesperson from the Directorate of Environmental Management has been designated as Tinker AFB's program manager for environmental matters. The Public Affairs Office (PAO) has designated staff with specific responsibilities to support this spokesperson. Tinker AFB will coordinate with the US Environmental Protection Agency (EPA), State of Oklahoma, and local agencies to identify and communicate, as appropriate, with representatives who will be responsible for oversight and review of the corrective action at the 3700 Fuel Yard. Information on Tinker AFB and agency representatives is available from the Directorate of Environmental Management.

7.3 HISTORY OF COMMUNITY INVOLVEMENT

In September 1989, EPA sponsored an open house at the five Oklahoma City metro area Superfund sites, one of which is Tinker AFB, to provide the public an opportunity to meet with the project managers and discuss remedial alternatives. On April 5, 1990, Tinker AFB held a public meeting to present the proposed plan for remediating groundwater contamination beneath Building 3001, along with proposed plans for remediating pit Q-51 and the north tank fuel area. Over 100 citizens attended the public meeting and were encouraged to participate in the discussions so that all comments could be considered before final plans were selected.

Other IRP sites at Tinker AFB are in the process of undergoing or have undergone remedial investigations and feasibility studies. The plans for addressing the restoration of these sites are described in detail in the December 1988 Superfund IAG. The Superfund CRP prepared by Tinker AFB in September 1991 that describes the activities associated with these sites is available for public review at the Public Affairs Office on the base.

7.4 DESCRIPTION OF THE SURROUNDING COMMUNITY

The Tinker AFB community is situated within the corporate limits of Oklahoma City and borders Midwest City and Del City. Oklahoma City was established on the afternoon of April 22, 1889, when thousands of pioneers crossed the borders of the ``unassigned lands" at the sound of gunfire at high noon. By nightfall, thousands had staked their claims in the area known today as Oklahoma City. It has since grown to become the 28th largest city in the United States, covering over 620 square miles with a population close to 450,000. Oklahoma City industries include oil processing and refining, livestock production, and agriculture. Oklahoma City has a manager-council form of government with eight councilmen and a mayor, all elected for staggered 4-year terms and representing various wards.

Midwest City, which is located adjacent to Oklahoma City and north of Tinker AFB, has a population of almost 60,000 and covers a 25-square mile area. It is primarily residential, with a large number of its citizens employed at Tinker AFB. It has a mayor and a manager-council form of government with four council members elected to 4-year terms from designated wards in the city.

Del City, which is located due west of Tinker AFB, has a population of 30,000 and covers 8 square miles. It has a mayor, manager-council form of government with four council members elected to 4-year terms from designated wards in the city. Like Midwest City, it is a residential community, with many of its citizens employed at Tinker AFB.

7.5 PUBLIC INFORMATION PROGRAM

Tinker AFB has conducted extensive interviews with community representatives to ascertain the level of interest in and concern with environmental issues at Tinker AFB and the community as a whole. The PAO will use information collected during this process, and in subsequent communications with the community, to tailor the community relations effort related to the 3700 Fuel Yard corrective action. These activities may include, as appropriate, public meetings, small discussion groups, informational publications, press releases to the local media, and placing key plans and reports in the repositories established as part of the base community relations effort.

SECTION 8.0
REFERENCES

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Radian, 1985. Radian Corp. Measurement of Gaseous Emission Rates from Land Surfaces Using and Emission Isolation Flux Chamber. User's Guide prepared for the USEPA. February.

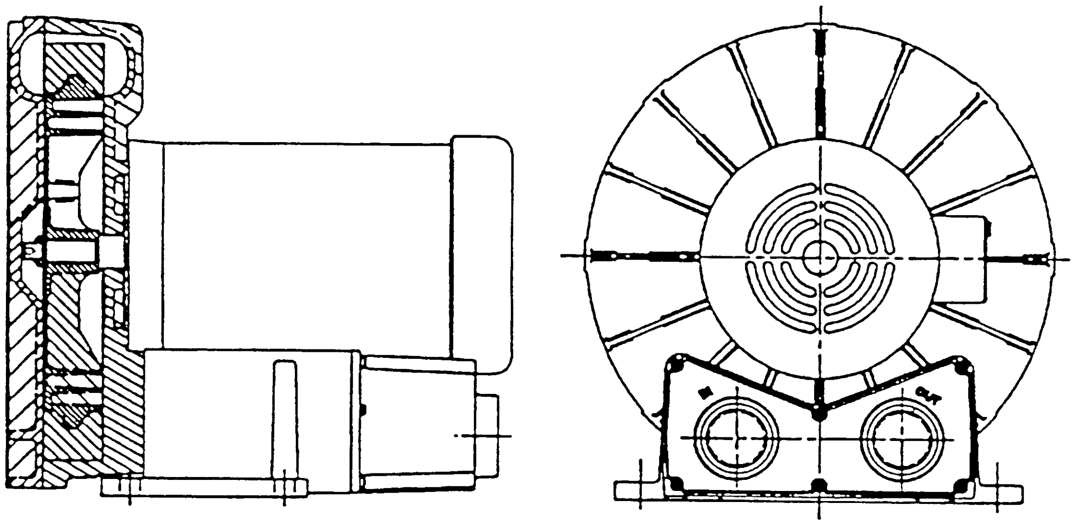
WSCI, 1992. Water and Soil Consultants, Inc. Draft Remedial Investigation Report, POL site, Area "C" 3700 Fuel Yard. May.

EXHIBIT A

REGENERATIVE BLOWER INFORMATION

Post Office Box 97
Benton Harbor, Michigan 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

Maintenance Instructions for Gast Standard Regenerative Blowers



For original equipment manufacturers special models, consult your local distributor

Gast Rebuilding Centers

Gast Mfg. Corp.
2550 Meadowbrook Rd.
Benton Harbor MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Gast Mfg Corp.
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Brenner Fiedler. & Assoc.
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Fax: 213/404-7975

Wainbee, Limited
121 City View Drive
Toronto, Ont. Canada M9W 5A9
Ph: 416/243-1900
Fax: 416/243-2336

Wainbee, Limited
215 Brunswick Drive
Pointe Claire, P.Q. Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/697-3070

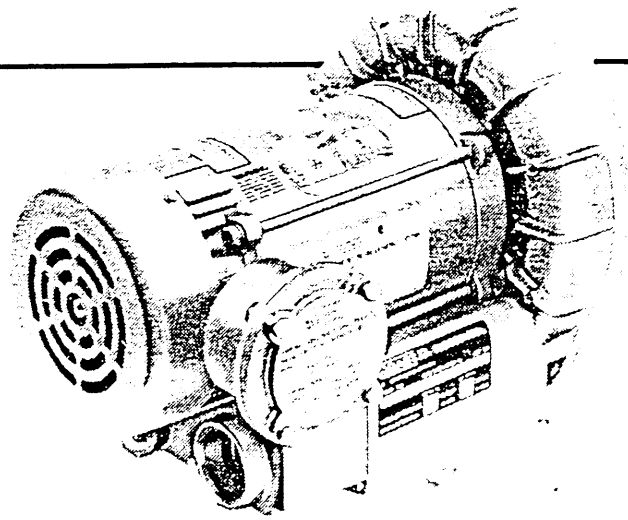
Gast Mfg. Co. Limited.
Halifax Rd, Cressex Estate
High Wycombe, Bucks HP12 3SN
Ph. 44 494 523571
Fax: 44 494 436588

Japan Machinery Co. Ltd.
Central PO Box 1451
Tokyo 100-91 Japan
Ph: 813/3573-5421
Fax: 813/3571-7865

For Soil Remediation to 260 cfm

GAST

R4, R5, R6P Series



MODEL R4 SERIES
48" H_2O MAX. VAC., 88 CFM OPEN FLOW

MODEL R5 SERIES
60" H_2O MAX. VAC., 145 CFM OPEN FLOW

MODEL R6P SERIES
90" H_2O MAX. VAC., 260 CFM OPEN FLOW

PRODUCT FEATURES

- Explosion-proof motors UL (class 1, group D; class 2, groups F & G)
- Sealed air stream
- Rugged construction
- Low maintenance

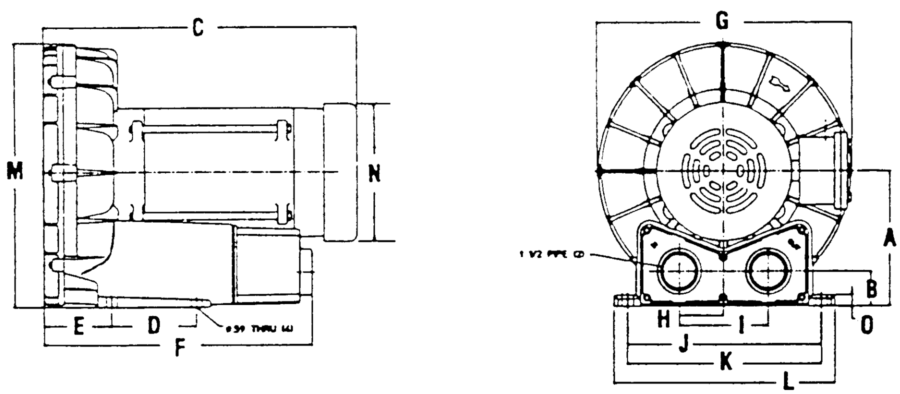
RECOMMENDED ACCESSORIES

- Inlet filter AJ151G (Reducing filter plumbing from 2½" to 1½" is needed to accommodate filter on R4 and R5 models.)
- Relief valve AG258
- Vacuum gauge AE134

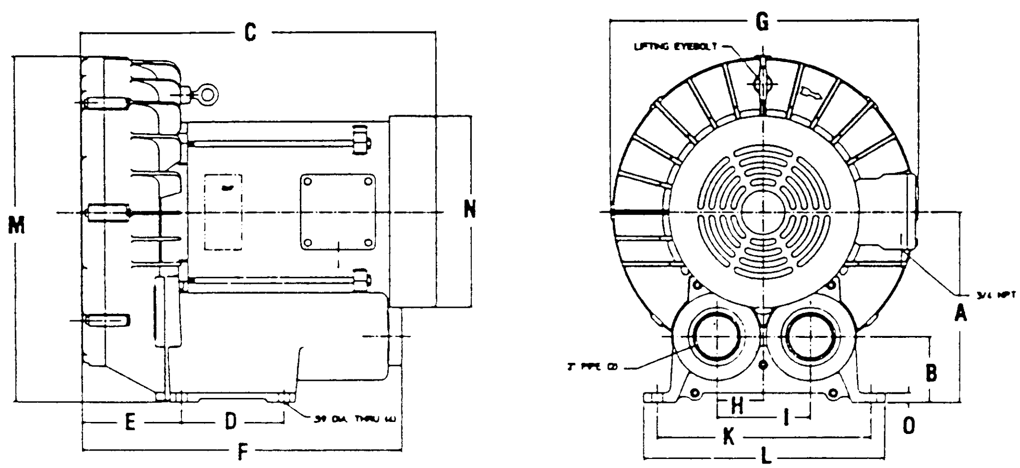
Product Dimensions Metric (mm) U.S. Imperial (Inches)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R4110N-50	157	43	360	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.16	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	360	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.17	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R5325R-50	178	46	423	114	91	361	344	60	121	260	262	298	350	183	15
	7.00	1.82	16.66	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	7.19	.59
R6P355R-50	248	80	482	140	137	438	428	64	127	–	290	325	463	257	13
	9.77	3.15	18.98	5.51	5.39	17.25	16.87	2.50	5.00	–	11.42	12.80	18.21	10.12	.50

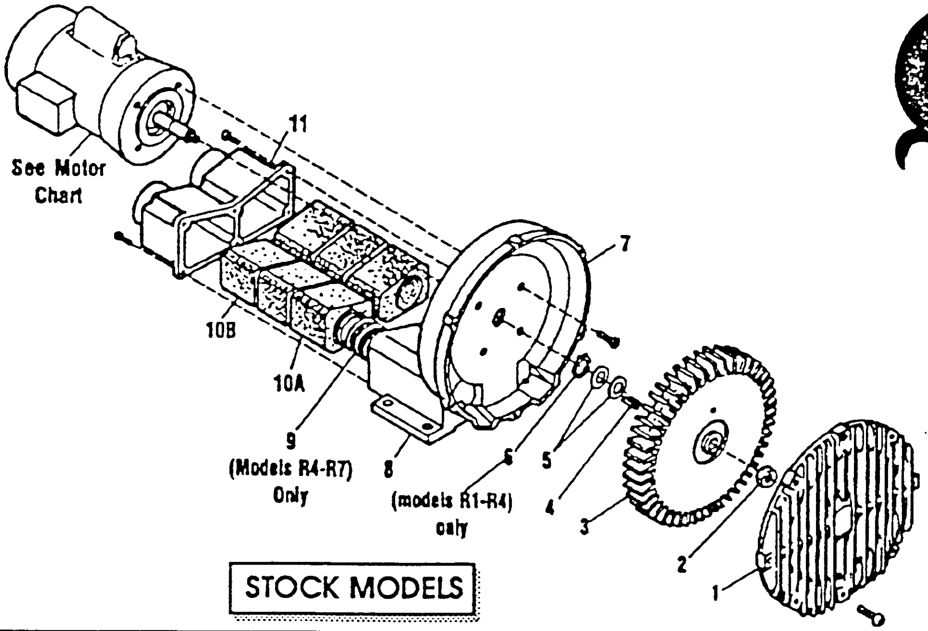
Model R4 Series
Model R5 Series



Model R6P Series



NOTE: These units with explosion-proof motors are designed specifically for qualified OEMs in the soil remediation industry. They are not intended to be applied for other uses without written acknowledgement from an authorized employee of Gast Manufacturing Corporation.



STOCK MODELS

Part Name	R1	R2	R3	R4	R5	R6	R6P	R6PP/R6PS	R7
#1 Cover	AJ101A	AJ101B	AJ101C	AJ101D	AJ101EQ	AJ101F	AJ101K	(2)AJ101KA	AJ101G
#2 Stopnut	BC187	BC187	BC181	BC181	BC181	BC181	BC181	(2)BC182	BC183
#3 Impeller	AJ102A	AJ102BQ	AJ102C	AJ102D	AJ102E	AJ102FR	AJ102K	(2)AJ102KA	AJ102GA
#4 Square Key	AH212C	AH212	AB136A	AB136D	AB136	AB136	AB136	(2)AB136	AC628
#5 Shim Spacer (s)	AJ132	AE686-3	AJ109	AJ109	AJ109	AJ116A	AJ116A	AJ116A	AJ110
#6 Retaining Ring	AJ145	AJ145	AJ149	AJ149					
#7 Housing	AJ103A	AJ103BQ	AJ103C	AJ103DR	AJ103E	AJ103F	AJ103K	AJ103KD	AJ103GA
#8 Muffler Box	-				AJ104E	AJ104F			
#9 Spring				AJ113DR	AJ113DQ	AJ113FQ	AJ113FQ		AJ113G
#10A Foam	(4)AJ112A	(4)AJ112B	(4)AJ112C	(4)AJ112DS	(4)AJ112ER	(6)AJ112F	(8)AJ112K		(8)AJ112GA
#10B Foam		(2)AJ112BQ	(2)AJ112CQ	(2)AJ112DR	(2)AJ112EQ				
#11 Muffler Extension/ Adapter Plate	AJ106H	AJ106BQ	AJ106CQ	AJ106DQ	AJ106EQ	AJ106FQ	AJ104K		AJ104GA
Shim Kit	K396	K396							K395

MOTOR CHART

REGENAIR MODEL NUMBER	MOTOR NUMBER	MOTOR SPECIFICATIONS 60 HZ VOLTS	50 HZ VOLTS	PHASE
R1102	J111X	115/208-230	110/220-240	1
R1102C	J112X	115		1
R2103	J311X	115/208-230	110/220	1
R2105	J411X	115/208-230	110/220	1
R2303A	J310	208-230/460	220/380-415	3
R2303F	J313	208-230	220	3
R3105-1/R3105-12	J411X	115/208-230	110/220-240	1
R3305A-1/R3305A-13	J410	208-230/460	220/380-415	3
R4110-2	J611AX	115/208-230	110/220-240	1
R4310A-2	J610	208-230/460	220/380-415	3
R5125-2	J811X	115/208-230		1
R5325A-2	J810X	208-230/460	220/380-415	3
R6125-2	J811X	115/208-230		1
R6325A-2	J810X	208-230/460	220/380-415	3
R6335A-2	J910X	208-230/460	220/380-415	3
R6150J-2	J1013	230		1
R6350A-2	J1010	208-230/460	220/380-415	3
R6P335A	J910X	208-230/460	220/380-415	3
R6P350A	J1010	208-230/460	220/380-415	3
R6P355A	J1110A	208-230/460	220/380-415	3
R7100A-2*	J1210B	208-230/460	220/380-415	3
R6PP/R6PS3110M	JD1100	208-230/460	220/380-415	3

* No lubrication needed at start up. Bearings lubricated at factory.

* Motor is equipped with alemite fitting. Clean tip of fitting and apply grease gun. Use 1 to 2 strokes of high quality ball bearing grease.

Consistency	*Type*	*Typical Grease*
Medium	Lithium	Shell Dolium R

Hours of service per year	*Suggested Relube Interval*
5,000	3 years
Continual NormalApplication	1 year
Seasonal service motor idle for 6 months or more	1 year beginning of season
Continuous-high ambients, dirty or moist applications.	6 months

All performance figures relate to stock models. A few high pressure units may be available. Consult your local distributor.

Regenair Model Number	0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	100"H_2O	Maximum Pressure "H_2O*
	PRESSURE						
R1	26	14					28
R2	42	26					38
R3105-1	52	38	14				42
R3105-12	52	36	23				55
R3305A-13	52	36	23				55
R4	90	70	50				52
R5	145	130	100				65
R6125-2	200	180					35
R6325A-2	200	180	152				40
R6335A-2	205	175	155	135			70
R6350A-2	200	180	150	130	110	80	105
R6P335A	290	250					30
R6P350A	300	260	230	200			60
R6P355A	300	260	230	200	160		90
R7100A-2	420	380	340	310	280	230	115
R6PP311OM	485	452	420	380	330		95
R6PS311OM	265	258	252	244	236	226	170

Regenair Model Number	0"H_2O	20"H_2O	40"H_2O	60"H_2O	80"H_2O	Maximum Vacuum "H_2O*
	VACUUM					
R1	25	14				26
R2	40	22				34
R3105-1	50	34	9			40
R3105-12	51	34	20			50
R3305A-13	51	34	20			50
R4	82	62	39			48
R5	140	115	90	50		60
R6125-2	190	155	125			45
R6325A-2	190	155	125			45
R6335A-2	190	150	125	100		75
R6350A-2	190	180	150	100	70	90
R6P335A	270	230				37
R6P350A	280	240	210	170		70
R6P355A	280	240	210	170	100	86
R7100A-2	410	350	300	250	170	90
R6PP311OM	470	425	375	320	220	80
R6PS311OM	240	225	210	195	175	130

***This number indicates the maximum static pressure differential recommended (with cooling air still flowing through unit). In general, units 1hp or less can be dead headed. Check with local representative or distributor to verify which models apply.**

Operation of the blower above the recommended maximum duty will cause premature failure due to the build up of heat damaging the components.

Performance data was determined under the following conditions:

1) Unit in a temperature stable condition.
2) Test conditions: Inlet air density at 0.075lbs. per cubic foot. (20°C(68°F), 29.92 in. Hg(14.7PSIA)).
3) Normal performance variations on the resistance curve within +/- 10% of supplied data can be expected.
4) Specifications subject to change without notice.
5) All performance at 60Hz operation.

70-6100
F2-205/8/92
AK811 Rev. E

GAST®

Post Office Box 97
Benton Harbor, MI. 49023-0097
Ph: 616/926-6171
Fax: 616/925-8288

INSTALLATION AND OPERATING INSTRUCTIONS FOR GAST HAZARDOUS DUTY REGENAIR BLOWERS

This instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, R5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, R6350R-50, R6P355R-50 and R7100R-50.

Gast Authorized Service Facilities are Located in the locations listed below

Gast Manufacturing Corporation
505 Washington Avenue
Carlstadt, N. J. 07072
Ph: 201/933-8484
Fax: 201/933-5545

Gast Manufacturing Corporation
2550 Meadowbrook Road
Benton Harbor, MI. 49022
Ph: 616/926-6171
Fax: 616/925-8288

Brenner Fiedler & Associates
13824 Bentley Place
Cerritos, CA. 90701
Ph: 213/404-2721
Ph: 800/843-5558
Fax: 213/404-7975

Wainbee Limited
215 Brunswick Blvd.
Pointe Claire, Quebec
Canada H9R 4R7
Ph: 514/697-8810
Fax: 514/-697-3070

Wainbee Limited
5789 Coopers Ave.
Mississauga, Ontario
Canada L4Z 3S6
Ph: 416/243-1900
Fax: 416/243-2336

Japan Machinery
Central PO Box 1451
Toyko 100-91, Japan
Ph: 813 3573-5421
Fax: 813 3571-7896

Gast Manufacturing Co. Ltd.
Halifax Road, Cressex Estate
High Wycombe, Bucks HP12 3SN
England
Ph: 44 494 523571
Fax: 44 494 436588

Safety

⚠ This is the safety alert symbol. When you see this symbol, personal injury is possible. The degree of injury is shown by the following signal words:

⚠ DANGER: Severe injury or death will occur if hazard is ignored.
⚠ WARNING: Severe injury or death can occur if hazard is ignored.
⚠ CAUTION: Minor injury or property damage can occur of hazard is ignored.
Review the following information carefully before operating.

General Information

⚠ DANGER: Do not pump flammable or explosive gases or operate in an atmosphere containing them. Ambient temperature for normal operation should not exceed 40 degrees C (105 degrees F). For higher ambient operation, consult the factory. Blower performance is reduced by the lower atmospheric pressure of high altitudes. If it applies to this unit, consult a Gast distributor or the factory for details.

Installation

⚠ WARNING: Electric Shock can result from bad wiring. Wiring must conform to all required safety codes and be installed by a qualified person.

Grounding is required.

The Gast Regenair blower can be installed in any position. The flow of cooling air over the blower and motor must not be blocked.

PLUMBING - The threaded pipe ports are designed as connection ports only and will not support the plumbing. Be sure to use the same or larger size pipe and fittings to prevent air flow restriction and over-heating of the blower. When installing plumbing, be sure to use a small amount of pipe thread lubricant. This protects the threads in the aluminum blower housing. Dirt and chips, often found in new plumbing, should not be allowed to enter the blower.

NOISE - To reduce noise and vibration, the unit should be mounted on a solid surface that will not increase sound. The use of shock mounts or vibration isolation material is recommended. If needed, inlet or discharge noise can be reduced by attaching muffler assemblies (see accessories).

ROTATION - The Gast Regenair blower should only rotate clockwise as viewed from the electric motor side. This is marked with an arrow in the casting. Proper rotation can be confirmed by checking air flow at the IN and OUT ports. On blowers powered by a three phase motor, rotation is reversed by changing any two of the three power wires.

Operation

⚠ WARNING: Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.
⚠ CAUTION: Attach blower to solid surface before starting. Prevent injury or damage from unit movement.

Air containing solid particles or liquid must pass through a filter before entering the blower (see accessories list for filter suggestions). Blowers must have mufflers, filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage.

⚠ CAUTION: Outlet piping can burn skin. Guard or limit access.
Mark "CAUTION Hot surface. Can cause burns."

Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air.

The blower must not be operated above the limits for continuous duty. "Standard" R1, R2, R3 and R4 can operate continuously with not air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do *not* close off inlet (for vacuum) or exhaust (for pressure) to reduce extra air flow. This could cause added heat and motor load.

ACCESSORIES - Gast pressure gauges AJ496 or AE133 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

Servicing

⚠ WARNING: Disconnect electric power before servicing. Be sure rotating parts have stopped. Electric shock or severe cuts can result. Inlet and exhaust filters need occasional cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove material coating the impeller and housing. If not done, the buildup can cause vibration, hotter operation and reduced flow. Noise absorbing foam in the mufflers may need replacement.

KEEP THIS INFORMATION WITH THE BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

TROUBLESHOOTING

Symptom	*Possible Diagnosis*	*Possible Remedy*
Excess Vibration	Impeller damaged by foreign material	Replace impeller
	Impeller contaminated by foreign material	Clean impeller, install adequate filtration.
Abnormal sound	Motor bearing failed	Replace bearings
	Impeller rubbing against cover or housing	Repair Blower, check clearances.
Increase in sound	Foreign material can coat or destroy muffler foam.	Replace foam muffler elements, trap or filter foreign material.
Blown fuse	Electrical wiring problem	Have qualified person check fuse capacity and wiring.
Unit very hot	Running at too high a pressure or vacuum	Install a relief valve

OPERATING AND MAINTENANCE INSTRUCTIONS

SAFETY

ıis is the safety alert symbol. When you see this symbol personal injury is possible. The degree of injury is shown by the following signal words:

ANGER Severe injury or death will occur if hazard is ıored.

WARNING Severe injury or death can occur if hazard is nored.

AUTION Minor injury or property damage can occur if hazard is ignored.

eview the following information carefully before operating.

GENERAL INFORMATION

is instruction applies to the following models ONLY: R3105N-50, R4110N-50, R4310P-50, R4P115N-50, 5125Q-50, R5325R-50, R6130Q-50, R6P155Q-50, 6350R-50, R6P355R-50 and R7100R-50. These blowers are intended for use in Soil Vapor Extraction Systems. The blowers are sealed at the factory for very low leakage. ıey are powered with a U.L. listed electric motor Class ı Div. 1 Group D motors for Hazardous Duty locations. Ambient temperature for normal full load operation ould not exceed 40° C (105° F). For higher ambient operation, contact the factory.

ast Manufacturing Corporation may offer general apication guidance: however, suitability of the particular blower and/or accessories is ultimately the responsibility of the user, not the manufacturer of the blower.

INSTALLATION

DANGER Models R5325R-50, R6130Q-50, R6350R-50, 5125Q-50, R6P155Q-50, R6P355R-50 AND R7100R-50 e Pilot Duty Thermal Overload Protection. Connecting this protection to the proper control circuitry is andated by UL674 and NEC501. Failure to do so could/ ay result in a EXPLOSION. See pages 3 and 4 for recommended wiring schematic for these models.

ARNING Electric shock can result from bad wiring. A qualified person must install all wiring, conforming to all required safety codes. Grounding is necessary.

ARNING This blower is intended for use on soil vapor extraction equipment. Any other use must be approved in iting by Gast Manufacturing. Corp. Install this blower any mounting position. Do not block the flow of cooling air over the blower and motor.

UMBING - Use the threaded pipe ports for connection ly. They will not support the plumbing. Be sure to use the same or larger size pipe to prevent air flow restriction and overheating of the blower. When installing fittings, sure to use pipe thread sealant. This protects the threads in the blower housing and prevents leakage. Dirt and chips are often found in new plumbing. Do not allow em to enter the blower.

NOISE - Mount the unit on a solid surface that will not increase the sound. This will reduce noise and vibration. We suggest the use of shock mounts or vibration isolation material for mounting.

ROTATION - The Gast Regenair Blower should only rotate clockwise as viewed from the electric motor side. The casting has an arrow showing the correct direction. Confirm the proper rotation by checking air flow at the IN and OUT ports. If needed reverse rotation of three phase motors by changing the position of any two of the power line wires.

OPERATION

⚠ *WARNING Solid or liquid material exiting the blower or piping can cause eye damage or skin cuts. Keep away from air stream.*

⚠ *WARNING - Gast Manufacturing Corporation will not knowingly specify, design or build any blower for installation in a hazardous, combustible or explosive location without a motor conforming to the proper NEMA or U.L. standards.* Blowers with standard TEFC motors should never be utilized for soil vapor extraction applications or where local state and/or Federal codes specify the use of explosion-proof motors (as defined by the National Electric Code, Articles 100,500 c1990).

⚠ *CAUTION Attach blower to solid surface before starting to prevent injury or damage from unit movement.* Air containing solid particles or liquid must pass through a filter before entering the blower. Blowers must have filters, other accessories and all piping attached before starting. Any foreign material passing through the blower may cause internal damage to the blower.

⚠ *CAUTION Outlet piping can burn skin. Guard or limit access. Mark "CAUTION Hot Surface. Can Cause Burns".* Air temperature increases when passing through the blower. When run at duties above 50 in. H_2O, metal pipe may be required for hot exhaust air. The blower must not be operated above the limits for continuous duty. Only models R3105N-50, R4110N-50 and R4310P-50 can be operated continuously with no air flowing through the blower. Other units can only be run at the rating shown on the model number label. Do not Close off inlet (for vacuum) to reduce extra air flow. This will cause added heat and motor load. Blower exhaust air in excess of 230°F indicates operation in excess of rating which can cause the blower to fail.

ACCESSORIES ...Gast pressure gauge AJ496 and vacuum gauges AJ497 or AE134 show blower duty. The Gast pressure/vacuum relief valve, AG258, will limit the operating duty by admitting or relieving air. It also allows full flow through the blower when the relief valve closes.

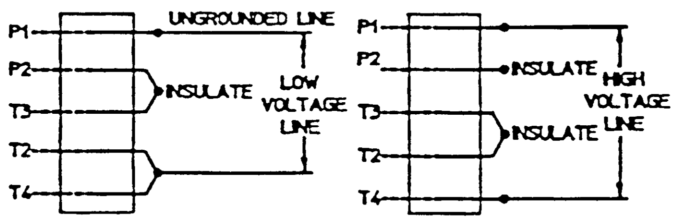
SERVICING

⚠ *WARNING To retain their sealed construction they should be serviced by Gast authorized service centers ONLY.* These models are sealed at the factory for very low leakage.

⚠ *WARNING Turn off electric power before removing blower from service. Be sure rotating parts have stopped. Electric shock or severe cuts can result.* Inlet and exhaust filters attached to the blower may need cleaning or replacement of the elements. Failure to do so will result in more pressure drop, reduced air flow and hotter operation of the blower. The outside of the unit requires cleaning of dust and dirt. The inside of the blower also may need cleaning to remove foreign material coating the impeller and housing. This should be done at a Gast Authorized Service Center. This buildup can cause vibration, failure of the motor to operate or reduced flow.

KEEP THIS INFORMATION WITH THIS BLOWER. REFER TO IT FOR SAFE INSTALLATION, OPERATION OR SERVICE.

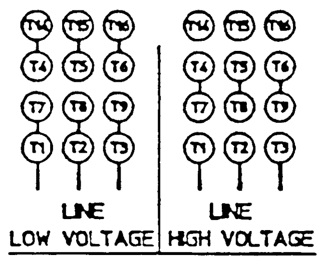
MOTOR WIRING DIAGRAM FOR R4110N-50 & R3105N-50



>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R4310P-50

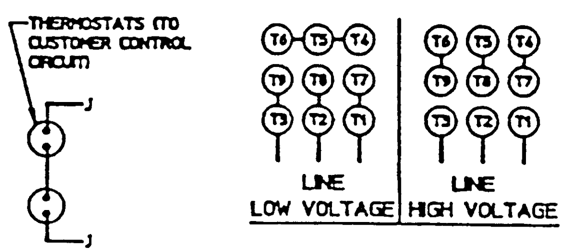
TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



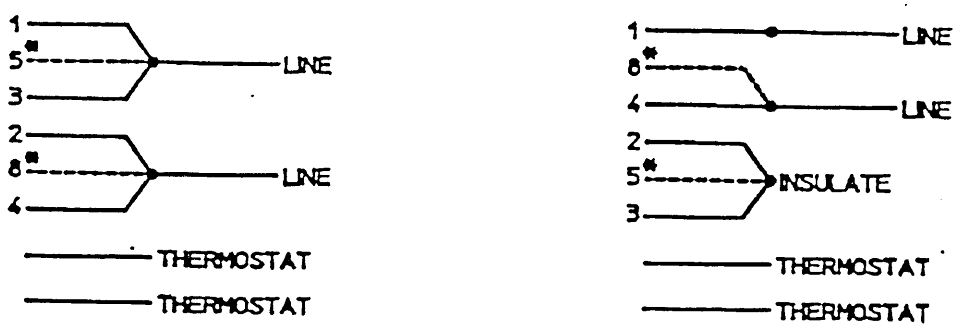
>>* WARNING
THIS MOTOR IS THERMALLY PROTECTED AND WILL AUTOMATICALLY RESTART WHEN PROTECTOR RESETS. ALWAYS DISCONNECT POWER SUPPLY BEFORE SERVICING.

MOTORS WIRING DIAGRAM FOR R5325R-50, R6350R-50, R6P355R-50, & R7100R-50

TO REVERSE ROTATION, INTERCHANGE THE EXTERNAL CONNECTIONS TO ANY TWO LEADS.



MOTOR WIRING DIAGRAM FOR R5125Q-50 & R4P115N-50

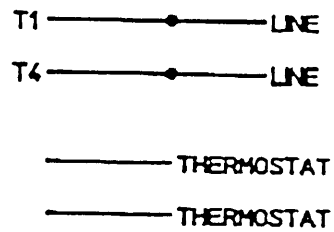


LOW VOLTAGE HIGH VOLTAGE

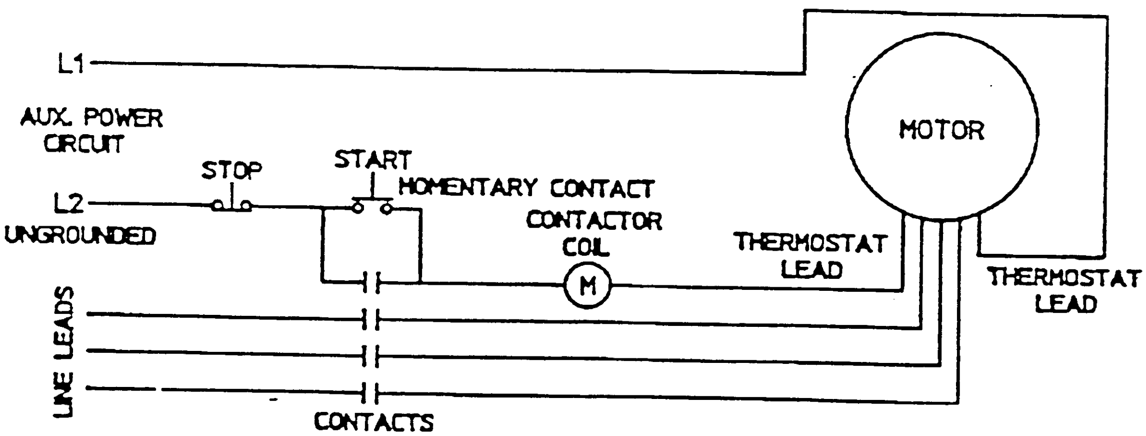
* R5125Q-50 BLOWERS PRODUCED AFTER SEPTEMBER 1992 (SER. NO. 0992)
DO NOT HAVE MOTOR LEADS 5 & 8.

MOTOR WIRING DIAGRAM FOR R6130Q-50 & R6P155Q-50

CONNECT THERMOSTAT TO MOTOR PROTECTION CIRCUIT



CONNECTION FOR THERMOSTAT MOTOR PROTECTION

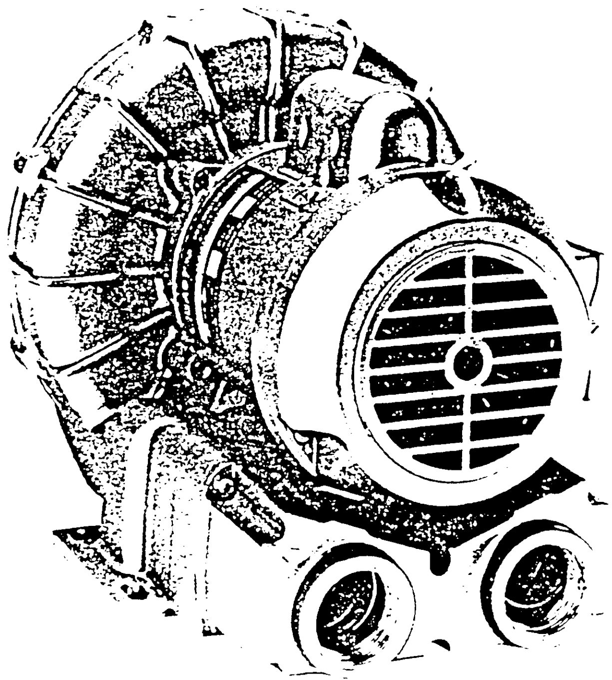


TERMOSTATS TO BE CONNECTED IN SERIES WITH CONTROL AS SHOWN. MOTOR FURNISHED WITH AUTOMATIC THERMOSTATS RATED A.C. 115-600V. 720VA

AK811 rev. E

Oilless Regenerative Blowers, Motor Mounted to 92 cfm

REGENAIR® R4 Series



MODEL R4110-2
52" H_2O MAX. PRESSURE, 92 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance
- Can be operated blanked-off

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz; 110/220-240V, 50 Hz, single phase
- 208-230/460V, 60 Hz; 190-230/380-415V, 50 Hz, three phase
- 575V, 60 Hz, three phase

RECOMMENDED ACCESSORIES

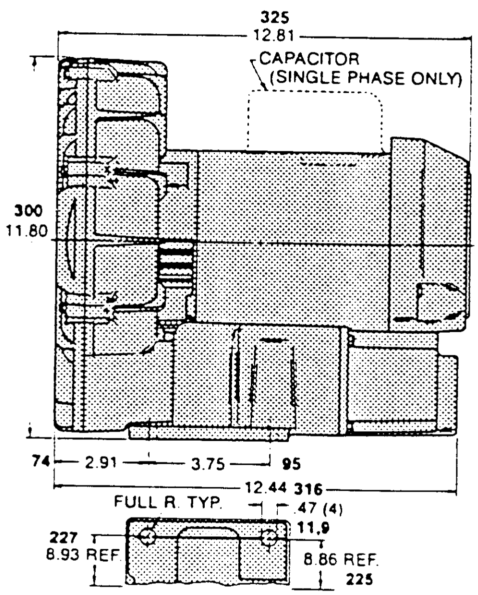
- Pressure gauge AJ496
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

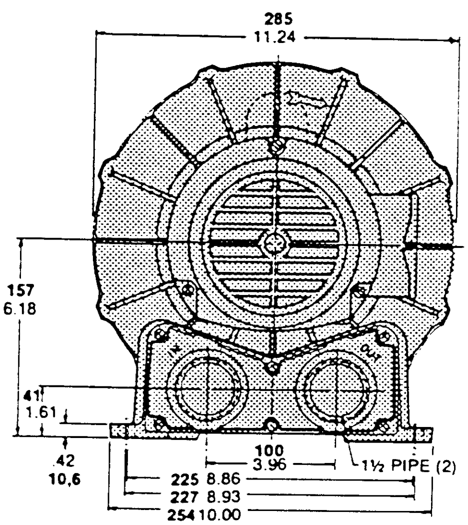
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

Product Dimensions Metric (mm) U.S. Imperial (inches)



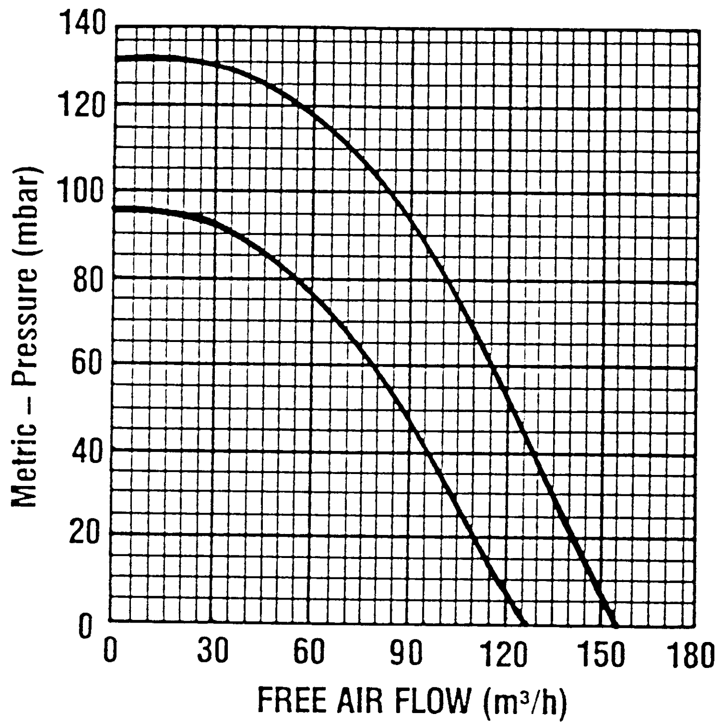


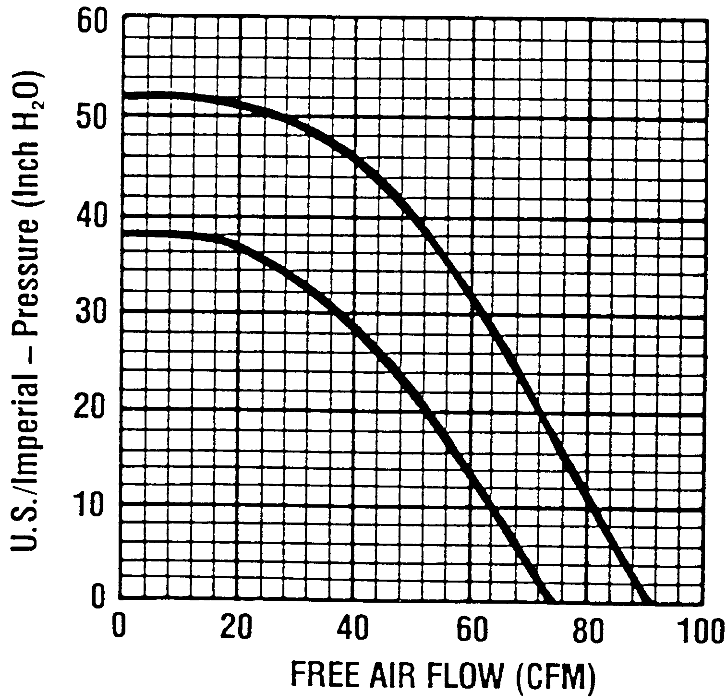
Product Specifications

Model Number	Motor Specs	Full Load Amps	HP	RPM	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m^3h	Net Wt. lbs.	Net Wt. kg
R4110-2	110/220-240-50-1	9.0/4.5-5.7	0.6	2850	38	95	74	126	41	18,6
	115/208-230-60-1	9.8/5.2-4.9	1.0	3450	52	130	92	156		
R4310A-2	190-220/380-415-50-3	2.6-3.3/1.3-1.4	0.6	2850	38	95	74	126	41	18,6
	208-230/460-60-3	3.4-3.2/1.6	1.0	3450	52	130	92	156		

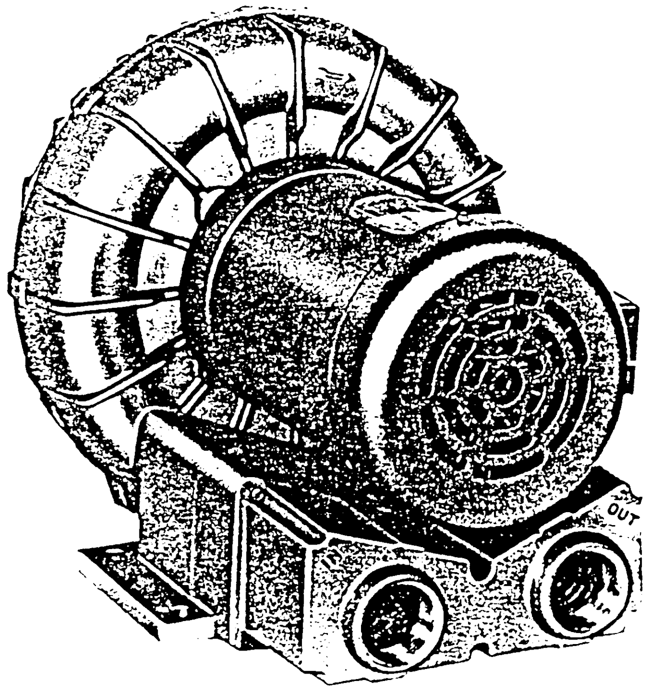
Product Performance (Metric U.S. Imperial)

Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.





REGENAIR® R5 Series



MODEL R5325A-2

65" H_2O MAX. PRESSURE, 160 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance

COMMON MOTOR OPTIONS

- 115/208-230V, 60 Hz, single phase
- 208-230/460V, 60 Hz; 190-220/380-415V, 50 Hz, three phase
- 575V, 60 Hz, three phase

RECOMMENDED ACCESSORIES

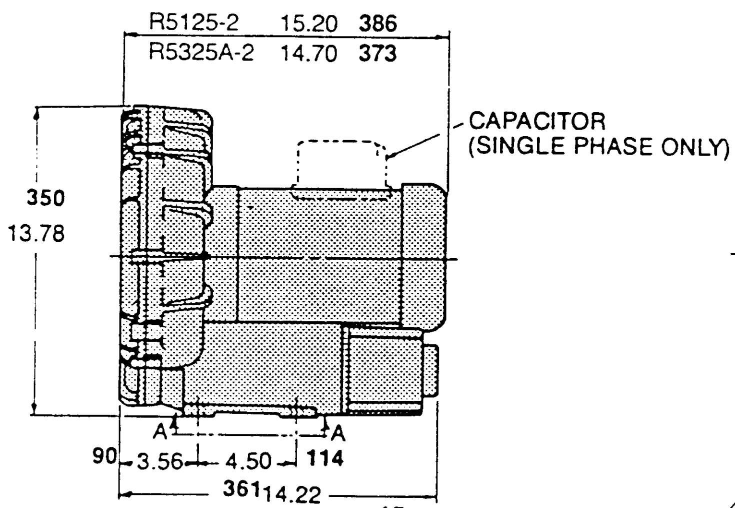
- Pressure gauge AE133
- Filter AG338
- Muffler AJ121D
- Relief valve AG258

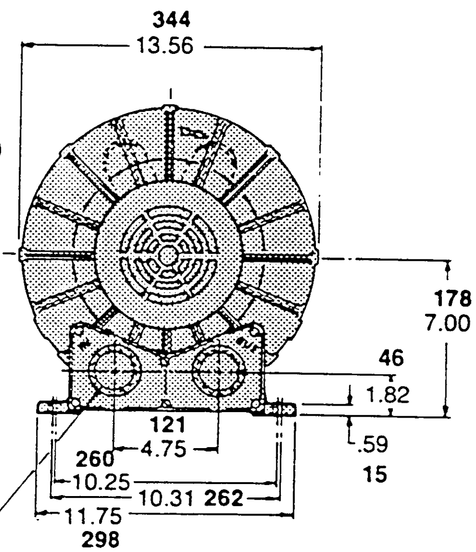
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

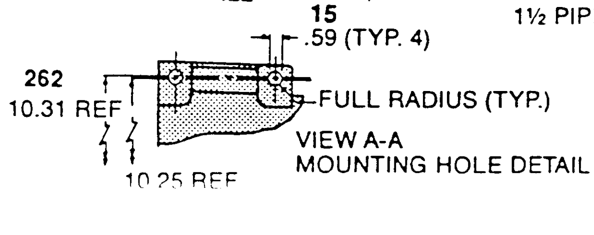
Important Notice:

Pictorial and dimensional data is subject to change without notice.

Product Dimensions **Metric (mm) U.S. Imperial (inches)**





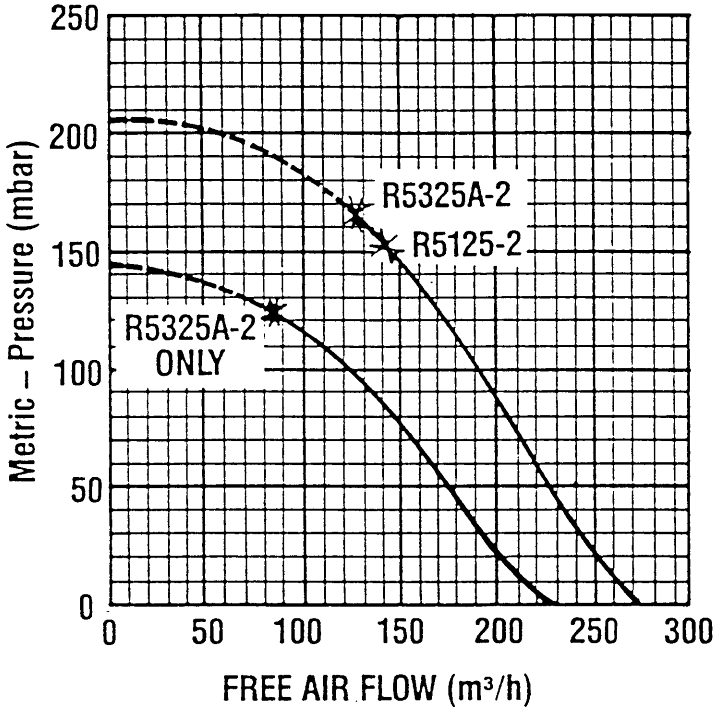


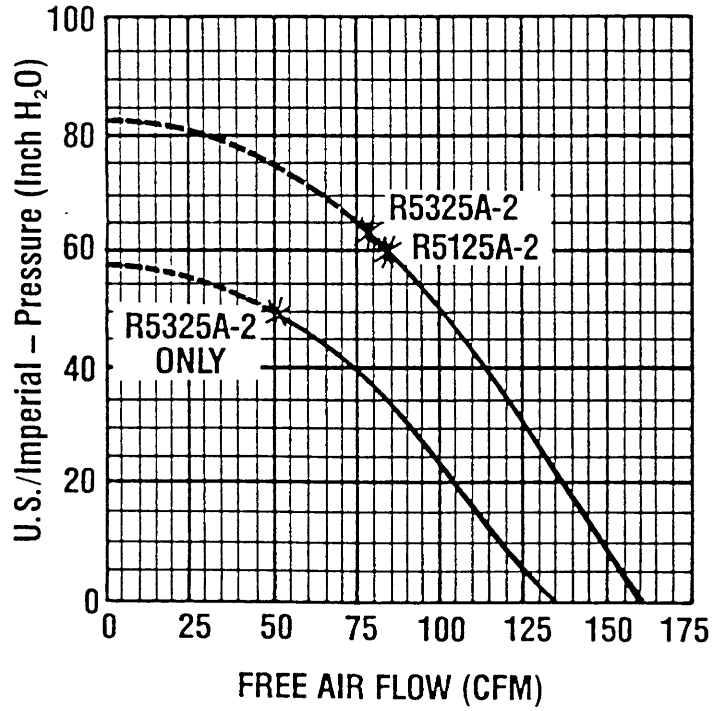
Product Specifications

Model Number	Motor Specs	Full Load Amps	HP	RPM	Max Pressure		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m³h	lbs.	kg
R5325A-2	190-220/380-415-50-3	6.6-6.7/3.3-3.5	1.35	2850	50	125	133	226	65	29,5
	208-230/460-3	6.9/3.45	2.5	3450	65	162	160	272		
R5125-2	115/208-230-60-1	22.4/12.4-11.2	2.5	3450	60	149	160	272	73	33,1

Product Performance (Metric U.S. Imperial)

Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.





*Recommended maximum duty.
- - - - Intermittent duty only.

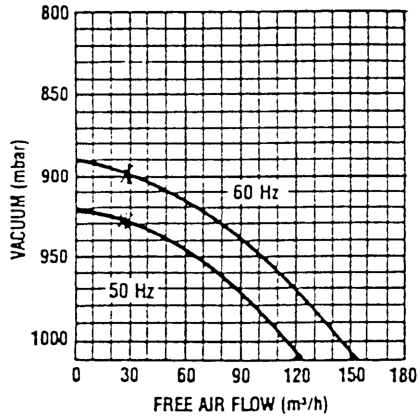
Product Specifications

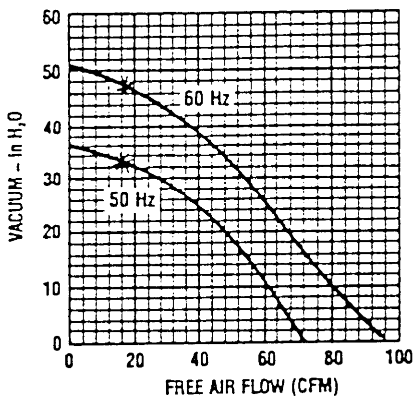
Model Number	Hz	Motor Specs	HP	RPM	Max Vac "H_2O	Max Vac mbar	Max Flow cfm	Max Flow m³h	Net Wt. lbs.	Net Wt. kg
R4110N-50	50	110/220-240-50-1	0.6	2850	35	924	72	122	60	28
	60	115/208-230-60-1	1.0	3450	48	895	88	150		
R4310P-50	50	220/380-50-3*	0.6	2850	35	924	72	122	58	27
	60	208-230/460-60-3*	1.0	3450	48	895	88	150		
R5125Q-50	60	115/230-60-1*	2.5	3450	60	865	145	246	77	35
R5325R-50	50	190-220/380-415-50-3*	1.85	2850	47	897	120	204	75	34
	60	208-230/460-60-3*	2.50	3450	60	865	145	246		
R6P355R-50	50	190-220/380-415-50-3*	4.5	2850	70	840	235	400	247	112
	60	208-230/460-60-3*	6.0	3450	90	790	260	442		

*Motors do not have thermal protection with automatic reset.

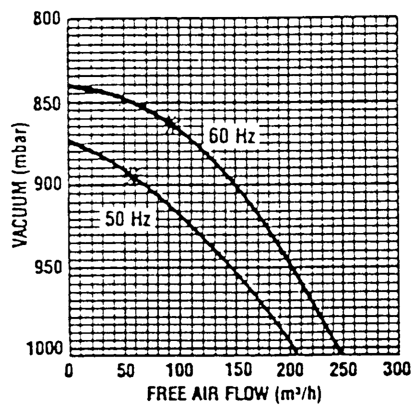
Product Performance (Metric U.S. Imperial)

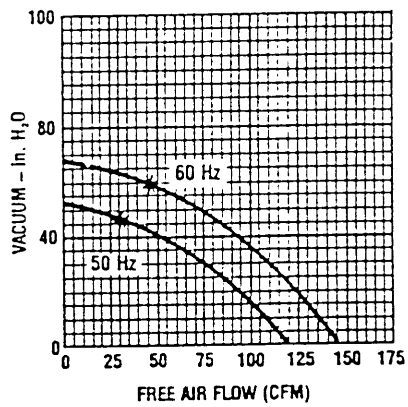
Model R4 Series



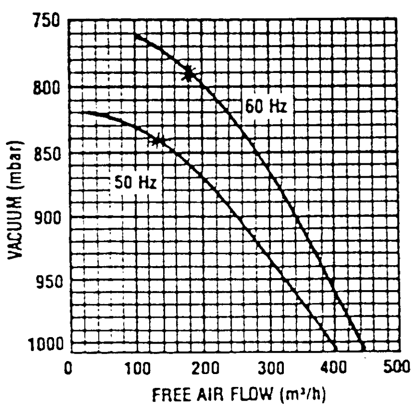


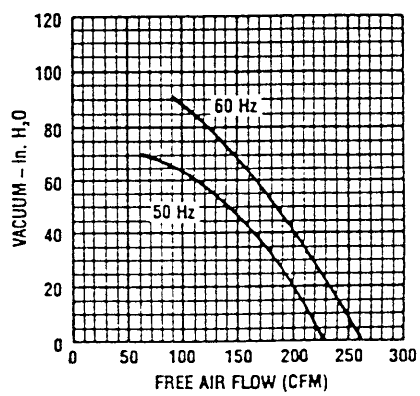
Model R5 Series





Model R6P Series

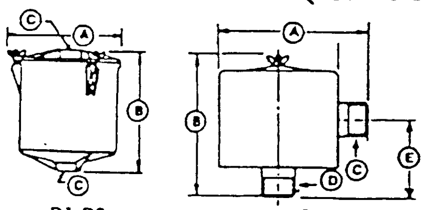




*Minimum flow permissible through the unit for trouble-free, continuous operation.

REGENAIR ACCESSORIES

Inline Filters (for vacuum)

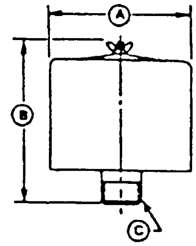


R1-R3 R4-R7

Model Number	R1 & R2	R3	R4, R5 &SDR4	R6P SDR5, SDR6 R6PP, R6PS	R7
Part #	AV460	AV460C	AG337	AJ151G	AJ151H
Dim A	8.25"	8.25"	11.75"	8.00"	16.25"
Dim B	8.875"	8.875"	4.75"	10.25"	27.13"
Dim C	1" FPT	1 1/4"FPT	1 1/2"MPT	2 1/2" MPT	3" MPT
Dim D	-	-	1 1/2" FPT	2 1/2"MPT	3" MPT
Dim E	-	-	2.38	5.50	18.50
Replacement Element	AV469	AV469	AG340	AJ135G	AJ135C
Micron	10	10	25	10	10

MPT = Male Pipe Thread
FPT = Female Pipe Thread

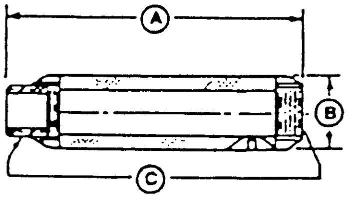
Inlet Filters (for pressure units only)



Model Number	R1 & R2	R3	R4, R5 &SDR4	R6, SDR5 SDR6, R6P R6PP, R6PS	R7
Part #	AJ126B	AJ126C	AG338	AJ126F	AJ126G
Dim A	6.00"	6.00"	10.63"	10.63"	10.00"
Dim B	4.62**	7.12**	4.81**	4.81**	13.12**
Dim C	1" MPT	1 1/4" MPT	1 1/2" FPT	2" FPT	2 1/2" MPT
Replacement Element	AJ134B	AJ134C	AG340	AG340	AJ135A
Micron	10	10	25	25	10

All are heavy duty for high amounts of particulates. Inlet filters for REGENAIR blowers are drip-proof when mounted as shown.

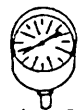
Mufflers



Model Number	R2	R3	R4, R5 SDR 4* &SDR5*	R6, SDR6* R6P R6PP, R6PS	R7
Part #	AJ121B	AJ121C	AJ121D	AJ121F	AJ121G
Dim. A	7.46**	7.94**	12.75**	17.05**	17.44**
Dim. B	2.38"	2.62"	3.25"	3.63"	4.25"
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT

* For Inlet Only
** Approximately

Pressure-Vacuum Gauge



Pressure Gauge, Part #AJ496, 2 5/8" Diameter, 1/4" NPT, 0-60 inches H_2O and 0-150 mbar

Pressure Gauge, Part #AE133A, 2 5/8" Diameter, 1/4" NPT, 0-200 inches H_2O and 0-500 mbar

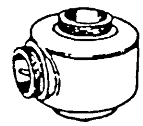
Vacuum Gauge, Part # #AJ497, 2 5/8" Diameter, 1/4" NPT, 0-60 inches H_2O and 0-150 mbar

Vacuum Gauge, Part #AE134, 2 5/8", Diameter, 1/4" NPT. 0-160 inches H_20 and 0-400 mbar

Fittings

Pipe Size	1"	1 1/4"	1 1/2"	2"	2 1/2"
Tee	BA415	BA431	BA432	BA433	BA434
Common Elbow	BA220	BA244	BA230	BA247	BA248
Nipple	BA752	BA809	BA783	BA810	BA813
Plastic Male Pipe Hose Barb	AJ117A	AJ117B	-	-	-
Hose I.D.	1.25	1.25	-	-	-
Metal Male Pipe Hose Barb	AJ117D	AJ117F	AJ117C	AJ117G	AJ117H
Hose I.D.	1.00	1.25	1.50	2.50	3.00

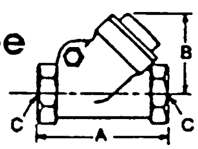
Relief Valve



Pressure/Vacuum Relief Valve, Part #AG258, 1 1/2" NPT, Adjustable 30-170 inches H_2O. 200 CFM maximum

Silencer for Relief Valve, Part #AJ121D

Horizontal Swing Type Check Valve

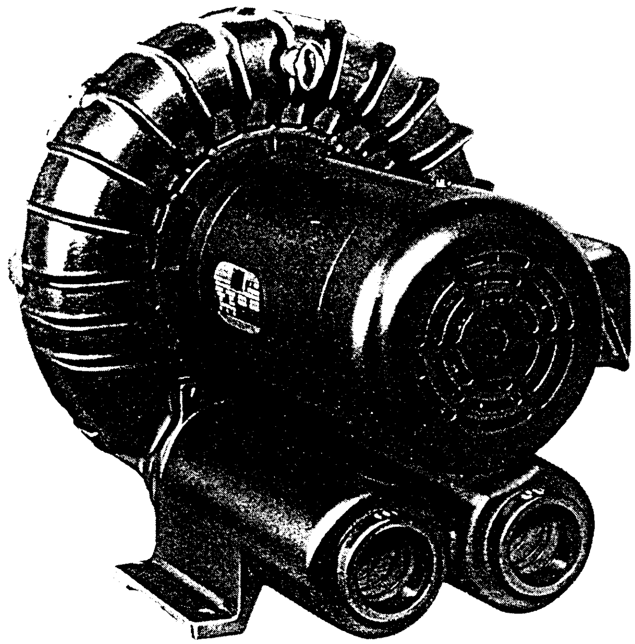


Model Number	R1, R2	R3	R4, R5 SDR 4 &SDR5	R6, SDR6 R6P R6PP, R6PS	R7
Part #	AH326B	AH326C	AH326D	AH326F	AH326G
Dim. A	3.57	4.19	4.50	5.25	8
Dim. B	2.32	2.69	2.94	3.82	5.07
Dim. C	1" NPT	1 1/4" NPT	1 1/2" NPT	2" NPT	2 1/2" NPT

Oilless Regenerative Blower, Motor Mounted to 270 cfm

GAST

R6P Series



MODEL R6P355A
86″ H_2O MAX. VAC., 270 CFM OPEN FLOW

MODEL R6P350A
70″ H_2O MAX. VAC., 270 CFM OPEN FLOW

MODEL R6P335A
35″ H_2O MAX. VAC., 270 CFM OPEN FLOW

PRODUCT FEATURES

- Oilless operation
- TEFC motor mounted
- Can be mounted in any plane
- Rugged construction/low maintenance

COMMON MOTOR OPTIONS

- 208-230/460V, 60 Hz; 190-220/380-415V, 50 Hz, three phase

RECOMMENDED ACCESSORIES

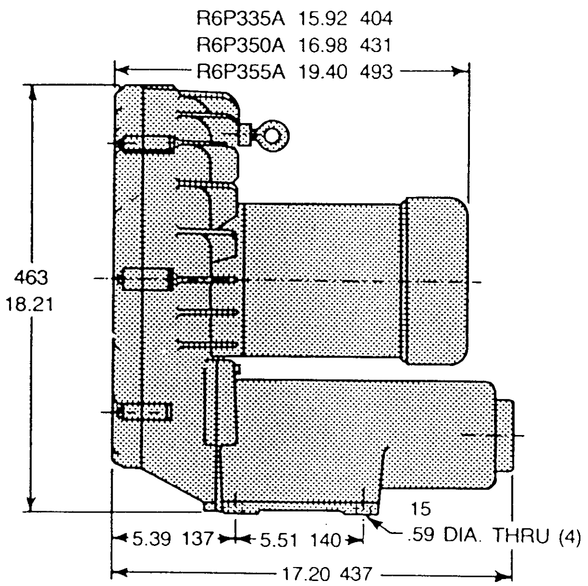
- Vacuum gauge AE134
- Automotive-type filter AJ151G
- Muffler AJ121F
- Relief valve AG258

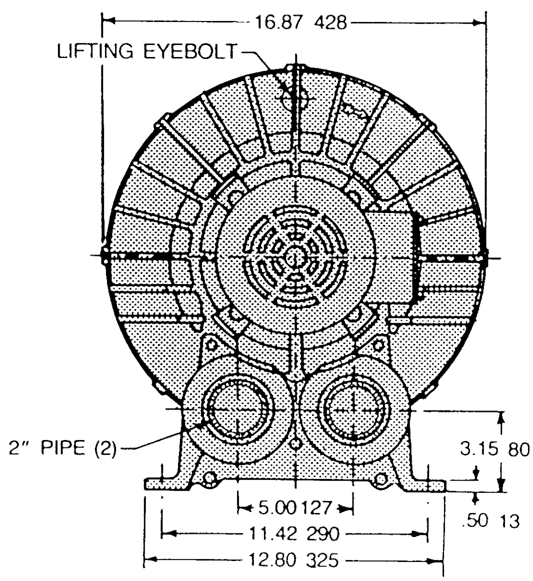
Various brand name motors are used on any model at the discretion of Gast Mfg. Corp.

Important Notice:

Pictorial and dimensional data is subject to change without notice.

Product Dimensions Metric (mm) U.S. Imperial (inches)





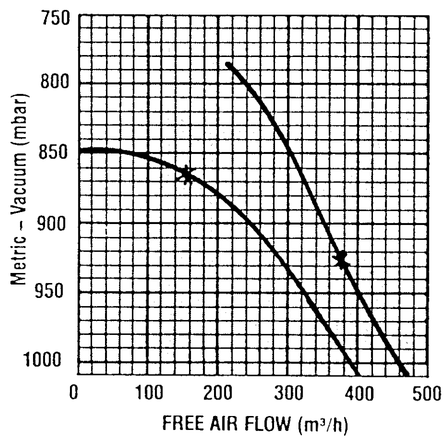
Product Specifications

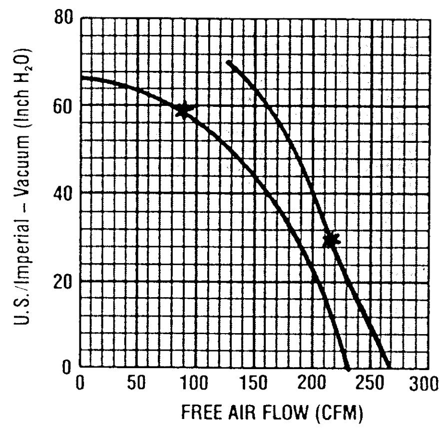
Model Number	Hz	Motor Specs	HP	RPM	Max Vac		Max Flow		Net Wt.	
					"H_2O	mbar	cfm	m³h	lbs.	kg
R6P335A	50	190-220/380-415-50-3	2½	2850	60	865	235	400	150	68
	60	208-230/460-60-3	3½	3450	35	926	270	460		
R6P350A	50	190-220/380-415-50-3	4½	2850	70	840	235	400	176	80
	60	208-230/460-60-3	5	3450	70	840	270	460		
R6P355A	50	190-220/380-415-50-3	5	2850	70	840	235	400	214	97
	60	208-230/460-60-3	5½	3450	86	799	270	460		

Product Performance (Metric U.S. Imperial)

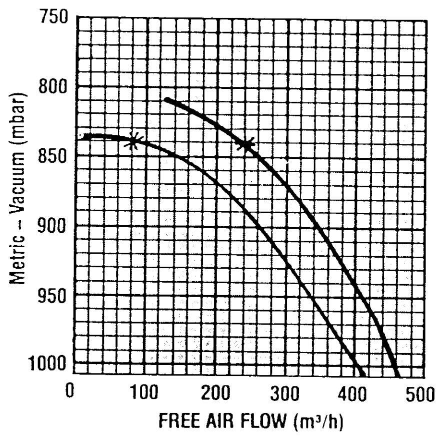
Black line on curve is for 60 cycle performance.
Blue line on curve is for 50 cycle performance.

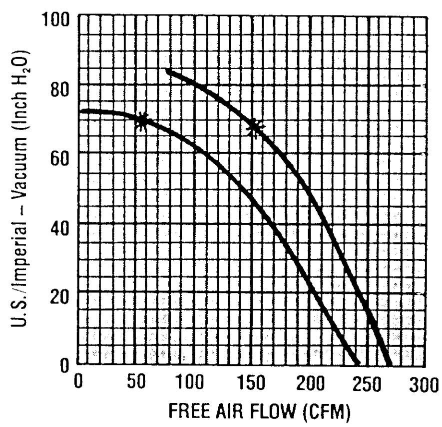
R6P335A



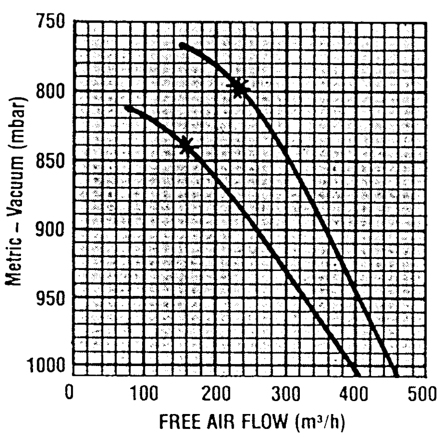


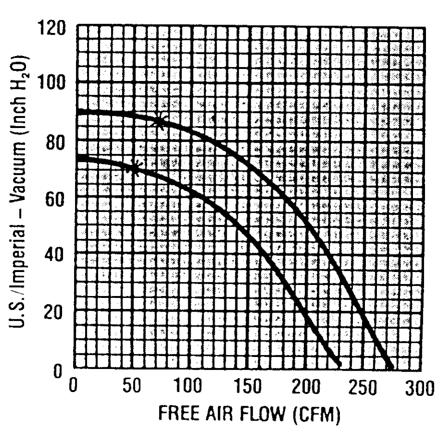
R6P350A





R6P355A





*Minimum flow permissible through the unit for trouble-free, continuous operation.

EXHIBIT B

DATA COLLECTION SHEETS

Blower Injection System Data Collection Sheet

Date	Time	Inlet Vacuum* (In. Water)	Inlet Temp.** (°F)	Outlet Pressure*** (In. water)	Outlet Temp.*** (°F)	Air Filter Changed (Y or N)	Blower Functioning (Y or N)	Comments	Checked By

* Gauge is located between the air filter and the blower.
** Same as ambient temperature.
*** Gauge is located on the outlet piping between the blower and the vent well.

APPENDIX A

PROJECT MANAGEMENT PLAN

Appendix A

PROJECT MANAGEMENT PLAN FOR *IN SITU* BIOVENTING TREATABILITY STUDY FOR 3700 FUEL YARD TINKER AIR FORCE BASE

Prepared For

DEPARTMENT OF THE AIR FORCE
OKLAHOMA CITY AIR LOGISTICS CENTER
TINKER AIR FORCE BASE

Prepared By

PARSONS ENGINEERING SCIENCE, INC.
AUSTIN, TEXAS

December 21, 1994

CONTENTS

TABLES

FIGURES

A1.0 INTRODUCTION

Tinker Air Force Base (AFB) has contracted Parsons Engineering Science (Parsons ES) to provide all services and supplies necessary to perform an *insitu* bioventing treatability study for the 3700 Fuel Yard at Tinker AFB. Tinker AFB is located in Oklahoma County in central Oklahoma, approximately 8 miles southeast of downtown Oklahoma City. The base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The base comprises 4,885 acres.

The 3700 Fuel Yard is located along the eastern boundary of Tinker AFB. Building 3703, a jet engine test facility, is located just past an asphalt parking area west of the fuel yard. Railroad tracks run along the northeastern boundary of the fuel yard to facilitate fuel delivery by rail tanker cars.

The 3700 Fuel Yard, also referred to as petroleum, oil, and lubricant (POL) area C, consisted of six 25,000-gallon underground storage tanks (USTs). The area has been in operation as an aviation fuel storage depot since the mid-1950s. In 1991, the six USTs were emptied and removed. At the time of tank removal, approximately 1,500 cubic feet of fuel-contaminated material was excavated and removed from the fuel yard. The resulting excavation was backfilled with uncontaminated sand, and the surface of the fuel yard was restored. Currently, jet fuel is stored at the site in surface storage and transfer facilities recently constructed at the site.

Several investigations have been conducted at the site and have concluded that residual fuel contamination of the soils has occurred in the general vicinity of the excavated USTs. The majority of this contamination appears to be confined to depths of 10 feet or less. A bioventing pilot test was installed at the site and operated for 1 year. The results of this test indicated that bioventing is an effective method of stimulating natural biodegradation of the fuel contaminants present in soils at the site. The purpose of the treatability study planned for the 3700 Fuel Yard is to determine if bioventing is a positive remediation alternative at this site and at other fuel contaminated soil sites at Tinker AFB.

The treatability study work plan has been developed to support the investigation and treatability study for the 3700 Fuel Yard at Tinker AFB. The work plan consists of this project management plan, a data collection quality assurance plan (appendix B), a data management plan (appendix C), and a health and safety plan (appendix D). The community relations plan is presented as a section of the work plan.

A2.0 OBJECTIVES

The objective of this treatability study is to determine the performance and operating parameters of a full-scale bioventing system and to define the relative costs of bioventing compared with other potential soil remedial technologies. To accomplish this objective, a bioventing system will be installed at the 3700 Fuel Yard and operated for 1 year. As part of this study, other sites at Tinker AFB will be evaluated to determine the feasibility of using bioventing as a remediation alternative.

A3.0 TECHNICAL APPROACH

Parsons Engineering Science will provide all personnel, equipment, materials, supplies, monitoring, operation and maintenance of specialized testing units, documentation, travel and transportation to complete the treatability study at the 3700 Fuel Yard. Parsons ES will conduct the following specific tasks, which are based on bioventing protocol documents and the Tinker AFB statement of work:

- Preparation of a pilot-scale *in-situ* bioventing treatability work plan for the 3700 Fuel Yard.
- Preparation of a corrective action plan for submittal to State of Oklahoma regulating authorities.
- Drilling a minimum of seventeen soil borings to further delineate the total petroleum hydrocarbon (TPH) plume, defined as >500 milligrams per kilogram (mg/kg) TPH. Three soil samples per boring will be collected in 5-foot intervals and analyzed for volatile organic compounds, semivolatile organic compounds, TPH as gasoline, TPH as diesel, RCRA metals, grain size distribution, moisture content, alkalinity, pH, total Kjeldahl nitrogen (TKN), and phosphate. Five of these seventeen borings will be completed as vent wells and connected together, via underground plumbing, to an appropriate sized blower to allow air injection into fuel-contaminated, oxygen-depleted, subsurface soils at the site. The remaining twelve borings will be completed as monitoring points set at approximately 5-, 10- and 15-foot depth intervals to allow soil gas monitoring for the duration of the treatability study.
- One groundwater sample will be collected from each of the three existing wells (2-8, 2-9, and 2-10) at the site and analyzed for volatile organic compounds, semivolatile organic compounds, TPH as gasoline, TPH as diesel, RCRA metals, dissolved oxygen, TKN, and phosphates.
- Weekly checks of the blower system will be performed to ensure proper operation.
- After 12 months of operations, five additional soil borings will be drilled adjacent to existing monitoring point borings. Samples will be collected at three depths that correspond to sample locations and depths from sampling activities 12 months earlier. These samples will be analyzed for the same parameters as previously. Proper disposition of all investigation-derived waste will be managed as required by pertinent laws and regulations.
- The 290 fuel farm, area A service station, BX service station, and fuel purge facility sites will be evaluated, using existing data and up to five manually driven soil gas points, for their applicability for bioventing remediation.

- *Insitu* respiration tests will be performed on a minimum of six monitoring points to determine the rate at which bacteria degrade fuel hydrocarbons in different portions of the site, and at different depths.
- Air permeability tests shall be performed on three vent wells to determine the relative pressure response from injecting air into vent wells located in different portions of the site.
- The twelve monitoring points installed as part of this study and the three existing monitoring points will be sampled initially and at 4-month intervals for the 1-year duration of the study. Each monitoring point has three extraction depths for a total of forty-five possible soil gas samples per sampling event. Air injection will be discontinued 21 days prior to sampling to allow the subsurface soil ecology to recover to stagnant air conditions, thus allowing comparison to initial readings. Each soil gas sample will be analyzed for percent oxygen, percent carbon dioxide, methane, total volatile hydrocarbons (TVH), and TPH.
- Air emission tests will be performed before and during operation of the bioventing system using a soil flux chamber to monitor for emissions released to the atmosphere resulting from air injection.

A4.0 ORGANIZATION

The project organization is shown in Figure A.1. The responsibilities of Parsons ES project team members are described below.

Project Manager

The project manager is responsible for the entire project team. The principal concern of the project manager is to ensure that the work is performed on time and within budget and that it meets the high standards of quality demanded by Parsons Engineering Science and Tinker AFB. The project manager will serve as the liaison for all communication between Parsons ES and Tinker AFB. The project manager is Brian Vanderglas. Mr. Vanderglas has both senior project scientist and project management experience conducting bioventing pilot studies, full-scale bioventing system installations, long-term bioventing system monitoring, and site and remedial investigation work in both CERCLA and RCRA regulatory environment.

Principal in Charge

The Parsons ES principal in charge is responsible for ensuring compliance with all contractual obligations of Parsons ES. The principal in charge will execute all agreements, subcontracts, and amendments to contracts and subcontracts. The principal in charge will also ensure that the contractual obligations of all subcontractors are met. The principal in charge is Ernest Schroeder, P.E.

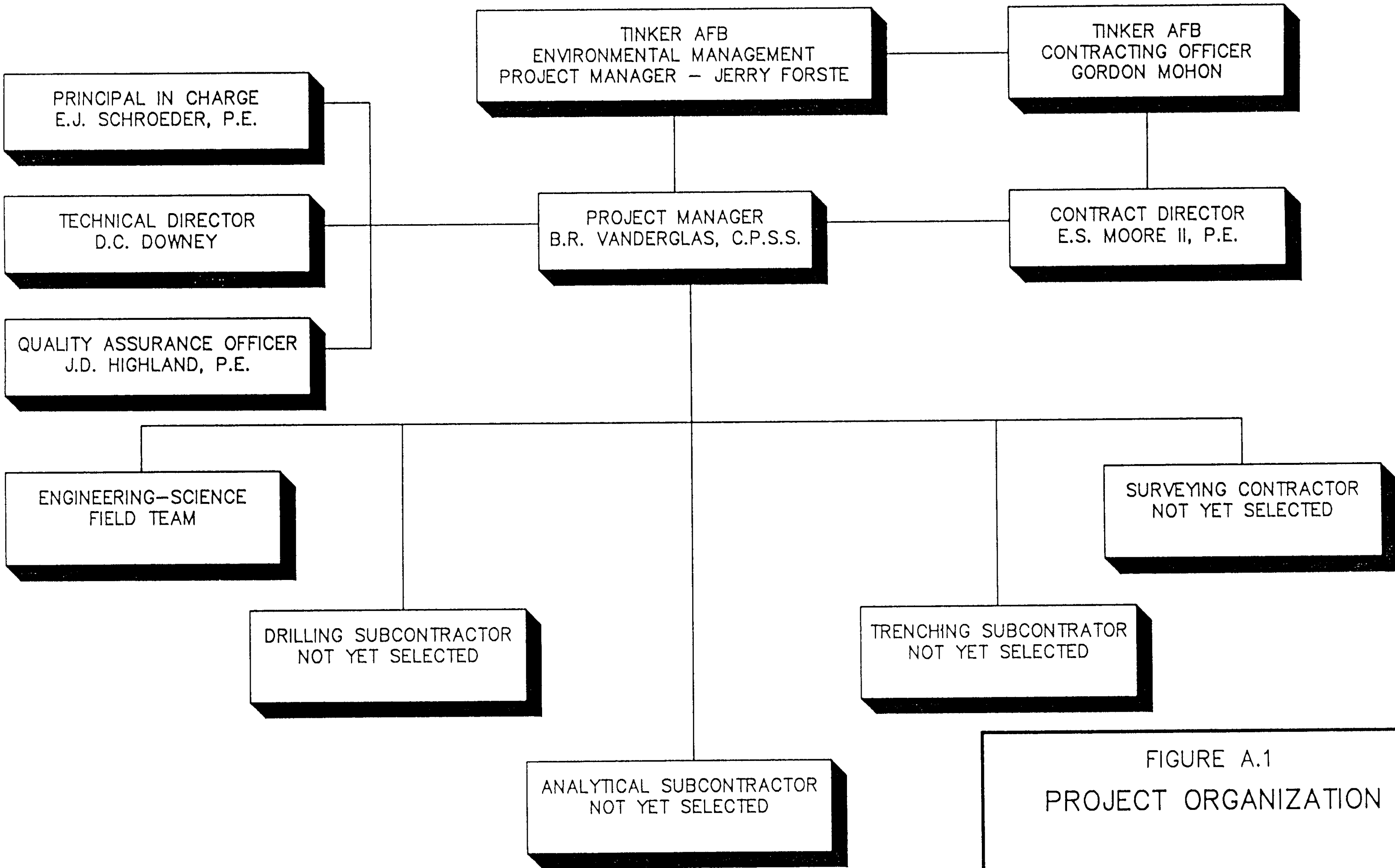


FIGURE A.1

PROJECT ORGANIZATION

TINKER AFB, OKLAHOMA

ENGINEERING–SCIENCE, INC.
AUSTIN, TEXAS

TKORG 10/03/94

Technical Director

The role of the technical director is to guide and review the technical aspects of the work through project completion to ensure that the highest standards are maintained. The technical director will direct the review of all project submittals, subcontracts, and deliverables. The technical director is Doug Downey. Mr. Downey has extensive experience in the evaluation and testing of both innovative and conventional remediation technologies for hazardous waste sites and leaking USTs. He is currently managing a major bioventing research project involving 110 sites at thirty-seven Air Force installations.

Quality Assurance Officer

The quality assurance officer will ensure that all documentation required by the quality assurance plan is correctly prepared and available in the project file. The quality assurance officer is David Highland, P.E.

Field Team Leader

The field team leader will be responsible for all field activities and will act as the main contact between the Parsons ES project manager and the Tinker AFB environmental project monitor. The field team leader will ensure that all field work is performed in accordance with state and federal regulations and the terms of all contractual agreements. The field team leader will assist with preparation of all documentation necessary for successful completion of the treatability study.

The field team leader will ensure that all subcontractor work is performed in accordance with subcontract specifications and will track the progress of work. The field team leader will coordinate with the project manager to administer terms and conditions of the subcontract and assist the project manager in approving invoices. The field team leader will also work with subcontractors on the scheduling of field activities and assist in processing contract change requests. The field team leader will designate a temporary field team leader in his absence. The field team leader is Curt Burdorf.

Health and Safety Officer

The health and safety officer will ensure that all field activities are performed in accordance with the Parsons ES health and safety plan and Occupational Safety and Health Administration (OSHA) requirements. The health and safety officer will hold a brief health and safety meeting daily prior the start of work. The site health and safety officer has the responsibility to stop work if it is being performed in an unsafe manner. The health and safety officer will designate a temporary health and safety officer in his or her absence. The site health and safety officer will be identified prior to the start of field activities.

Project Field Team

The project field team will consist of the field team leader, the site health and safety officer, and other individuals who assist the field team leader with performance of field activities. The project field team will collect all soil and air samples, prepare all chain-of-custody records, prepare samples for delivery to the laboratory, install bioventing plumbing, and monitor all subcontracted work.

<u>Tinker AFB Points of Contact:</u>

Contracting Officer
Gordon Mohon
OPC-ALC/PKOSS
7858 Fifth Street, Suite 1
Tinker AFB, OK 73145-9106
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A5.0 PROJECT SCHEDULE

The project schedule is given in Figure A.2. The schedule may be subject to change as needed. All changes will be coordinated through the Parsons ES project manager and the Tinker AFB contracting officer. Table A.1 is list of deliverables with due dates based on the statement of work.

A6.0 PROJECT DOCUMENTATION

A6.1 Central Project Files

Central project files will be administered in the Parsons ES Austin office. Parsons ES branch offices involved in the project will provide weekly updates of project documents. Separate files will be maintained for:

- Project control documentation
- Project correspondence
- Technical data
- Project accounting
- Subcontract documents, monthly progress reports
- Original copies of project deliverables.

A6.2 Field Files

Field files will be set up and maintained by the field team leader at the project site and/or the Parsons ES Oklahoma office (when established). Additional information is provided in the Data Management Plan. The following items will be maintained in the field files:

- RFI work plan
- Field procedure guidance documents
- Project health and safety plan
- Project management plan
- Project quality assurance plan
- Field log book(s)
- Daily progress reports
- Work permits
- Copies of chain-of-custody documents, lab reports, and manifests
- Copies of subcontracts
- Copies of boring logs
- Photograph log
- Subcontract correspondence
- Change orders
- FARs
- Project schedule updates.

Additional job files will be created as needed by the field team leader. All files will be given to the project manager after completion of field activities.

A6.3 Correspondence Control

All written communication to Tinker AFB must be signed by the project manager or his designee. All correspondence from Parsons ES to Tinker AFB will be directed to the Tinker AFB contracting officer or environmental project manager, as appropriate.

All correspondence, including letters, memos, transmittal forms, and telephone logs, will be maintained in the central project file. Correspondence logs will be maintained for incoming and outgoing correspondence. The correspondence log will be updated weekly with an index indicating the designating number, date, author, and subject.

Figure A.1
Project Schedule

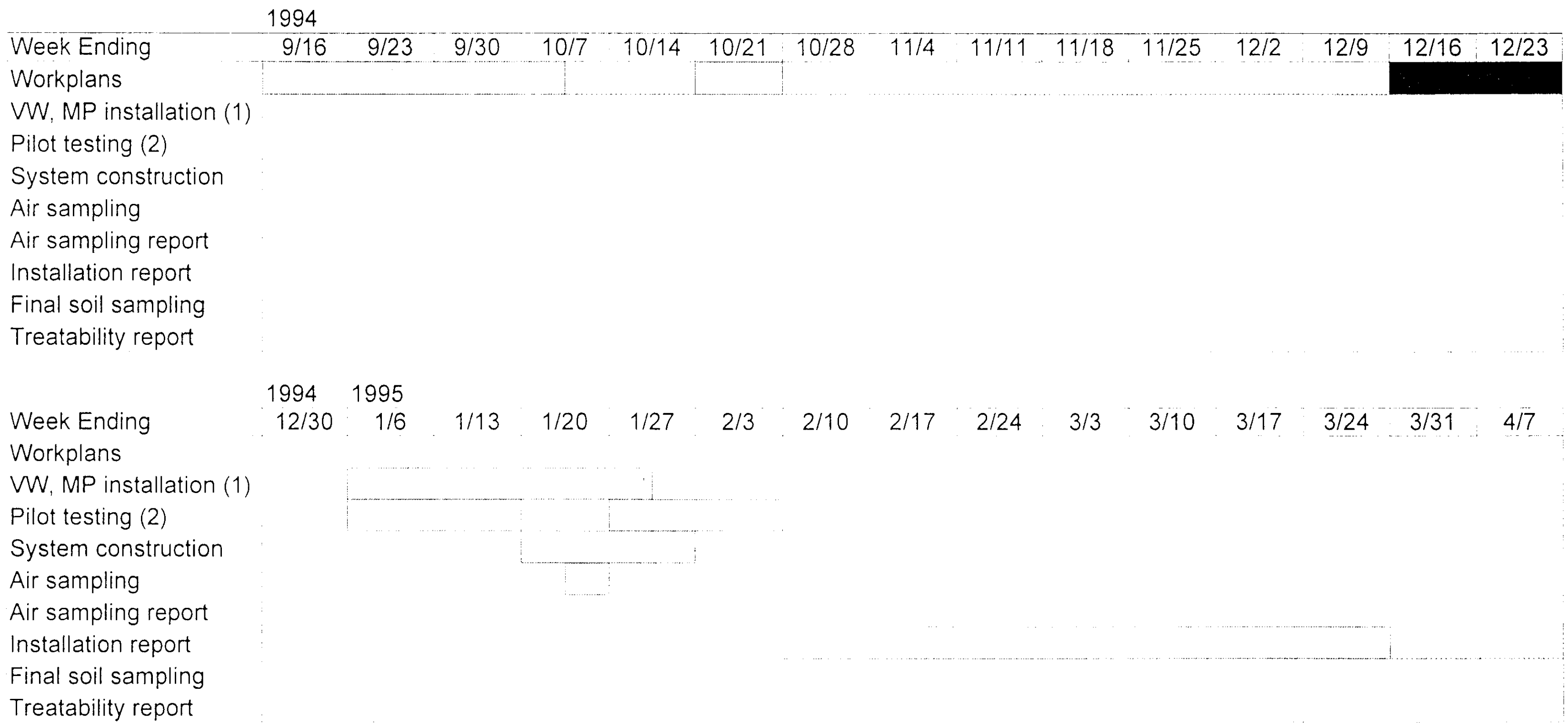


Figure A.1
Project Schedule (continued)

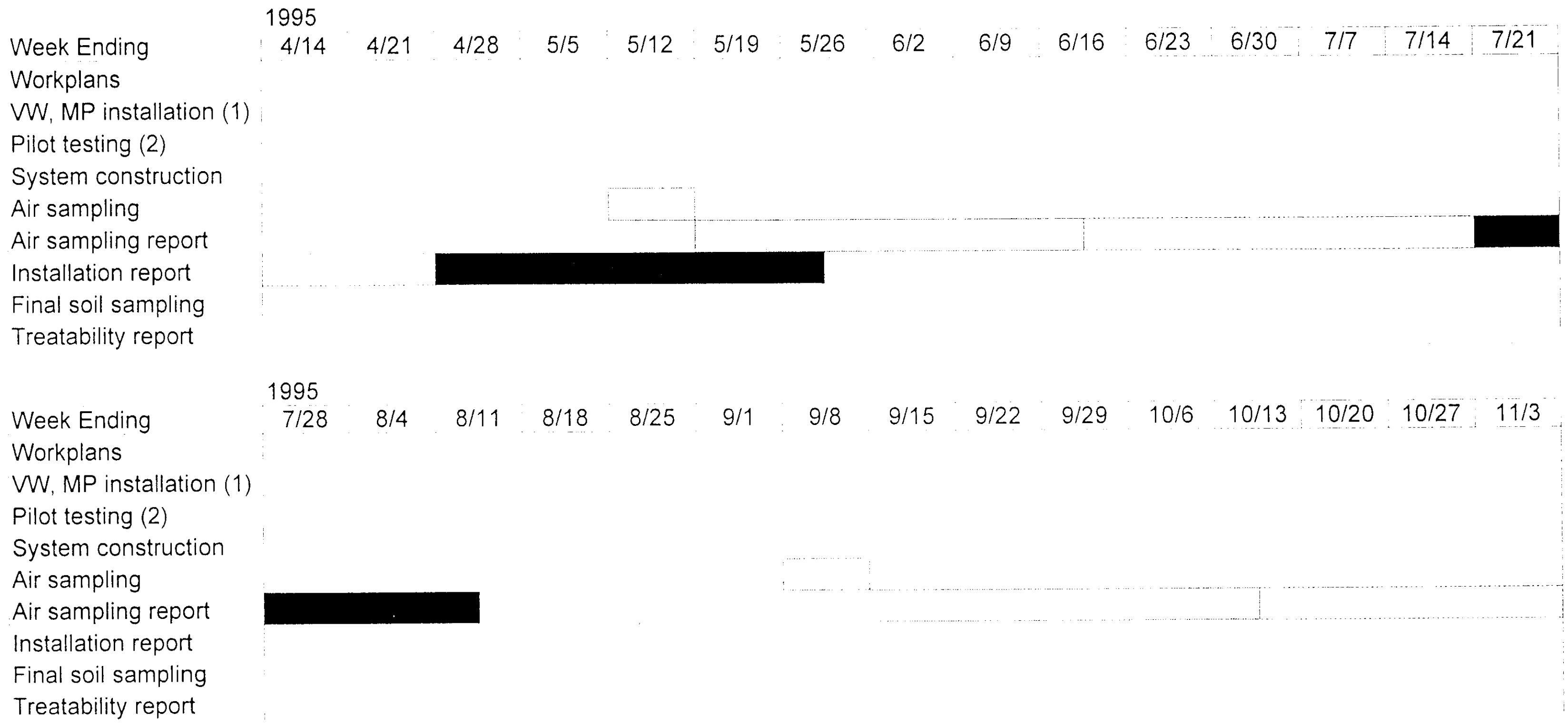
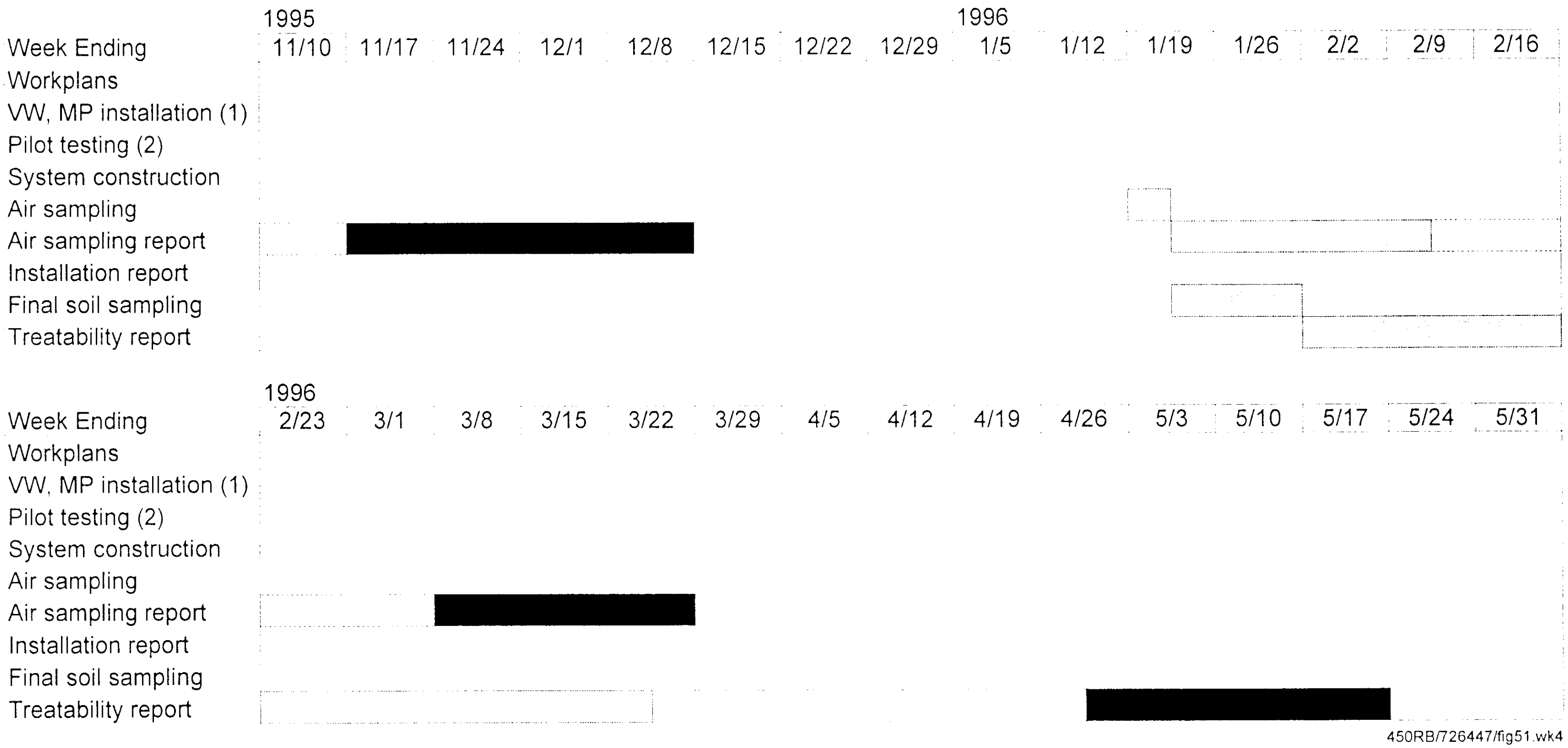


Figure A.1
Project Schedule (continued)



(1) VW = vent well; MP = monitoring point
(2) Includes respiration testing, air permeability testing, soil flux (emission) testing at 3700 fuel yard, and soil gas screening at four other fuel sites.

ES draft document preparation or field activities

Tinker AFB document review

ES final document preparation

Table A.1. List of Deliverables for *Insitu* Bioventing Treatability Study for 3700 Fuel Yard

Submittal	Draft due date*	Final due date*
Work plan**	21 October 1994	23 December 1994
Corrective action plan**	21 October 1994	23 December 1994
Material approval submittals (A036)	No draft	23 December 1994
Operation and maintenance plan	20 February 1995	24 March 1995
Photographic record (A076)	No draft	20 February 1995
Daily field log (A022)	No draft	20 February 1995
Completed installation report with well/boring record (A051)	24 March 1995	23 May 1995
Air sampling report (1st)	12 June 1995	09 August 1995
Air sampling report (2nd)	09 October 1995	07 December 1995
Air sampling report (3rd)	05 February 1996	05 April 1996
In-situ bioventing treatability study report**	19 March 1996	15 May 1996
Daily field log (A022)	No draft	19 March 1996
IRPIMS data	No draft	19 March 1996
Final report disk	No draft	15 May 1996
Monthly progress report	No draft	Due monthly, October 1994 through June 1996

* Dates based on statement of work, notice to proceed on September 6, 1994.

** Internal draft cycle not included on deliverable lists.

APPENDIX B

DATA COLLECTION QUALITY ASSURANCE PLAN

Appendix B

DATA COLLECTION QUALITY ASSURANCE PLAN FOR *IN SITU* BIOVENTING TREATABILITY STUDY FOR 3700 FUEL YARD TINKER AIR FORCE BASE

Prepared For

DEPARTMENT OF THE AIR FORCE

OKLAHOMA CITY AIR LOGISTICS CENTER

TINKER AIR FORCE BASE

Prepared By

PARSONS ENGINEERING SCIENCE, INC.

AUSTIN, TEXAS

December 21, 1994

CONTENTS

FIGURES

Page

TABLES

Page

SECTION B1.0
PROJECT DESCRIPTION

This Data Collection Quality Assurance Plan (DCQAP) describes the procedures to be followed by Parsons Engineering Science, Inc. (Parsons ES) during the *in-situ* bioventing treatability study at the 3700 Fuel Yard site (also referred to as POL Area "C") at Tinker AFB in Oklahoma City, Oklahoma. The purposes of this plan is to guide the field work by describing appropriate sample collection, handling, and analytical protocols to be followed to assure that data obtained is of satisfactory quality and that the integrity of the samples is maintained.

B1.1 SAMPLE COLLECTION RATIONALE

Soil samples, subsurface soil gas samples, groundwater samples, air emission (soil flux) samples, and miscellaneous field screening data is planned at the site to evaluate the performance of the bioventing treatability study.

B1.1.1 Soil Samples

Soil samples will be collected during installation of the bioventing system to delineate the extent of the subsurface contaminated soil area (or volume), and to establish contaminant levels in soils prior to initiating remedial activities (air injection). After one year of mostly continuous biodegradation enhancement at the site, additional soil samples will be collected to evaluate the quantity of contaminants removed through remedial activities during the one year test period.

B1.1.2 Soil Gas Samples

Soil gas samples will be collected from three depth intervals at each of the 15 multi-depth monitoring points on four occasions throughout the operation of the one year bioventing study. These samples will be collected initially after installation of 12 additional monitoring points to complement the existing three monitoring points and prior to beginning air injection. Each point will be sampled at 4, 8, and finally after 12 months of air injection to assess the relative reduction of contaminant levels in the soil atmosphere throughout the study. Additional soil gas samples will be collected from a background monitoring point constructed in an undisturbed area to evaluate natural soil gas characteristics.

B1.1.3 Soil Flux Samples

Soil flux samples will be collected to determine if contaminants are being emitted to the atmosphere from the contaminant source area under natural conditions, and during active air injection periods. This will be accomplished by collecting flux samples at nine locations prior to initiating the study to establish normal emission rates from the site. The same nine locations will be resampled during active operations of the bioventing system.

B1.1.4 Groundwater Samples

Groundwater samples will be collected from the three monitoring wells located in the immediate vicinity of contaminant plume. This groundwater date will be used to provide current groundwater characteristics of the perched groundwater zone present at approximately 18 feet below ground surface (BGS).

B1.1.5 Samples for Field Screening

Miscellaneous field screening data will also be collected during *in-situ* respiration and air permeability testing to determine operating parameters of the bioventing system prior to initiating air injection. Field screening instruments (such as oxygen and carbon dioxide meters) will also be used to assist in the evaluation of soil gas characteristics at four other fuel sites. Data from this field screening will be used with existing site information to determine if the *in-situ* bioventing treatment technology is applicable for remediating the contaminants below regulatory standards.

SECTION B2.0
FIELD OPERATIONS

B2.1 SOIL SAMPLING

B2.1.1 Preliminaries

All necessary digging, drilling, and well installation permits will be obtained prior to mobilizing to the field. In addition, all utility lines will be located and marked, and proposed drilling locations will be cleared prior to any drilling activities. Tinker AFB will assist the field team in obtaining all utility clearances. The Parsons ES field team leader will be responsible for relocating soil borings if utilities or other concerns are encountered.

B2.1.2 Equipment Decontamination Procedures

Water to be used in drilling, equipment cleaning, or grouting will be obtained from one of the base's onsite water supplies. Water use approval will be verified by contacting the appropriate facility personnel. Only potable water will be used for the activities listed above. The Parsons ES field hydrogeologist will make the final determination as to the suitability of site water for these activities.

Prior to arriving at the site, and between each drilling site, the drill rig, augers, drilling rods, bits, casing, samplers, tools and other downhole equipment will be decontaminated using a high-pressure, steam/hot water wash. A decontamination pad will be constructed in the 3700 Fuel Yard near the drum storage area. Only potable water will be used for decontamination. Water from the decontamination operations will be allowed to collect in the decontamination pad collection tanks. This collected water will be transferred to 55-gallon drums for temporary storage at the end of each day. Precautions will be taken to minimize any impact to the area surrounding the decontamination pad that might result from the decontamination operations.

All sampling tools will be cleaned onsite, prior to use and between each sampling event, with a clean water/phosphate-free detergent mix, an isopropanol rinse, and a distilled water final rinse. All well completion materials that are not factory sealed will be cleaned onsite prior to use with a high-pressure, steam/hot water wash using approved water. Materials that cannot be cleaned to the satisfaction of the Parsons ES field hydrogeologist will not be used.

B2.1.3 Procedures

Drilling in unconsolidated soils will be accomplished using hollow-stem augers. The borings will be drilled and continuously sampled to the proposed total depth of the monitoring well. Auger outer diameter (OD) will not be less than 8 inches. Determination of well completion details will be at the discretion of the Parsons ES field hydrogeologist. It is likely that most boreholes for vent well installation will be drilled to a final diameter of at least 10 inches within the suspected source area. Boreholes drilled for monitoring point installation will be drilled to a final diameter of at least 8 inches.

Continuous soil samples will be obtained using a CME® split-barrel continuous sampling device or another similar method judged acceptable by the Parsons ES field hydrogeologist. Samples will be collected from the surface through the capillary fringe smear zone to slightly below the ground water table. The Parsons ES field hydrogeologist will identify which samples from the continuous sampling device will be submitted for chemical analysis. Soils that exhibit possible contamination will be preferentially selected for chemical analysis. Three soil samples for chemical analysis will be collected per borehole at approximately 5 to 6 foot intervals. Also, one sample per borehole will be collected for geotechnical analysis. The soil samples will be placed in appropriate samples jars and properly labeled. Sample containers will be then placed on ice in coolers until delivered to the analytical laboratory via next day delivery service. Sample handling and custody is described in greater detail in section 5.0 of this DCQAP. Sample identification is discussed in the data management plan (Appendix C of this work plan).

If subsurface conditions are such that the planned drilling technique does not produce acceptable results (e.g. unstable borehole walls or poor soil sample recovery) another technique deemed more appropriate to the type of soils present will be used. Any alternate soil sampling procedure used must be approved by the Parsons ES field hydrologist and will be appropriate for the subsurface lithologies present at the site.

The Parsons ES field hydrogeologist will maintain a descriptive log of all soils cores recovered from each borehole. Recovered soil cores will be described with respect to lithology, grain size, color, moisture content, consistency, strength, and visible contamination in a consistent manner. An example of the proposed geologic boring log form is presented in Figure B2.1.

Representative portions of the soil cores will also be collected and quickly transferred to temporary sample containers for headspace testing. These temporary containers will be sealed and held for at least 15 minutes in an environment of 65 degrees Fahrenheit or higher. Semi-quantitative measurements will be made by puncturing the container seal with an organic vapor analyzer and reading the concentration of headspace gases. The organic vapor analyzer typically relates the concentration of total volatile organic compounds in the headspace samples to an isobutulene calibration standard. The

Figure B2.1 Drilling Log Form

PAGE ___ OF ___

DRILLING LOG	PARSONS ENGINEERING SCIENCE, INC.	REF LOGBOOK:

SITE LOCATION: 3700 FUEL YARD	WELL OR BORING NO.:
CLIENT/PROJECT: TINKER AIR FORCE BASE	CONTRACT NO: F34650-93-D-106 D.O. 5008
DATE:	DRILLING CONTRACTOR: RONE ENGINEERS
DRILLING METHOD:	DRILLING RIG:
SAMPLING METHOD:	DRILLER:
BOREHOLE DIA.:	LOGGED BY:
WATER FOUND (ft-BGL):	TOTAL DEPTH (ft-BGL):
DRILLING START:	DRILLING END:

DEPTH (feet)	SAMPLE INTERVAL	RECOVERY	HNU SCAN (ppm)	LITHOLOGIC DESCRIPTION	HNU HDSP (ppm)	SAMPLE NO.	COMMENTS

FIGB2-1 12/20/94

organic vapor analyzer will also be used to monitor the worker breathing zone and to screen the recovered soil cores to assist in the sample selection.

The five boreholes for the injection vent well installation will be drilled and sampled first. Construction details will be recorded in the field logbook. The twelve monitoring point boreholes will be installed after setting the vent wells. Construction details for vent wells and vapor monitoring points are discussed in section 4.0 of the work plan. Each monitoring point will be completed at-grade (flush-mount) with a protective cover and a 6-inch thick, 2-foot-diameter concrete pad immediately surrounding the well cover. The concrete will be sloped gently away from the protective casing to facilitate runoff during precipitation events.

B2.2 SOIL GAS SAMPLING

Twelve multi-depth monitoring points (VMP) will be installed in the suspected TPH plume delineated at the 3700 Fuel Yard, and one background, multi-depth VMP will be installed in a nearby location which is relatively unaffected by site contamination. These VMPs will complement the existing VMPs installed during the bioventing pilot test performed in 1992. Each monitoring point will be screened at three distinct depth intervals (5, 10, and 15 feet bgs). Data from these intervals will be used to characterize the initial soil gas contamination and to monitor the effectiveness of the full-scale bioventing treatability study after 4, 8, and 12 months of operation. All three depths in each of the 15 monitoring points will be sampled at four different times over a one year period. Additionally, all three screened intervals of the background monitoring point will be sampled during the initial round of soil gas sampling. Generally, soil gas samples will be collected by attaching a vacuum pump to the monitoring point using flexible tubing and pulling soil air through the screened interval. Before retaining a soil gas sample, at least four to five casing volumes of soil gas will be evacuated through the probe to ensure a representative sample of soil air from the surrounding formation is obtained. After purging the monitoring point (typically 30 to 60 seconds), the flexible tubing is attached to a vacuum sampling chamber. An air sampling Tedlar™ bag is connected to the sampling tube within the vacuum sampling chamber. The vacuum pump is also attached to the vacuum sampling chamber to create a low pressure system within the dessicator causing air to be drawn up from the screened interval into the Tedlar™ bag.

Once full, the sample in the Tedlar™ bag will be transferred to a Summa® canister. This is accomplished by connecting the bag to a special fitting on the top of the canister. The Summa® canisters typically possess a one liter vacuum that pulls the air sample directly from the Tedlar™ bag into the canister by simply opening a valve. Once complete, the canister tag is labeled and sampling information, including canister identification numbers, are recorded in the field log book. The canisters are packed in shipping boxes and sent to the laboratory via next day delivery service.

B2.3 SOIL FLUX SAMPLING

Nine flux (or air emission) samples will be collected at the locations described in section 4.5.1 of the work plan for this treatability study. Flux samples will be collected using procedures outlined in the EPA guidance document "*Measurement of Gaseous Emission Rates from Land Surfaces Using a Emission Isolation Flux Chamber* (February 1985). This approach uses a flux chamber (enclosed device) to sample gaseous emissions from a defined surface area. The flux chamber is placed over the soil surface to be tested and a seal to the surface is created. Ultra zero grade breathing air (hydrocarbon free) is added to the chamber at a fixed, controlled rate. The volumetric flow rate of this sweep air is recorded. Typically, the flow needs to be great enough to provide positive pressure within the chamber. Sweep air is continuously added to the chamber for 30 minutes. At 5 liters per minute flow rate, approximately one chamber volume of air is purged in 6 minutes. Using a photovac hydrocarbon meter, or a comparable instrument that operates by pulling air via vacuum through the instrument, the hydrocarbon content is screened at 6 minutes intervals and recorded on a flux data sheet. A copy of a typical data sheet is presented as Figure B2.2 The temperature is also monitored by placing a thermometer probe inside the chamber during sweep air injection.

If screening results indicate that volatile organic compound concentrations in the chamber purge air have stabilized after 30 minutes, then an air emission sample will be collected. This is accomplished by attaching a Summa® canister to the purge air exit port and opening the valve which releases the vacuum in the canister to pull the sample into the canister. Once collected, the samples are labeled and placed in a shipping box for eventual shipment to the air testing laboratory. Sample collection information, including the Summa® canister identification number, will be recorded in the field log book.

B2.4 GROUNDWATER SAMPLING

The three monitoring wells, 2-8, 2-9, and 2-10, were constructed in 1992.

Before a well is purged, the water level will be measured and recorded to the nearest 0.01 foot using an electric water level indicator. Immiscible layer are not anticipated but if present, an interface probe will be used to determine their thickness. Before samples are collected, the wells will be purged by removing at least five casing volumes of water from each well. If the well does not recharge fast enough to allow the removal of five casing volumes, the well will be pumped or bailed dry before sampling. All purged water will be collected in a drum for disposal as discussed in the investigation derived waste section of the workplan (section 4.4). Temperature, pH, and conductivity values will be measured and recorded after three casing volumes are removed during purging. The sample will be collected after three casing volumes have been removed and the temperature, pH, and conductivity have stabilized. If these parameters do not stabilize, the sample will be collected after ten casing volumes have been removed.

Figure B2.2 Flux Chamber Gas Emission Measurement Field Data Sheet

FLUX CHAMBER EMISSIONS MEASUREMENT DATA

Date ______________________ Sampler(s) ______________________

Location ______________________ Zone/Grid Point ______________________

Surface Description ______________________

Concurrent Activity ______________________

Time	Sweep Air Rate Q (L/Min)	Residence No. (Q/V)	Gas Conc. (ppmv)	Air Temperature Chamber (C)	Air Temperature Ambient (C)	Sample Type/No.	Comments:
		0					
		1					
		2					
		3					
		4					
		5					

Comments: ______________________

____

____

____

Groundwater samples will be collected from the monitoring wells using a decontaminated Teflon® bailer. For each well sampled, a new nylon or polypropylene cord will be used. The water level in each well will be measured and recorded in a logbook before sampling begins. The water level should be recovered to at least 90 percent of its original, prepurge level before sampling. Sample containers will be filled directly from the bailer. Sample containers for volatile organic analyses will be filled such that no headspace or air bubbles remain in the bottle.

All samples will be placed in precleaned (to EPA level 3) glass and plastic bottles for shipment to the laboratory. The analytical requirements for groundwater samples are described in Section B3 of this DCQAP.

Individual sample bottles will be labeled and placed into insulated shipping coolers with ice. A chain -of-custody record describing the contents of the cooler will be placed in a sealed plastic bag and taped to the inside upper lid of the cooler. The shipping coolers will be sealed with security labels taped over opposite ends of the lid. The coolers will be shipped for overnight delivery to the laboratory.

Pertinent sampling information, such as sample identification, date, and time of sampling, will be recorded in the field logbook. Sampling information will also be recorded on groundwater sampling forms, and eventually entered in the Installation Restoration Program Information Management System (IRPIMS) database. The sampling form, shown of Figure B2.3, will record the following:

- Site identification and well number,
- Time and date,
- Total depth of the well, depth to water before and after purging, actual volume of water purged, the thickness of any floating hydrocarbon layer, depth to water before and after sampling,
- Field measurements of pH, temperature, turbidity, and conductivity, and equipment calibration information, and
- Appearance of the purged water, the condition of the well, weather conditions, and other comments.

B2.5 SAMPLING FOR FIELD SCREENING

Soil gas screening will be performed to assist in the evaluation of bioventing as a remediation alternative at four other fuel sites. These sites include the 290 Fuel Farm, Area A service station, BX service station, and the fuel purge facility. Soil gas samples will be collected using existing monitoring wells and a maximum of five manually driven soil gas points. The existing wells can be sampled by securing rubber couplers modified with a ball valve to the top of the casing providing an air tight seal. Soil gas from the screened formation above the groundwater is withdrawn through flexible tubing attached

Figure B2.3

Groundwater Sampling Form

Diameter (Inches)	Volume (Gals/ft)
2	0.16
4	0.65
6	1.47
8	2.61
10	4.08
12	5.88
14	8.00

GROUNDWATER SAMPLE RECORD

Tinker AFB	TINKER	AFIID
Location identification	_______	LOCID
Date	_______	LOGDATE
Time	_______	LOGTIME
Sample beginningdepth	_______	SBD
Sample ending depth	_______	SED
Sampling method	_______	SMODE
Sampling matrix	_______	MATRIX
Sample type	_______	SACODE
Analytical method	_______	ANCODE

WELL CONDITION

____

____

____

____

____

____

____

VOLUME MEASUREMENTS

Casing inside diameter	_______	in
Static water level	_______	ft
Total casing depth	_______	ft
Length of water column	_______	ft
PURGE VOLUME (calculated at bottom)	_______	gal
Water level (post purging)	_______	ft

Purge volume = _______ ft water column × ________ gals/ft
casing vol. × 1/2/3/4/5 volumes (*circle one*)= _______ gals

PURGE RECORD

Time	Volume/Bail No.	Temp °F	pH	Elec Cond		Visual Appearance/Odor
______	______	______	______	______	______	______
______	______	______	______	______	______	______
______	______	______	______	______	______	______
______	______	______	______	______	______	______
______	______	______	______	______	______	______

Sample:

Weather: ______________________________ Sampled by:__________

____

to the ball valve using a vacuum pump and a vacuum chamber, as described in section B2.2 of this DCQAP. By attaching a vacuum gauge to the inlet side of the vacuum pumps, the air permeability of the soil can be estimated to determine how easily air can be injected in a future bioventing system. This method of soil air sample extraction is also employed when using the soil gas points driven into the soil. Samples collected in Tedlar™ bags are directly measured for percent oxygen, percent carbon dioxide, and total volatile hydrocarbons using portable field instruments. Use and calibration of these instruments is discussed in section B6 of this DCQAP.

SECTION B3.0
ANALYTICAL PROCEDURES

The analytical program for this bioventing treatability study consists of laboratory analysis of subsurface soil, soil air, surface soil flux (air emission), and groundwater samples. Analytical methods used shall be approved EPA standard methods and National Institute of Occupational Safety and Health (NIOSH) analytical methods when available. Methods and procedures described in US EPA Guidance SW-846 will be used for all applicable samples. SW-846 methods are validated, documented, and published by the federal government. These methods specify information on minimum performance characteristics such as detection limits, precision, and accuracy. Table B3.1 lists the chemical analytical protocol for each of the environmental media to be sampled.

The list of parameters included in the analytical program is primarily limited to those associated with petroleum hydrocarbon contamination, such as volatile and semivolatile organic compounds and metals. Also included are physical characteristics of soils and available nutrients. Conductivity, pH, temperature, and dissolved oxygen of groundwater will be measured in the field. Percent oxygen and carbon dioxide in the soil gas will also be measured in the field.

Table B3.1. Methods of Chemical and Geotechnical Analysis for Soil, Soil Gas and Flux, and Groundwater Samples

Analysis	Method Number	Matrix	Reference
Volatile organic compounds	SW5030/SW 8260	soil	1
Semivolatile organic compounds	SW3520/SW8270	soil	1
Total petroleum hydrocarbon (as gasoline)	modified SW8015	soil	1
Total petroleum hydrocarbon (as diesel)	modified SW8015	soil	1
Arsenic	SW3050/SW7060	soil	1
Barium	SW3050/SW6010	soil	1
Beryllium	SW3050/SW6010	soil	1
Cadmium	SW3050/SW6010	soil	1
Chromium	SW3050/SW6010	soil	1
Iron	SW3050/SW6010	soil	1
Lead	SW3050/SW7421	soil	1
Mercury	SW3050/SW7421	soil	1
Selenium	SW3050/SW7740	soil	1
Silver	SW3050/SW6010	soil	1
Grain size Distribution	ASTM D422	soil	2
Moisture content	ASTM D2216	soil	2
Alkalinity	Colorimetic	soil	3
Soil pH	E150.1	soil	6
Total Kjeldahl Nitrogen	E351.2	soil	6
Total Phosphates	E365.4	soil	6
Volatile organic compounds	SW 8260	groundwater	1
Semivolatile organic compounds	SW8270	groundwater	1
Total petroleum hydrocarbon (as gasoline)	modified SW8015	groundwater	1
Total petroleum hydrocarbon (as diesel)	modified SW8015	groundwater	1
Arsenic	SW7060	groundwater	1
Barium	SW6010	groundwater	1
Beryllium	SW6010	groundwater	1
Cadmium	SW6010	groundwater	1

Table B3.1. Methods of Chemical and Geotechnical Analysis for Soil, Soil Gas and Flux, and Groundwater Samples (continued)

Analysis	Method Number	Matrix	Reference
Chromium	SW6010	groundwater	1
Iron	SW6010	groundwater	1
Lead	SW7421	groundwater	1
Mercury	SW7421	groundwater	1
Selenium	SW7740	groundwater	1
Silver	SW6010	groundwater	1
Dissolved oxygen	Direct field measurement	groundwater	4
Total Kjeldahl Nitrogen	E351.2	groundwater	6
Total Phosphates	E365.4	groundwater	6
Percent oxygen	Direct field measurement	Soil gas	5
Percent carbon dioxide	Direct field measurement	Soil gas	5
Methane	Direct field measurement	Soil gas	7
Total volatile hydrocarbons (including TPH)	Direct field measurement EPA TO-14	Soil gas	5, 8
Total volatile hydrocarbons	EPA TO-14	Soil flux Chamber air	8

<u>References:</u>

1. U.S.E.P.A., Test Methods for Evaluating Solid Waste, SW846, 1986.
2. American Society for Testing and Materials, 1993 Annual Book of Standards.
3. Page A.L., R. Hinler, and D.R. Keeney (eds.), Methods of Soil Analysis, Part 2, American Society of Agronomy, 1982.
4. Yellow Springs Instruments, Test Procedures for Dissolved Oxygen Meter.
5. GasTech Instruments, Test Procedures for Operating Oxygen/Carbon Dioxide Meter.
6. Kerr Research Laboratory, modified EPA methods.
7. Instrument dependent (equipment not yet selected).
8. EPA Compendium Methods for Analysis of Toxic Organic Compounds in Ambient Air.

SECTION B4.0
QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT

Data quality objectives (DQOs) are qualitative and quantitative statements that specify the quality of the data required to support the bioventing treatability study activities. Through the development of DQOs, the objectives and methods to be used in the treatability study are clearly defined. Data quality objectives support such activities as site screening, characterization, risk assessment, evaluation of engineering alternatives, selection of decisions, and implementation.

The goals of the data collection program are usually expressed in terms of precision, accuracy, representativeness, comparability, and completeness. The data quality will be evaluated for both field and laboratory quality assurance/quality control activities. Data quality objectives are based on the use of the data. Analytical data quality levels for chemical analyses are described in this section. No criteria are set for geotechnical analyses, or measurements made directly in the field with field instruments.

B4.1 ANALYTICAL DATA QUALITY LEVELS

Analytical data quality is specified in terms of levels defined in the Data Quality Objectives Guidance Document (EPA, 1987a). Five analytical levels are defined:

- Level I – Field screening using portable instruments, such as photoionization detectors. Results may not be compound specific, but results are available in real-time. It is the least costly of the analytical options.
- Level II – Field analyses using more sophisticated portable analytical instruments, such as a portable gas chromatograph, oxygen/carbon dioxide meters, and helium. In some cases, the instruments may be set up in a mobile laboratory on site. A wide range in the quality of data may be attained, depending on the use of suitable calibration standards, reference materials, sample preparation equipment, and the training of the operator. Results are available in real-time or several hours.
- Level III – All analyses performed in an offsite analytical laboratory using standard, documented procedures, such as those outlined in EPA guidance SW-846. Results can be used for risk assessment.
- Level IV – Analyses performed in off-site laboratories according to EPA contract laboratory program (CLP) protocols, which require stringent QA/QC procedures,

documentation, and data validation or laboratory procedures with equivalent QA/QC procedures. Results are for risk assessment and cost recovery litigation.

- Level V – Analyses by non-standard methods performed in an off-site analytical laboratory.

In this Tinker AFB Treatability Study, the following analytical levels will be used as indicated:

- Level I analytical requirements will be used for the screening of air in the breathing zone during drilling activities for health and safety purposes. Level I will also be used to screen soil core samples in order to select portions for laboratory chemical analysis. Additionally, total volatile hydrocarbon meters will be used for *in-situ* respiration testing during the pilot testing of the bioventing system, and to collect soil gas screening data on four other fuel contamination sites to assess the applicability of remediating those four sites using bioventing technology.
- Level II analyses will be used to determine dissolved oxygen, field conductance, pH, and temperature of groundwater samples. Additionally, oxygen/carbon dioxide meters will be used for *in-situ* respiration testing, initial soil gas characteristics, and oxygen influence monitoring.
- Level III analyses will be used to satisfy the requirements for site characterization, disposal of wastes and evaluation of bioventing as a treatment technology at Tinker AFB.
- Level IV and V analyses will not be required.

An effective QA program addresses quality objectives for both sampling and laboratory methodology. Parsons ES field QA efforts are aimed primarily at assuring that samples are representative of the conditions in the various environmental media at the time of sampling. Laboratory QA efforts are aimed primarily at assuring that analytical procedures provide sufficient accuracy and precision to quantify contaminant levels in environmental samples. The laboratory shall also ensure that analyzed portions are representative of each sample, and that the results obtained from analysis of each sample are comparable to those obtained from analysis of other similar samples.

B4.2 PROJECT QA OBJECTIVES

The overall QA objectives for the treatability study are to develop and implement procedures that will provide data that are of known, documented, and defensible quality. QA/QC is ensured through appropriate sample collection, preservation and transport methods, combined with an evaluation of analytical performance through the analysis of quality control samples.

When analytical data fail to meet the required QC objectives, the technical report will discuss why the objectives were not met. Two major categories of non-compliance need to be considered:

- Requirements that are fully under a laboratory's control
- Requirements limited by the nature of the sample matrix.

Corrective action for non-compliance that is fully under a laboratory's control (laboratory blanks, calibration standards, tuning, and laboratory check or control samples) will be addressed with a thorough reevaluation of the system and all calculations and, where practical, reanalysis of non-compliant samples.

Corrective action for non-compliance that is limited by the nature of the sample matrix (field blanks, matrix spikes, and duplicates) will be addressed with a thorough check of the system and all calculations and the attachment of appropriate data qualifiers to non-compliant data.

The quality of data generated by sampling, monitoring, and analyses will be evaluated in terms of accuracy, precision, and completeness as described below and the results of this evaluation will be included in the quality assurance section of the reporting. Measures to assure that the data are comparable and representative are also described in the following subsections. For ease of reference, the definitions and associated numerical goals for each criteria are discussed together.

B4.3 DEFINITION OF CRITERIA AND GOALS

B4.3.1 Accuracy

Accuracy is a measure of the difference between a measured value and the "true" or accepted reference value. The accuracy of an analytical procedure is determined by the analysis of a sample containing a known quantity (spike) of material. The accuracy of data for this project will be determined through the use of matrix spikes and sample surrogate spikes (for organic analyses). Matrix spikes are evaluated by analyzing a normal environmental sample along with a spike of that sample.

The objective for laboratory accuracy is to equal or exceed the accuracy demonstrated for the analytical method on samples of similar matrix composition and contaminant concentration. The level of recovery of an analyte and the resulting degree of accuracy expected for the analysis of QA samples and spiked samples are dependent upon the sample matrix, method of analysis, and the contaminant. The concentration of the analyte relative to the detection limit of the method is also a major factor in determining the accuracy of the measurement.

The accuracy of laboratory data will be evaluated by determining the percent recovery (% Rec) of matrix spike samples and surrogates. In addition, method (reagent) blanks will be evaluated to ensure that contamination in the field or laboratory is not introducing a systematic error into the analytical results. The % Rec for spiked samples is calculated as follows:

$$\% \text{ Rec} = \frac{SSR - SR}{SA} \times 100\%$$

where:

% Rec = Percent recovery

SSR = Measured concentration in spiked sample

SR = Measured concentration in unspiked sample

SA = Concentration of spike added to the sample.

In addition to the matrix spikes, blank spikes (laboratory control samples) will be prepared and analyzed by the laboratory. For laboratory control samples (LCSs), the unspiked sample should be free of analytes (e.g., for blank samples, the SR is zero), and the accuracy is thus calculated as follows:

$$\% \text{ Rec} = \frac{SSR - SR}{SA} \times 100\%$$

Field spiking of environmental samples will not occur, since the laboratory spiking methods are expected to occur under more controlled conditions and should therefore provide more reliable data than that which could reasonably be implemented in the field. However, field measurements for parameters such as pH or percent oxygen will be assessed for accuracy in the field. Specifically, field instruments will be assessed for accuracy by the response to a known sample (such as a calibration standard). The objective for accuracy of field measurements is to achieve and maintain factory equipment specifications for the field equipment.

B4.3.2 Precision

Precision is an expression of the agreement between multiple measurements of the same property carried out under similar conditions. Precision thus reflects the reproducibility of the measurement. Precision is evaluated most directly by recording and comparing multiple measurements of the same parameter made on the same sample under similar conditions.

Precision is expressed in terms of the standard deviation or the relative percent difference (RPD) between the values resulting from duplicate analyses. RPD is calculated as follows:

$$RPD = \frac{|V_1 - V_2|}{(V_1 + V_2)/2} \times 100\%$$

where:

RPD	=	Relative Percent Difference
V1, V2	=	The two values obtained by making replicate measurements or analyzing duplicate samples.
$\lvert V_1 - V_2 \rvert$	=	The absolute value of the difference between the two measurements.
$(V_1 + V_2)/2$	=	The average value of the two measurements.

Because the concentration of analytes may be below detection limits in many environmental samples, RPD data will be generated by preparing matrix spikes in duplicate. The precision of the analytical method will thus be measured by calculating the RPD between the duplicate spikes, as well as environmental samples. For field duplicate samples, sample values exceeding the detection limit by 5x must meet an RPD criteria of ±40 percent for water and ±70 percent for soils. A control limit of ±2x the detection limit for water and ±4x for soil is applied to sample values less than 5x the detection limit. Section 10 describes the corrective action that will be taken if field precision is not met. Table B4.1 lists the precision objectives for field measurements such as pH, temperature, conductivity, photoionization detector (PID) readings and water level measurements, along with the corrective actions taken if the precision objective is not met.

B4.3.3 Completeness

Completeness is a measure of the amount of valid data obtained from the measurement system relative to the amount anticipated under ideal conditions. Only 10 percent of the laboratory reported data will be validated. This will serve only to spot check the quality of data generated by the analytical laboratory. The percent completeness will be calculated as follows:

$$PC = \frac{N_A}{N_I} \times 100\%$$

where:

PC = Percent completeness

Table B4.1 Precision Objectives for Field Measurements
Tinker AFB 3700 Fuel Yard

Measurement Data	Precision Objective	Corrective Action
pH	Consecutive readings agree within $\pm$0.1 pH units	Recalibrate
Temperature*	Visually inspect the instrument before each use	Replace thermometer
Conductivity	$\pm$0.1 mS/cm	Recalibrate
HNU readings	$\pm$15 percent from calibration readings at specified span setting	Return instrument for maintenance
Water level measurements	$\pm$0.01 feet	Return instrument for service
Percent oxygen	$\pm$0.5 percent from calibration readings	recalibrate instrument
Percent carbon dioxide	$\pm$0.5 percent from calibration readings	recalibrate instrument
Dissolved oxygen	$\pm$0.5 mg/liter oxygen	replace dissolved oxygen membrane on probe
Total volatile hydrocarbon	$\pm$10 ppm from calibration readings	recalibrate instrument

* No corrective action as no standard measurement is available in the field.

N_A = Actual number of valid environmental sample analyses.

N_I = Planned number of environmental sample analyses.

Valid data will be defined as all data and/or qualified data considered to meet the data quality objectives for this project. The planned number of analyses may vary from the samples proposed, due to site-specific conditions.

At the end of the data validation process, an assessment of the completeness will be made. If data gaps are apparent, an attempt will be made to collect the required data. A target completeness of 90 percent of the validated data (10 percent of the total) for each analytical method has been established.

B4.3.4 Comparability

Comparability expresses the confidence with which one data set can be compared to another. The comparability of all data collected for this project will be ensured by adherence to the approved sample collection procedures, field measurement procedures, and analytical procedures contained in this plan. Data will be reported as described in Section B7 of this DCQAP. The comparability of the laboratory data will also be ensured through the use of calibration and reference standards, that are traceable to the National Institute of Standards and Technology (NIST) or EPA. For field collected data, appropriate protocols will be used to calibrate the field instruments in accordance with manufacturers specifications.

B4.3.5 Representativeness

Samples must be representative of the environmental media being sampled. Sample handling and analytical procedures incorporate consideration of obtaining the most representative sample possible. Representativeness of specific samples will thus be achieved by the following:

- Collect samples from locations representing the site conditions,
- Use approved sampling methodology and equipment,
- Use approved sampling procedures, including equipment decontamination,
- Use approved analytical methodologies for the parameters while achieving required detection limits, and
- Analyze within the designated holding times.

Sample representativeness is also affected by the portion of each collected sample which is chosen for analysis. The laboratory shall ensure that the samples are adequately homogenized prior to taking aliquots for analysis. However, it should be recognized that many means of homogenization expose the sample to significant risk of contamination or loss through volatilization. Certain methods of homogenization should thus be avoided or modified to minimize these risks.

Duplicate samples will be collected to provide information on the variability of the contaminants in the field. Duplicate samples will be collected at a rate of one per ten groundwater samples, one per ten soil samples, and one per ten air samples.

To ensure that the sampling equipment has been successfully decontaminated, equipment rinsate blanks will be collected at a rate of ten percent of the total samples collected from each matrix. Equipment blanks on the soil air and flux sampling equipment will be collected at a rate of twenty percent of the total from each of theses matrices. The equipment rinsate blanks will be analyzed for the same constituents as the other field samples collected from similar matrices during the field event.

Trip blanks will be used to verify that no volatile cross-contamination of samples occurred during shipment to the laboratory for analysis. A trip blank will accompany all samples shipped to the laboratory for volatile organic analysis.

To ensure that sample chemistry is not affected by the ambient environment, one ambient conditions blank will be collected during the initial sampling activities for volatile organic analysis. A second ambient condition (field) blank will be collected during the 12 month verification sampling activities. If possible, the ambient conditions blank will be collected when a sample is being collected downwind of possible volatile organic compound (VOC) sources.

SECTION B5.0
SAMPLE CUSTODY AND MANAGEMENT

A sample is physical evidence collected from a site or the environment. As such, handling must be documented in a manner that ensures analytical results are legally defensible. The documentation must provide all information necessary for proper analysis. The following sections describe custody procedures in the field as well as at the laboratories.

B5.1 FIELD OPERATIONS

Sample custody documentation procedures described in this section will be followed throughout all sample collection at Tinker AFB during the *in-situ* bioventing treatability study. Components of sample custody procedures include the use of field logbooks, sample labels, and chain-of-custody forms. Parsons ES sampling personnel must complete all proper forms and documents for each sample taken. After collection, containerization, and documentation, samples will be maintained under the custody of field team members until being relinquished to an overnight courier service. The sample shipment container must not be unsealed until the laboratory receives custody and breaks the seal.

A sample is considered under custody if:

- It is in actual possession of the sampling crew,
- it is in the view of the sampling crew, after being in their physical possession,
- it was in the physical possession of the sampling crew and then was secured to prevent tampering, or
- it is in a designated and identified secure area, such as in a locked trailer or vehicle.

B5.1.1 Field Logbooks

Bound field logbooks will be maintained by the Parsons ES field supervisor and other team members to provide a daily record of significant events, observations, and measurements during the field investigation. All entries must be signed and dated.

All information pertinent to the field survey and/or sampling will be recorded in the logbooks or on field forms. The logbooks will be bound books with consecutively numbered pages. Waterproof ink will be used in making all entries. Entries in the logbook will include at least the following:

General information:

- Names and titles of author and assistant, date and time of entry, and physical/environmental conditions during field activity,
- Purpose of sampling activity,
- Location of sampling activity, and
- Names and titles of field crew.

Sampling documentation:

- Sample media (e.g., surface water, soil),
- Description of sampling point,
- Date and time of collection,
- Sample identification number, and
- References for photographs of the sampling site

Other information:

- Names and titles of any site visitors,
- Field observations and unusual field drilling conditions, and
- Any measurements made, such as pH, conductivity, temperature, turbidity including specific calibration data and documentation of field equipment (serial number, decontamination, etc.).

All original data recorded in field logbooks, sample labels, sample seals, and chain-of-custody (COC) records will be written with waterproof ink. None of the field logbooks or chain-of-custody documents will be destroyed or discarded, even if they are illegible or contain inaccuracies that require a replacement document.

If a previously recorded value is discovered to be incorrect, the wrong information will be crossed out in such a manner that it is still legible, the correct value will be written in, and the change will be initialed and dated. If the change is made by someone other than the original author, or if the change is made on a subsequent day, a reason for the change will be recorded at the then current active location in the logbook, with cross references.

B5.1.2 Sample Labels

All physical samples obtained at the site will be placed in an appropriate sample container for preservation and shipment to the designated laboratory. Each sample will be identified with a separate identification label. The sample identification scheme is described in the Data Management Plan (appendix C of this workplan). The ice chests will be sealed with a custody seal. Example sample identification label and seal are shown in Figure B5.1. The tag should indicate if it is a split sample. The label will document:

- Analyses to be performed,
- Sample identification number,
- Source/location of sample,
- Preservatives used,
- Date,
- Time (a four-digit number indicating the 24-hour-clock time of collection; for example, 1430 for 2:30 P.M.), and
- Sampler's initials

B5.1.3 Chain-of-Custody (COC) Forms

A COC form will be completed for each cooler of samples to track the samples and provide a written record of all persons contacting the samples. The COC form will list sample information (sample identification, type, date, and time of collection), analyses requested, and the signature of each person receiving and relinquishing the samples. An example COC form is shown in Figure B5.2.

Two copies of this record will accompany the samples to the laboratory. The laboratory will maintain one file copy, and the completed original will be returned to the project manager as a part of the final report. This record will be used to document sample custody transfer from the sampler, and to the laboratory.

Shipments will be sent by common carrier for overnight delivery, and a bill of lading will be prepared. Bills of lading will be retained as part of the permanent documentation. The bill number will be recorded on the chain-of-custody form.

B5.1.4 Shipping of Samples

Samples will be shipped and delivered to the designated laboratory analysis daily. During sampling and sample shipment, the Parsons ES field team leader (or his designee) will contact the designated laboratory to inform them of shipments.

The samples will typically be shipped in ice chests by overnight carrier such as Federal Express. A chain-of-custody form will be placed within each chest. Each chest will be sealed with tamper-resistant tape and custody seals. The seals will be signed by the sample custodian shipping the samples.

Figure B5.1 Custody Seal and Sample Label

ES

ENGINEERING-SCIENCE, INC.
8000 CENTRE PARK • SUITE 200
AUSTIN, TEXAS 78754
(512) 719-6000 FAX (512) 719-6099

SAMPLE I.D.	DATE
	TIME
ANALYSIS	SAMPLER
	PRESERVATIVE

Signature

Date

CUSTODY SEAL

Engineering-
Science, Inc.
8000 Centre Park Dr.
Suite 200
Austin, Texas 78754
(512) 719-6000 ph
(512) 719-6099 fax

Engineering-
Science, Inc.
8000 Centre Park Dr.
Suite 200
Austin, Texas 78754
(512) 719-6000 ph
(512) 719-6099 fax

CUSTODY SEAL

Date

Signature

FIGB5-1 12/20/94

CHAIN OF CUSTODY RECORD

PARSONS ENGINEERING SCIENCE
AUSTIN, TEXAS

PROJECT NAME/LOCATION:	CARRIER:
PROJECT NUMBER:	AIRBILL OR CARRIER ID #:
SAMPLER(S): (Signature)	LABORATORY:

Date	Time	Sample ID	Sample Type	Matrix	Sampling Method	Begin Depth	End Depth	NUMBER OF CONTAINERS	PRESERVATIVE / ANALYSIS REQUIRED	FIELD LOT CONTROL NUMBER: Ambient Condition Blank	Equipment Blank	Trip Blank	Cooler Letter	REMARKS

Relinquished by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time	Relinquished by: (Signature)	Date	Time
Received by: (Signature)	Date	Time	Received by: (Signature)	Date	Time	Received by: (Signature)	Date	Time

White : Laboratory returns with data; Yellow : Laboratory copy; Pink : Sampler copy;

chain-1.dwg

FIGB5-2 12/20/94

B5.2 LABORATORY OPERATIONS

A designated laboratory sample custodian will perform the following procedures in order to maintain a chain-of-custody once the samples have arrived at the laboratory.

- Check the original field prepared chain-of-custody and compare them with the labeled contents of each sample container for correctness and traceability.
- Check the temperature of a water sample enclosed with the environmental samples or check the temperature in the cooler. Record the temperature on the chain-of-custody form. Sample preservation will be documented in the field. The laboratory shall check the chain-of-custody forms for the preservation noted by the field team.
- If there are no problems with sample integrity or chain-of-custody information, the sample custodian will sign, date, and note the time in the "laboratory receipt box" on the original chain-of-custody form. Pertinent information, such as shipping company name, should be recorded in the remarks section of the original chain-of-custody form.
- Once received, the sample custodian shall assign a laboratory work order number to the samples received from one shipment. The samples shall not be logged if the sample containers are mislabeled, broken, or if custody seals are broken. The project manager and laboratory project manager will be notified of any such situations immediately, and corrective actions will be implemented.
- The laboratory work number is used for identification of samples within the laboratory. Each sample will receive a unique laboratory work number when it is received by the laboratory. The sample custodian shall log the laboratory work number and the field sample identification into a laboratory sample custody log. The laboratory sample custody log may either be hard copy or computerized, depending on the laboratory.
- In addition to correlating laboratory work numbers with field sample identification, the laboratory log shall also contain the laboratory storage cooler number (if applicable) that the sample will be stored in while on the laboratory premises. Samples will be logged when they are removed and returned from storage for analysis.
- Upon analysis, a laboratory lot control number will be assigned to the sample. All samples within a given laboratory analysis group (e.g., samples sharing the same laboratory QC measurement samples) will have identical laboratory lot control numbers.

Laboratory lot control numbers should not be confused with field lot control numbers. The field lot control numbers will be based on associated field shipping cooler, trip blank, equipment blank, and ambient condition blank. As described in the IRPIMS data loading handbook (USAF, 1991), laboratory lot control numbers designate a batch of autonomous group of environmental samples and associated QC samples. This group is equivalent to the EPA SW-846 concept of an analytical batch.

Sample custody within the laboratory is maintained by a secure perimeter in which no unauthorized personnel are allowed entry without proper identification, i.e., visitors badge.

Samples received by the laboratory will be retained until after QA/QC auditing has been performed on the analytical results by both the laboratory and Parsons ES. Sample containers and remaining sample material should be disposed of appropriately when all analyses and related quality QA/QC work are completed. Disposal of the sample will be recorded on the sample custody log.

SECTION B6.0
CALIBRATION PROCEDURES, REFERENCE, AND FREQUENCY

Instruments and equipment will be used to gather, generate, or measure environmental data both in the field and in the laboratory. These instruments will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications.

Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory or field personnel performing quality control activities. These records will be filed at the location where the work is performed and will be subject to a QA audit.

B6.1 FIELD CALIBRATION PROCEDURES

Calibration of the field instruments and equipment will be performed at least daily or at more frequent intervals as specified by the manufacturer. Calibrations will be reinitiated as appropriate after a period of elapsed time due to meals, work shift change, or damage incurred. Calibration standards used as reference standards will be traceable to the NIST or EPA-published standards/protocols. Calibration activities, calibration gas lot numbers, and sources will be recorded in the field logbook. Suggested calibration methods and frequency are listed in Table B6.1.

Field measurements will be made using the following monitoring equipment:

- HNU photoionization detector (PID),
- Organic vapor analyzer (OVA),
- Sensidyne one-stroke pump and tubes,
- GasTech® volatile hydrocarbon indicator,
- GasTech® oxygen/carbon doixide meter,
- Yellow Springs Instrument, Dissolved oxygen meter, model 518,
- Thermometer,
- Helium meter, and
- Water level indicator.

Table B6.1 Calibration Methods and Frequency
Tinker AFB Bioventing Treatability Study

Parameter	Equipment	Calibration	Source of Calibration Standards	Equipment Maintenance	Equipment Decontamination
Volatile organic compounds	Photoionization detector (PID).	Daily according to manufacturer's instructions with ambient air (considered 0 mg/L) and isobutylene gas (100 mg/L).	Commercially available, premixed, in cylinders.	Avoid prolonged use in humid environments; keep probe away from dirt or free water; recharge battery.	Replace instrument filter; clean lamp.
VOCs	OVA.	Daily, and every 2-3 hours during use, methane in air.	Scott specialty gases.	Charge batteries, keep probe out of liquids.	N/A
pH	Hydac pH temperature, and conductivity meter.	Daily with known pH buffer solutions.	Commercially available.	Keep instrument face dry. Keep pH probe moist. Replace battery when necessary.	Squirt pH probe with water after every use.
Conductivity	Hydac pH, temperature, and conductivity meter.	Daily with Solution of known conductance.	Commercially available.	Keep instrument face dry. Replace battery when necessary.	Clean sample cup with water and paper towel after every use.
Water level	Water level indicator.	Check against steel tape.	Commercially available.	Replace battery when necessary.	Squirt probe with water after every use.
Percent oxygen /percent CO_2	Gas Tech meter.	Daily according to manufacturer's instruction using ambient air as 21% OX, and 0.04% CO_2, and Nitrogen calibration gas as 0% OX, 5% CO_2	Commercially available.	Replace battery when necessary. Replace oxygen sensor as needed.	N/A

B6.2 LABORATORY CALIBRATION PROCEDURES

Analysis of laboratory blank samples, duplicate samples, spiked blanks, and matrix blanks will be performed where possible to document the effectiveness of calibration procedures. The number, frequency, and type of these samples will be sufficient to verify the success of the calibration program.

Calibration of laboratory equipment will be based on approved written procedures. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing quality control activities. These records will be filed at the location where the work is performed and will be subject to a QA audit. For all instruments, the laboratory will maintain a factory-trained repair staff, with in-house spare parts, or will maintain service contracts with vendors.

The laboratory will perform instrument calibration consistent with their standard operating procedures (SOPs) and specified calibration procedures and frequencies. These SOPs will be based on either the manufacturer criteria, or the analytical method. As appropriate, SW846 will be used as a guideline for the analytical methods.

Calibrated and continuing calibration verification of instruments and equipment will be performed at approved intervals as specified by the manufacturer or the analytical method (whichever is more frequent). Calibration standards used as reference standards will be traceable to the National Institute of Standards and Technology or EPA when applicable.

Equipment, instruments, tools, gages, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations and written procedures developed by the operators. In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based on experience and previous use of the equipment. In the event that a standard operating procedure mandates specific preventive maintenance procedures that are more frequent than recommended by the manufacturer, then the frequency specified in the SOP will be followed.

SECTION B7.0
DATA REDUCTION, VALIDATION, AND REPORTING

This section describes the data management, data reduction, data quality assessment, and data validation/reporting functions associated with QA and QC.

B7.1 DATA REDUCTION

This section describes both field and laboratory data reduction. Data generated under this project will derive from two sources, field measurement and sampling, and sample analyses will be performed by an analytical laboratory.

B7.1.1 Field Data Reduction

Field measurements will be made by field geologists, engineers, scientists, and technicians. Field data will be recorded to provide a permanent record of field activities, and the information will be noted in the technical report using standard reporting units.

During processing of field data, periodic validation checks will be performed. The purpose of these checks is to identify ``outliers" that is, data which do not conform to the pattern established by other observations. Because of the limited number of observations, detailed statistical analysis of the data to be obtained during this program is not feasible and the principal method of validation will be routine checks to assure that data are correctly transcribed and that reported identification codes and sampling information match the corresponding information in the field records. In addition, data will be compared against those obtained in previous investigations (where available) and against applicable standards and guidelines. Primarily, checks will be prompted by observation of skewed data results during recording onto field logbooks or test forms.

Although outliers may be the result of transcription errors or instrumental breakdowns, they may also be manifestations of a greater degree of spatial or temporal variability than expected. Therefore, after an outlier has been identified, a decision must be made concerning its further use. Obvious mistakes in data will be corrected when possible, and the correct value will be inserted. If the correct value cannot be obtained, the data may be excluded. An attempt will be made to explain the existence of the outlier. If no plausible explanation can be found for the outlier, it may be excluded, but a note to that effect will be included in the report. Also, an attempt will be made to determine the effect of the outlier when both included and excluded in the data set and the results will be discussed in the report.

B7.1.2 Laboratory Data Reduction

The first step in laboratory data reduction is data processing. In general, data will be processed by an analyst in one or more of the following ways:

- Manual calculations of instrument calibration and sample results (typically performed on method-specific bench sheets),
- Manual input of raw data for subsequent computer processing, and/or
- Direct acquisition and processing of raw data by a computer.

Regardless of how data processing is done, sufficient documentation will be presented to allow another analyst to review and check the work.

Raw data are entered in bound laboratory notebooks. The data entered are sufficient to document all factors used to arrive at the reported value for each sample. Calculations may include factors such as sample dilution ratios or conversion to dry-weight basis for solid samples.

B7.2 DATA QUALITY ASSESSMENT

Upon completion of all planned field and analytical work specified for completing the treatability study, Parsons ES will assess the quality of data generated as a result of these activities. Both field and laboratory data will be assessed.

B7.2.1 Review of Field Records

The Parsons ES field team leaders, project quality assurance officer, and project manager shall ensure that all field records are evaluated for the following:

- Completeness of field records. The check of field record completeness shall ensure that all requirements for field activities in the SOW and work plans have been fulfilled, complete records exist for each field activity, and that the procedures specified in this DCQAP (or approved as field change requests) were implemented. Field documentation shall ensure sample integrity and provide sufficient technical information to recreate each field event. The results of the completeness check will be documented and environmental data affected by incomplete records will be identified in the technical report.
- Identification of valid samples. The identification of valid samples involves interpretation and evaluation of the field records to detect problems affecting the representativeness of environmental samples. The lithologic and geophysical logs may be consulted to determine stratigraphic variations within the subsurface. Records should also note sample properties such as clarity, color, odor, etc. Photographs may show the presence or absence of obvious sources of potential contamination, such as operating combustion engines near a well during sampling. Judgments of sample validity shall be documented in the

technical report, and environmental data associated with poor or incorrect field work shall be identified.

- Correlation of data. The results of field tests obtained from similar areas shall be correlated. The findings of these correlations shall be documented and the significance of anomalous data shall be discussed in the technical report.
- Identification of anomalous field test data. Anomalous field data shall be identified and explained to the extent possible. For example, headspace readings obtained at one boring location that are significantly higher than at any other boring shall be explained in the technical report.
- Accuracy and precision of field data and measurements. The assessment of the quality of field measurements shall be based on instrument calibration records and a review of any field corrective actions. The accuracy and precision of field measurements shall be discussed.

Field record review is an ongoing process. Field team leaders will be responsible for ensuring that proper documentation is recorded during each site's sampling activities.

B7.2.2 Review of Laboratory Data

All laboratory data shall be reviewed by the laboratory. At a minimum, the review of laboratory data shall focus on the following subjects:

- Chain-of-custody forms,
- Holding times,
- Method calibration limits,
- Method blanks,
- Laboratory established detection limits,
- Analytical batch control records including spike recoveries and spike replicate results,
- Corrective actions,
- Formulas used for analyte quantitation,
- Calculations supporting analyte quantitation, and
- Completeness of data.

The establishment of detection and control limits shall be verified. Any control limits outside of the acceptable range specified in the analytical methods shall be identified. Any trends or problems with the data shall be evaluated. The absence of records supporting the establishment of control criteria and detection limits shall also be noted. Analytical batch quality control, calibration check samples, method calibrations, continuing calibration verifications, corrective action reports, the results of reanalysis, sample holding times, sample preservations, and any resampling and analysis shall all be evaluated.

Samples associated with out-of-control QC data will be identified in the technical report, and an assessment of the utility of such analytical results will be made. The check of laboratory data completeness shall ensure that:

- All samples and analyses required by the SOW and associated work plans have been processed,
- Complete records exist for each analysis and the associated QC samples, and
- Procedures specified in this DCQAP have been implemented.

The results of the completeness check shall be documented.

Quality control sample results (laboratory control samples, matrix spike, matrix spike duplicates, surrogates, initial calibration standards, and continuing calibration standards) are compared against stated criteria for accuracy and precision. QC data must meet acceptance levels prior to processing the analytical data. If QC standards are not met, the cause is determined. If the cause can be corrected without affecting the integrity of the analytical data, processing of the data will proceed. If the resolution jeopardizes the integrity of the data, reanalysis will occur. If the reanalysis does not resolve the conformance problem, the results of the original run and the reanalysis run shall be reported in the data package. The nonconformance will be noted in the case narrative of the data package and the appropriate laboratory corrective action will be initiated immediately.

B7.3 DATA VALIDATION AND REPORTING

This section describes field, laboratory, and Parsons ES data validation and reporting activities.

B7.3.1 Field Reporting

The following standard reporting units will be used during phases of the project:

- Oxygen and carbon dioxide readings will be reported to the nearest 0.5 percent,
- photoionization readings will be reported to 0.2 ppm,
- temperature will be reported to the nearest 1°F,
- soil sampling depths will be reported to the nearest 0.5 foot, and
- water level measurements will be reported to the nearest 0.01 foot.

B7.3.2 Laboratory Data Verification and Reporting

All analytical data will be verified prior to being released by the laboratory. Laboratory data verification will consist of reviewing the data for both editorial and technical validity. The editorial review consists of a check for typographical, transpositional, and omissional errors. This review also includes a proofreading of any text which may accompany the data. The technical review consists of a check to see that all precision, accuracy, and detection limit requirements have been met.

The results of the laboratory analysis will be presented as a completed data package to the laboratory QC coordinator for review and approval. The review will encompass data package completeness, discrepancies, errors, and acceptability of quality control data. Any discrepancies or questions from the reviewer will be addressed by the analyst. Once all approvals have been obtained, the data will be tabulated as a summary of analytical results. This review should be signed by the laboratory QC coordinator.

These reports will be reviewed by project personnel. If questions arise during this review, the report will be rerouted to the appropriate laboratory representative for explanation or clarification of the questions. When all questions have been resolved, the data will be reported. The report must contain a case narrative, data summary, and QC forms.

Reporting of analytical results for this project will include environmental and QC sample analysis data in hard copy format, as well as a computer disk containing IRPIMS formatted data. Laboratory deliverables are described in Table B7.1. Analytical hard copy reports will contain the following items:

- Case narrative including any special conditions,
- Laboratory name,
- Client name,
- Date of issue,
- Project identification,
- Field sample number,
- Laboratory sample number,
- Sample matrix description,
- Analytical method and extraction method reference citation,
- Individual parameter results (including second column and primary results where appropriate),
- Date and time of analysis (extraction initiated and completed, first run and subsequent runs),

Table B7.1 Data Set Deliverables for Bioventing Treatability Study

Method Requirements	Deliverables
All methods	
Holding time information and methods requested.	Signed chain-of-custody forms
Discussion of laboratory problems.	Case narratives
LCS with results on control chart. Run with each batch of samples processed.	Control chart
All appropriate control limits for surrogates, MS/MSDs, LS/LSDs, tunings, calibrations and internal standard recoveries be listed on the corresponding reporting forms.	
Organics	
Results to be reported on CLP form 1 or equivalent. Sample results using EPA data flags. Report results for all method blanks associated with sample and QC.	CLP form 1 or equivalent; one per sample
Surrogate recovery from samples reported on CLP form 2. Surrogates to be used in volatiles, semivolatiles, and PCBs. Report surrogate recoveries for all samples, QC and method blanks.	CLP form 2 or equivalent
Matrix spike/spike duplicate. One spike and spike duplicate per 20 samples of similar matrix.	CLP form 3 or equivalent
Laboratory spike/laboratory spike duplicate. Reported if MS/MSD is out of control.	CLP form 3 or equivalent
Method blank include method blanks associated with all QC.	CLP form 4 or equivalent
GC/MS tuning for volatiles/semivolatiles.	CLP form 5 or equivalent
GC/MS initial calibration data for volatiles and semivolatiles.	CLP form 6 or equivalent
GC/MS continuing calibration data.	CLP form 7 or equivalent
Total petroleum hydrocarbons	
Method blank, one per batch.	Report result; no format
Sample results.	Report results; no format
Matrix spike/spike duplicate or calibration information.	Report result, if applicable
Calibration check report RPD or percent difference from initial calibration.	Report percent or percent difference; no format

Table B7.1, continued

Method Requirements	Deliverables
Requirements for inorganic analytical methods (metals):	
- Sample data sheets	SW-846 form or equivalent
- Initial and continuing calibration	SW-846 form or equivalent
- Method blank, taken through sample preparation	SW-846 form or equivalent
- ICP interference check sample	SW-846 form or equivalent
- Spike sample recovery	SW-846 form or equivalent
- Post-digestion spike sample recovery for ICP metals	SW-846 form or equivalent
- Post-digestion spike for GFAA	Recovery will be noted
- Replicate samples	SW-846 form or equivalent
- Laboratory control sample	SW-846 form or equivalent
- Standard addition results	SW-846 form or equivalent
- ICP serial dilutions	SW-846 form or equivalent
- Instrument detection limits (quarterly)	SW-846 form or equivalent
- ICP interelement correction factors (annually)	SW-846 form or equivalent
- ICP linear ranges (quarterly)	SW-846 form or equivalent
Requirements for inorganic analytical methods (metals), continued	
- Preparation log	SW-846 form or equivalent
- Analysis run log	SW-846 form or equivalent
Requirements for other methods:	
- Preparation and analysis logs	No format
- Sample results	No format
- Matrix spike/matrix spike replicate results	No format
- Laboratory control sample or blank spike if matrix spike/matrix spike replicate is not available	Control chart or percent recovery and relative percent difference results
- Method blank results	No format
- Initial calibration results	No format
- Continuing calibration check	No format. Report percent relative standard deviation or percent difference from initial calibration

Notes: CLP = Contract Laboratory Program, EPA
GC = Gas chromatography
MS = mass spectrometry
ICP = inductively - coupled plasma
BFB = p-bromofluorobenzene
DFTPP = decafluorotriphenyphosphine;
LCS = laboratory control sample

- Detection limits achieved,
- Concentration units,
- Dilution or concentration factors, and
- Corresponding QC forms.

B7.3.3 Parsons ES Data Validation and Reporting

Using the reviews of field records and laboratory data, environmental data that are not representative of environmental conditions because they were generated through poor field or laboratory practices shall not be used in the evaluation process. This determination shall be made using the professional judgment of a multi-disciplinary team (e.g., chemists, hydrologists, engineers), and other personnel having direct experience with the data collection effort. This coordination is essential for the identification of valid data and the proper evaluation of that data. The usefulness of historical data will also be evaluated. The fundamentals of the EPA functional guidelines for evaluating data shall be used to validate the usability of laboratory data. Only 10 percent of the analytical laboratory data will be validated. This validation will be done to evaluate the overall quality of the data being provided by the laboratory for this study.

After the data are determined acceptable, the following steps shall be implemented to interpret the data:

- Evaluate field duplicate/duplicate results. Field duplicate/duplicate results not within control limits could indicate a heterogeneous sample medium, poor sampling technique, or a lack of analytical precision. If laboratory duplicates are precise, the problem may be associated with field activities. If homogenized samples show poor precision, the imprecision is probably in the laboratory analytical process.
- Evaluate field and laboratory blank results. Analyses of blanks shall be assessed to determine sources of contamination and the impact of any contamination on the analytical results for environmental samples. Examples of sources capable of contaminating field blanks (for example, trip blanks) include combustion engine exhaust, container cleaning solvents, pollution from offsite sources, or the water/container used. Method blank results are useful to detect laboratory contamination from reagents, instruments, ambient sources, or sample handling. The presence of a contaminant in a blank requires corrective action to eliminate the source of contamination and re-establish analytical control. Contamination proven to be a constant, low-level systematic error shall be noted in the technical report, and its impact on the results shall be evaluated. Under no circumstances shall the results for environmental samples be ``corrected" for blank contamination.

- Evaluate sample matrix effects. Assessment of the sample matrix can help to define the sources of anomalous data. The matrix can cause either a high or low bias to the results of normal environmental samples. High analytical results can be caused by natural background material in the sample. For example, thallium appearing in the ICP analysis of saline waters may be a spectral interference caused by other substances in the sample. Also, high calcium concentrations in water analyzed by ICP may generate spectral interferences for other metals. Potential matrix effects shall be identified through the evaluation of matrix spike and matrix spike replicate samples. The impacts of matrix interferences on results shall be described in the technical report.
- Interpret and integrate environmental data to formulate conclusions and recommendations. The replicate and duplicate results, blank results, and potential matrix interference effects will be considered in evaluating the data.

Following evaluation of the data, a technical report on the treatability study will be prepared and submitted. If the data is determined to be unacceptable based on a 10 percent review of the reported data, then additional data reports will be evaluated for validity of overall data. In the event the overall quality of the data does not meet the 90 percent completeness criteria, then the laboratory will be required to correct the problem.

SECTION B8.0
INTERNAL QUALITY CONTROL CHECKS FOR FIELD AND LABORATORY OPERATIONS

This section describes the internal quality control checks for field and laboratory operations.

B8.1 FIELD QUALITY CONTROL CHECKS

As a check on field QA/QC, field blanks, equipment blanks, field duplicates, and trip blanks shall be collected. Matrix spike and matrix spike duplicate samples will be collected in the field, but will be used to check laboratory quality control.

Type II reagent-grade water will be used for trip blanks, ambient condition blanks, and equipment blanks. This water must have analytical data or a manufacturer's certification that verifies the quality of the water and shows it to be free of analytes and contaminants that may interfere with the required laboratory analyses. The water's electrical conductivity will be less than 1.0 micromho per centimeter (at 25°C). Type II reagent-grade water will be purchased and stored only in glass or Teflon containers with Teflon caps or cap liners.

B8.1.1 Ambient Conditions Blanks

Ambient conditions will be collected during the sampling activities by pouring type II reagent grade water into a sample container at a sampling site. An ambient conditions blank does not need to be collected for each type of sampling. Two ambient conditions blanks will be collected over the course of the project. One will be collected during the initial field sampling, and one will be collected following the completion of the 12 month treatability study during the 12 month verification sampling. When possible, ambient conditions blanks will be collected when sampling is downwind of possible volatile organic compound sources, such as fueling trucks. These blanks will be analyzed for the same volatile organic compounds as the environmental samples. The sample identification for field blanks will be FIELDQC. The sample type will be AB1.

B8.1.2 Trip Blanks

One trip blank will accompany every cooler shipped to the laboratory which contains soil and/or water samples to be analyzed for volatile organic compounds. A trip blank is a volatile organic compound sample bottle filled in the laboratory with type II reagent-grade water, transported to the site, handled like a sample, and returned to the laboratory for analysis. Trip blanks will not be opened in the field. This blank will be analyzed for volatile organic compounds only. The sample identification for trip blanks will be FIELDQC. The sample type will be TB1.

B8.1.3 Equipment Blanks

One equipment rinsate blank will be collected for 10 percent of samples collected from soil and groundwater sampling events, respectively, and 20 percent from soil gas and soil flux chamber samples. An equipment blank for soil and groundwater samples is type II reagent-grade water that is poured into the sampling device, transferred to a sample bottle, and transported to the laboratory for analysis. An experiment blank for soil air and flux samples will be collected by pulling ambient air through sampling equipment. This blank will be subjected to all the laboratory analyses requested for environmental samples for each media on the same day of sampling. The sample ID will be FIELDQC. The sample type will be EB, numbered sequentially starting with 1 (e.g. EB1) each day.

B8.1.4 Field Duplicate Samples

Ten percent of each different matrix being sampled will be duplicates. The matrices sampled include soil, groundwater, soil air, and soil flux chamber air. A field duplicate is one of two samples collected independently at a sampling location during a single act of sampling. Field duplicates cannot be disguised so that laboratory personnel are unable to distinguish what sample corresponds to the duplicate sample due to IRPIMS format. The sample identification for duplicate samples will be the same as the identification for the environmental sample. The sample type will be FD1.

B8.2 LABORATORY QUALITY CONTROL CHECKS

This section describes the internal quality control checks for laboratory operations.

B8.2.1 Method Blank Samples

Lab blank samples (also referred to as method blanks) are designed to detect contamination of the environmental samples in the laboratory. Method blanks verify that method interferences caused by contaminants in solvents, reagents, glassware or in other sample processing hardware are known and minimized. The blank shall be deionized, distilled water (ASTM type II or equivalent) for water samples, or a purified solid matrix for soil/sediment samples. One blank will be analyzed every day that samples are analyzed. The concentration of target compounds in the blanks must be less than or equal to project reporting level. If the blank is not under the specified limits, then the source of contamination will be identified and corrective action taken, including reanalysis of the sample group.

B8.2.2 Laboratory Replicate Samples

Laboratory replicates will not be conducted. Lab replicates involve splitting a sample in the laboratory in order to check the precision of analytical results. Because most environmental samples are expected to be below detection limits, the precision cannot be evaluated on such samples. As a result, matrix spike and matrix spike duplicates will instead be used to evaluate the precision of analytical results.

B8.2.3 Matrix Spike/Matrix Spike Replicate Samples

Laboratory matrix spike samples and laboratory control samples are designed to check the accuracy of the analytical procedures by analyzing a normal sample with a known amount of analyte added in the lab. Laboratory matrix spike duplicates are the second of a pair of laboratory matrix spike samples. The matrix spike duplicates are designed to check the precision and accuracy of analytical procedures by analyzing a normal sample with a known amount of analyte added.

In order to evaluate the effect of the sample matrix on analytical data, triplicate volume is collected for one sample out of every group of 20 samples collected from similar matrices. Matrix spike and matrix spike duplicates will be collected in the field in the same manner that field duplicate samples are collected. Two portions of the sample (the matrix spike and the matrix spike replicate) are spiked with a standard solution. These spiked samples are analyzed, and the percent recovery and relative percent difference are calculated. The results of the analysis are used to determine accuracy and precision. Field blanks or duplicates are not to be used as matrix spike/matrix spike duplicates.

Laboratory control limits will be provided to the Tinker AFB RI/FS project manager after the laboratory has been selected. The results of the analysis of the matrix spike and replicate spikes will be reviewed. This information will be used to update the control chart. If the matrix spike and replicate matrix spike results are out of compliance, corrective actions will be instituted.

B8.2.4 Laboratory Control Samples

Laboratory control samples include blank spikes and blank spike duplicates. Blank spikes are designed to check the accuracy of the analytical procedure by measuring a known concentration of an analyte of interest. The blank spike replicate is the second of a pair of blank spike samples. The blank spike replicate is designed to check the precision and accuracy of the analytical procedures by measuring a known concentration of an analyte of interest in the pair of blank spikes.

In order to prepare blank spikes or blank spike duplicates, clean laboratory matrices (laboratory water or purified solid matrix) are spiked with the same spiking compounds used for matrix at levels approximately 10 times greater than the detection limit. The percent recovery is charted, and non-conformance shall be discussed in the report narrative.

B8.2.5 Surrogate Spike Analysis

Surrogate spike analyses are used to determine the efficiency of recovery of analytes in the sample preparations and analyses. All GC and/or GC/MS samples (including laboratory/method blanks, matrix spikes, matrix spike duplicates, normal environmental samples) are fortified with surrogate spiking compounds before purging or extraction. Recoveries will be reported, and, if out of compliance, corrective actions and reanalysis will occur.

SECTION B9.0
PERFORMANCE AND SYSTEMS AUDIT

This section describes participation in external and internal systems and performance audits for laboratory work.

B9.1 SYSTEM AUDITS

System audits review laboratory operations and the resulting documentation. An on-site audit ensures that the laboratory has all the personnel, equipment, and internal standard operating procedures needed for performance of contract requirements in place and operating. The system audits ensure that proper analysis documentation procedures are followed, that routine laboratory QC samples are analyzed, and that any non-conformances are identified and resolved.

The selected laboratory shall be one that conducts ongoing internal system audits. The results of these audits shall be documented by the laboratory QA manager, and the laboratory shall provide Parsons ES with the results of these audits.

Tinker AFB may also conduct audits. The frequency and schedule of any such audits will be established by Tinker AFB and coordinated directly with each laboratory.

B9.2 PERFORMANCE AUDITS

Performance audits involve the analysis of ``performance samples" by the laboratory. For example, as part of the EPA CLP Performance Evaluation, the laboratory analyzes quarterly performance evaluation (PE) samples. This provides evidence that the laboratory personnel involved fully understand the required analytical methods and that these methods can be performed satisfactorily by laboratory personnel using the laboratory equipment and instrumentation. The samples also provide evidence that the laboratory understands the documentation and reporting requirements of the contract.

Project-specific performance audits will not be planned. Instead, the results of external audits due to ongoing laboratory certification processes shall be used. Specifically, the results of external performance audits which are conducted during the lifetime of the project shall be reported to the Parsons ES project QA officer. In addition, any anomalies identified through the use of field duplicates and field replicates will be investigated. However, these differences may be due either to field or laboratory activities. The results of all audits (internal or external) which are conducted during the period of the project shall be reported to Parsons ES.

SECTION B10.0
CORRECTIVE ACTIONS

The following procedures have been established to ensure that conditions adverse to quality (e.g., malfunctions, deficiencies, deviations, and errors) are promptly investigated, documented, evaluated, and corrected.

B10.1 RESPONSE

When a significant condition adverse to quality is noted, the cause of the condition will be determined and corrective action taken to prevent repetition. Condition identification, cause, reference documents, and corrective action planned to be taken will be documented and reported to the project manager, project QA officer or laboratory QC coordinator. The project QA officer and laboratory QC coordinator are responsible for notifying the Parsons ES project manager immediately upon the identification of any significant QA/QC issues requiring corrective action.

The project manager, project QA officer, and laboratory QC coordinator shall ensure that involved field team leaders, field team members, and/or subcontractors are informed of any QA/QC issues affecting their work. The senior individual in charge of the activity found to be deficient will initiate corrective action. The project manager, project QA officer, or laboratory QC coordinator will approve such corrective actions. Following implementation of corrective action, the senior individual in charge will report actions taken and results to the project manager and project QA officer. A record of the action taken and results will be attached to the audit report.

Implementation of corrective action is verified by documented follow-up action. All project personnel have the responsibility, as part of the normal work duties, to identify, report, and solicit approval of corrective actions for conditions adverse to quality.

Corrective actions shall be initiated in the following instances:

- When predetermined acceptance criteria are not attained (objectives for precision, accuracy, and completeness),
- When the prescribed procedure, or any data compiled are faulty,
- When equipment or instrumentation is determined to be faulty,
- When the traceability of samples, standards, or analysis results are questionable,
- When quality assurance requirements have been violated,

- When designated approvals have been circumvented,
- As a result of systems or performance audits,
- As a result of a management assessment,
- As a result of intralaboratory or interlaboratory comparison studies and, or
- At any other instance of conditions significantly adverse to quality.

Project management and staff, such as field investigation teams, QA auditors, document and sample control personnel, and laboratory groups, monitor work performance in the normal course of daily responsibilities.

The project manager, project QA officer, laboratory QC coordinator, or designated alternates may audit work at the sites, laboratory, and office. Items, activities, or documents ascertained to be in noncompliance with QA requirements will be documented and corrective actions mandated through the audit report. The project QA officer or laboratory QC coordinator will log, maintain, and control the audit findings.

B10.2 REESTABLISHMENT OF CONTROL

Finding and correcting sampling and analytical problems are the responsibility of all project personnel. Many out-of-control events do not require the immediate action of management; however, it is important to document these occurrences and to take corrective action. The re-establishment of in-control status of the system must also be documented. For example, if a field team member discovers that an OVA is not properly calibrated, the member may simply recalibrate the instrument and note the original out-of-control response. The results of the recalibration shall also be noted. Appropriate management personnel will be notified of these occurrences. For example, the field team leader may be notified of the OVA event. All personnel will be made aware of the need to report and to correct problems promptly.

Any deviation from project requirements as specified in this document requires proper documentation using a field change request form. The field team leader or their designee will complete this form in the field and forward it to the Parsons ES project manager. The project manager will communicate the deviation from project requirements and send the Field Change Request form to Tinker AFB as quickly as possible. Upon receipt, Tinker AFB will review and indicate final disposition of the request and return the original document to the author. A copy of the document should be retained for the project file. Changes that require an immediate response will be initiated by telephone and then documented using the procedure described above.

B10.3 DOCUMENTATION

The project QA officer and laboratory QC coordinator are responsible for documenting all out-of-control events or non-conformances with QA protocols. The laboratory shall notify the Parsons ES project manager or Parsons ES QA officer of any laboratory QA/QC non-conformances upon their discovery. Copies of all field change requests and corrective action forms shall be maintained in the project files.

SECTION B11.0
PREVENTIVE MAINTENANCE

This section describes preventive maintenance procedures for laboratory and field equipment.

B11.1 LABORATORY INSTRUMENTS

Laboratory analytical instruments are serviced at intervals recommended by the manufacturer. Service contracts for regular maintenance and emergency service are maintained for major instruments. An instrument repair maintenance log book is kept for each instrument. All logbooks shall be kept in an easily accessible location for ready reference by the laboratory analysts using the instrument. Entries include the date of service, type of problem encountered, corrective action taken, and initials and affiliation of the person providing the service.

The instrument use log book is monitored by the analysts to detect any degradation of instrument performance. Changes in response factors or sensitivity are used as indication of potential problems. These are brought to the attention of the laboratory supervisor and preventative maintenance or service is scheduled to minimize down time. Back-up instrumentation and an inventory of critical spare parts are maintained to minimize delays in completion of analyses.

B11.2 SERVICE SCHEDULE

Manufacturer's procedures identify the schedule for servicing critical items in order to minimize the downtime of the measurement system. The laboratory assumes the responsibility of adhering to this maintenance schedule, arranging any necessary repairs, and ensuring prompt service as required. Service to all equipment and instruments shall be performed by qualified personnel.

In the absence of any manufacturer's recommended maintenance criteria, a maintenance procedure will be developed by the operator based upon experience and previous use of the equipment. In the event that the analytical method mandates specific preventive maintenance procedures which are more frequent than that recommended by the manufacturer, the frequency specified in the method shall be followed.

B11.3 EQUIPMENT MAINTENANCE

All equipment will be periodically maintained in accordance with the manufacturers specifications and will be decontaminated if needed on a regular basis. All maintenance activities will be documented in the field logbook. Each field instrument will have its own logbook to review previous maintenance and calibration results and record any maintenance and calibration results as required by this treatability study.

B11.4 DECONTAMINATION

A majority of the field monitoring equipment planned for this study does not require decontamination. Equipment decontamination of specific field instruments is summarized in Table B6.1.

SECTION B12.0
QUALITY ASSURANCE REPORTS

Quality assurance reports include reports on audits, reports on corrections of deficiencies found in audits, and the final QA/QC report submitted as part of the technical report on sampling activities.

B12.1 INTERNAL QA REPORTS

At monthly intervals beginning with the initiation of sampling activities, the laboratory will submit an internal QA report to the Parsons ES QA officer that documents laboratory-related QA/QC issues. These reports will include discussions of any conditions adverse or potentially adverse to quality, such as:

- Responses to the findings of any internal or external systems or performance laboratory audits;
- Any laboratory or sample conditions which necessitate a departure from the methods or procedures specified in this QAP;
- Any missed holding times or problems with laboratory QC acceptance criteria; and
- The associated corrective actions undertaken.

Such reports shall not prevent notification to project management of such problems when timely notice can reduce the loss or potential loss of quality, time, effort, or expense.

Any field-related QA memos or forms shall be forwarded by field team leaders to the project manager, who will ensure that the project QA officer receives copies. The project technical director and project manager (or designated individual) will review these reports for completeness and the appropriateness of any corrective actions. They will be retained in the project files, and will be summarized in the QA report included in the final project documents. Appropriate steps will be taken to correct any QA/QC concerns as they are identified. The Parsons ES project manager will ensure that the Tinker AFB technical project manager and the Parsons ES program manager is informed of any significant QA/QC developments.

B12.2 FINAL QA REPORT

A QA report will be submitted after the project sampling and analysis as part of the technical report. The laboratory and field change request/corrective action forms will be used to assist in developing the final QA Report. Analytical and QC data will be included, summarizing data quality information for the project. In the final report, both laboratory and field QC data will be presented, including a summary of QA activities and any problems or comments associated with the analytical and sampling effort. Any corrective actions taken in the field, the results of any audits, and any modifications to laboratory protocols will be discussed.

APPENDIX C

DATA MANAGEMENT PLAN

Appendix C

DATA MANAGEMENT PLAN FOR *IN SITU* BIOVENTING TREATABILITY STUDY FOR 3700 FUEL YARD TINKER AIR FORCE BASE

Prepared For
DEPARTMENT OF THE AIR FORCE
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December 21, 1994

CONTENTS

TABLES

SECTION C1.0
DATA DOCUMENTATION

C1.1 INTRODUCTION

This Data Management Plan contains procedures for documenting and tracking investigation data and results. The plan identifies and establishes data documentation materials and procedures, reporting procedures, and documents, as well as the format to be used to present the raw data and conclusions of the investigation. The purpose of the plan is to facilitate processing the data so that they are accurate, accessible, and maintained. Data acquired during site investigations will be formatted for entry into the Installation Restoration Program Information Management System (IRPIMS).

This section contains procedures for documenting and tracking investigation data and results.

C1.2 FIELD DATA

During RCRA Facility Investigation (RFI) field activities, field logbooks will be kept in accordance with Section B2.0 of the Data Collection Quality Assurance Plan (Appendix B of the work plan). These logbooks will contain information such as date, time, and location of sampling; field personnel present; sampling method; containers; preservation (if any); sample ID numbers; field measurements; weather conditions; and other pertinent information that would allow recreation without relying on the collector's memory. Each boring will be lithologically described and recorded on boring log forms as specified in the Data Collection Quality Assurance Plan (DCQAP).

The sample identification will consist of two segments. The first segment will designate the sample type and site code. The second segment will identify the sequentially numbered sample location. The first segment will include a two-digit sample location type descriptor followed by the two-digit site code identifier, the number 32. The site code for the 3700 Fuel Yard is ST32. The descriptor codes for sample location type are as follow:

- "SB" will be used for soil samples collected from soil borings,
- "AS" will be used for soil gas samples collected from multidepth monitoring points,
- "GW" will be used for groundwater samples collected from the three onsite monitoring wells, and

- "SF" will be used for soil flux sampling points.

The second segment will be a sequential two-digit number for each soil type. The sampled depth interval will be in parentheses following the sample location number for soil boring soil samples. For soil gas samples collected from multidepth vapor monitoring points, the letters A, B, and C will designate the sampled interval, and will follow the soil gas location number. The upper interval at approximately 5 feet below ground level (bgs) will be identified with the letter A; the middle interval at approximately 10 feet bgs will be identified with the letter B; and the deepest interval at approximately 15 feet bgs, will be identified with the letter C. Example identification codes for each type of samples are provided below:

- A soil sample collected from soil boring 3 at 5 to 5.5 feet bgs will read: "SB32-03(5-5.5)",
- a soil gas sample collected form vapor monitoring point 12 from the 10 foot interval will read: "AS32-12B",
- a groundwater sample collected from well 2-8 will read: "GW32-2-8", and
- a soil flux sample collected from flux chamber location 2 will read: "SF32-02".

For location that will be sampled on more than one occasion (for example, soil gas periodic monitoring), the sample date will differentiate the sample identification.

Samples collected from all locations will be identified in the field logbook and on the sampling log by using the same information recorded in the environmental sampling information file (BCHSAMP) data fields, as defined in the *IRPIMS*[1] *Data Loading Handbook*, version 2.2 (Environmental Information Management Program Office staff, 1991). Because some sampling information for soil flux or soil gas may not be part of IRPIMS, some codes for the analytical methods may need to be developed as part of this project.

For field duplicates, samples will be identified with coded or false identifiers to disguise either the sampling location or the sample identification. The coded or false identifier will be used on the sample container label, the chain-of-custody (COC) form, and any correspondence with the laboratory. The true location and sample identification will be recorded in the sampling records and field logbook.

Field screening data reporting for the *in-situ* respiration, air permeability, and soil gas screening at other fuel sites will be compiled in field logbooks for entry into the data acquisition system. Dissolved oxygen and groundwater characteristics during groundwater samples will be recorded on groundwater sampling forms and in the field book.

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1 Installation Restoration Program Information Management System

C1.3 TINKER AFB DATABASE

Data collected in the field as well as laboratory results will be entered into the Tinker AFB database. The database is based upon the IRPIMS. Specific records can be accessed and browsed, exported, or printed by Tinker AFB personnel. Thus, records specific to the treatability study can be copied to diskettes or printed as a report. Each data file has a standard report format. These standard report formats will be made available to Parsons Engineering Science as applicable to specific data that is generated (i.e., geochemical analysis report, groundwater level data, vent well construction data, lithologic description of boreholes, air sampling data, etc.). The user can select which fields to export to diskette. Printed reports and exporting can be done on short notice for data already in the database.

Tinker AFB personnel do not have the ability to change data in the database or add new data. This function will be performed by Parsons ES. Updated disks and reports containing any new data obtained during treatability activities (along with any other new or modified data) will be prepared on a periodic basis. For instance, soil air sampling is planned initially, and at 4 month intervals for up to one year. Data from each update report will be identified by site code and location identification, date, and a summary of what data were collected.

ASCII data files will be created using the Installation Restoration Program Information Management System (IRPIMS) format. The files which will be submitted to Tinker AFB include:

- Location Definition Information (BCHLDI) - contains information such as location identification number, coordinates, location classification, elevation, depth, and diameter (if a boring location).
- Lithologic Description Information (BCHLTD) - contains geologic information normally included in boring logs. Types, depths, and descriptions of strata encountered as well as any aquifers penetrated are included in this file.
- Sample Event File (BCHSAMP) - contains information on each sampling event. This includes location, depth, medium, and date sampled, as well as field measurements such as pH and conductivity.
- Sample Preparation Information (BCHTEST) - reports information relating a single sampling event to one or more sample extraction and analysis events. This includes location, matrix, analytical method, laboratory sample identification, extraction method, extraction date and time, analysis date and time, and laboratory lot control number.
- Analytical Results (BCHRES) - contains laboratory results, including laboratory name, sample number, method used, parameter tested, value obtained, detection limit, and units.

- Air Force Installation and Contract Information (BCHCON) - contains a record which captures basic installation information, as well as information pertaining to the contract.

C1.4 DATA REDUCTION, VALIDATION, AND REPORTING

For the data generated and processed to be scientifically valid, defensible, and comparable, the correct equations and procedures must be used to prepare the data. This section describes the data reduction, and procedures to be used in this project. Data validation procedures are described in the following section.

Field Data Reduction

On-site data from the sampling for off-site analysis will be documented in field log books and transcribed into the data acquisition system. The field data include the sample ID (location), time, date, sampler's initials, sampling method, and the matrix being sampled. Air permeability, *in-situ* respiration, soil flux and other data collection and calculations will be transcribed into appropriate data bases and calculation sheets for incorporation into reports for data presentation.

Laboratory Data Reduction

The procedures used for calculations and data reductions in the analytical laboratory are specified by each analytical method employed. Raw data will be entered in bound laboratory notebooks. The laboratory data reduction procedures are described in Section B7.0 of the Data Collection Quality Assurance Plan.

SECTION C2.0
FILING

C2.1 BASE PROJECT FILE REQUIREMENTS

Files containing data obtained during these treatability activities will be maintained. The files will contain up-to-date information such as raw data and the laboratory deliverables, as well as all treatability study or air sampling report deliverables. Any data, including raw data not yet entered into the database (between periodic updates), will be available in these files.

Also included in these files will be information concerning sample custody documentation procedures, chain-of-custody forms, training records, records on personnel medical exams, meeting minutes, surveillance, audit reports, and any other records associated with project activities. Data will be validated in accordance with Section 7.0 of the QAP.

C2.2 CONTRACTOR

C2.2.1 Central Project Files

Central project files will be administered in the Parsons ES Austin office. Separate files will be maintained for:

- Project control documentation,
- Project correspondence,
- Technical data,
- Project accounting,
- Subcontract documents,
- Monthly reports, and
- Original copies of project deliverables.

C2.2.2 Field Files

Field files will be set up and maintained by the field team leader. Copies of the following items will be maintained in the field files:

- RFI work plan,
- Project health and safety plan,
- Project management plan,
- Project quality assurance plan,
- Field log book(s),
- Daily progress reports,
- Work permits,
- Copies of chain of custody documents, lab reports, and manifests,
- Copies of subcontracts,
- Photograph log,
- Subcontract correspondence,
- Change orders,
- FARs,
- Project schedule updates,
- Technical data, and

Original items from this list will be maintained in the central files in Austin. Additional job files will be created as needed by the field team leader. Field files generated during field operations will be given to the project manager after completion of field activities.

C2.2.3 Correspondence Control

All written communication to Tinker AFB must be signed by the project manager. All correspondence from Parsons ES to Tinker AFB will be directed to the Tinker AFB contracting officer or environmental project monitor, as appropriate.

All correspondence, including letters, memos, transmittal forms, and phone logs, will be maintained in the central project file. Correspondence logs will be maintained for incoming and outgoing correspondence. The correspondence log will be updated monthly with an index indicating the designating number, date, author, and subject.

SECTION C3.0
REPORTS

Three types of reports will be prepared during or immediately following field activities. These are monthly Progress Reports, a completed installation report, *in-situ* bioventing treatability report, and three air sampling reports. Each is discussed in the following sections. Reports will be subject to internal technical and QA/QC review, and will be checked for accuracy. Draft reports will be identified as such by having "DRAFT" stamped on them. Final Reports will be submitted by OC-ALC in accordance to the deliverables schedule provided in the project management plan (Appendix A).

C3.1 PROGRESS REPORTS

Progress reports will be prepared and submitted monthly. These reports are a summary of the activities that occurred during the previous month. These reports will contain the following:

- A description and estimate of the percentage of the study completed.
- Summaries of contacts pertaining to corrective action or environmental matters with representatives of the local community, public interest groups, or state government during the reporting period.
- Summaries of problems or potential problems encountered during the reporting period.
- Actions being taken to rectify problems.
- Changes in key project personnel during the reporting period.
- Projected work for the next reporting period.
- Summaries of all findings to date, including summaries of laboratory data.
- Summaries of all changes made in the statement of work during the reporting period.

C3.2 COMPLETED INSTALLATION REPORT

The completed installation report shall include information that was collected during the installation of the bioventing system at the 3700 Fuel Yard. This includes results of the air permeability, *in-situ* respiration, and oxygen influence testing performed to establish the operating parameters of the constructed air injection system. It will also contain analytical results from the initial soil gas sampling of each multi-depth monitoring point, groundwater sampling data, subsurface soil sampling, and from the air emission soil flux testing.

The completed installation report will describe the procedures, methods, and results of all data collection activities performed for the treatability study. It will also describe details from the bioventing system installation. Table C3.1 presents suggested table of contents for the installation report. The following data and/or information may be presented in the reports in tabular form:

- Sampling location coordinates,
- results of soil flux data comparing air emissions from before initiating injection and after bioventing system is operational,
- analytical results of initial soil air testing,
- results of subsurface soil sample analysis,
- comparisons of background analytical data of soil, soil flux, and soil air (multi-depth MPs) sample media,
- influence of air injection at VWs on MP oxygen levels,
- air permeability testing data (pressure responses),
- oxygen utilization rates, and
- any screening data deemed appropriate for tabular presentation.

The data may also be included in one or more of the following graphical displays:

- Layout and topography,
- sampling location,
- geologic cross-sections, profiles, or transects,
- contamination delineation maps (vertical and horizontal),
- respiration test data,
- air permeability test data, and
- any other data, screening or otherwise, which would be useful to present graphically.

Finally, as-built drawings of the installed bioventing system will be included. The following drawings will be prepared and included in the report:

- As built drawings for vent well construction detail,
- as built drawings for monitoring point construction detail,

Table C3.1. Suggested Installation Completion Report

Executive Summary

- Section 1: Introduction
- Section 2: Investigation Activities
  - 2.1 Pilot Test Activities
    - 2.1.1 Site layout
    - 2.1.2 Air injection vent wells construction
    - 2.1.3 Monitoring point construction
    - 2.1.4 *In-Situ* respiration test
    - 2.1.5 Air permeability test
    - 2.1.6 Oxygen influence measurement
  - 2.2 Sampling Activities
    - 2.2.1 Soil sampling
    - 2.2.2 Soil gas sampling
      - 2.2.2.1 At site 3700 Fuel Yard
      - 2.2.2.2 At other fuel sites
    - 2.2.3 Soil flux sampling
    - 2.2.4 Groundwater sampling
- Section 3 Investigation Results and Conclusions
  - 3.1 Pilot Test Results
    - 3.1.1 *In-Situ* respiration testing results
    - 3.1.2 Air permeability results
    - 3.1.3 Oxygen influence results
  - 3.2 Results of Sampling Activities
    - 3.2.1 Soil sampling results (plume delineation)
    - 3.2.2 Initial soil gas at 3700 Fuel Yard site
    - 3.2.3 Air emission results
    - 3.2.4 Groundwater results
    - 3.2.5 Soil gas screening results at other fuel sites

- as built bioventing system layout with piping specifications and vault construction detail, and
- as built schematic drawing for air delivery systems (includes valves, blower, gauges, etc.).

C3.3 AIR SAMPLING REPORT

The air sampling report will be completed after receipt of periodic air sampling activities. The air sampling reports will include the results of the most recent round of analysis along with any other information or changes relative to the bioventing system in the 3700 Fuel Yard. The three rounds of sampling are scheduled at 4 month intervals with the first air samples collected after 4 months of system operation. The air sampling report will compare the analytical results of soil gas samples and will discuss any significant changes or abnormalities that may have occurred since the last report. The reports will include a brief description of site sampling activities along with data presentation and discussion.

The analytical results will be presented in tabular format and, where applicable, the results of previous soil gas testing will also be included for comparison. If changes have been significant, and/or isolated to certain portions of the site, graphical depiction's may also be used to show the areas most affected by the remedial actions.

C3.4 *IN-SITU* BIOVENTING TREATABILITY REPORT

This final report will discuss the effectiveness of the bioventing system at 3700 Fuel Yard. It will compare results of air analyses taken during the project and the soil samples collected from the beginning and end of the one year test to determine the effectiveness of the system. It will also include an overview of all activities and observations associated with this project. A discussion and estimate of the use of bioventing technology for remediating fuel contaminated soils at 290 Fuel Farm, Area A service station, BX service station, and Fuel Purge Facility will be included.