HYDROCARBON ABATEMENT PROPOSAL
NORTH FUEL TANK AREA
TINKER AIR FORCE BASE
BUILDING 3001

June, 1988

Submitted To:

UNITED STATES ARMY
CORPS OF ENGINEERS
P.O. Box 61
Tulsa, Oklahoma 74121-0061

Submitted By:

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GROUNDWATER TECHNOLOGY, INC.

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GROUNDWATER TECHNOLOGY, INC.

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1.0 INTRODUCTION

The United States Army Corps of Engineers, Tulsa District office, is conducting Remedial Investigations/Feasibility Studies (RI/FS) at the Tinker Air Force Base in Oklahoma City, Oklahoma. During the remedial investigation, a fuel oil/diesel product plume has been identified, floating on perched groundwater, beneath an underground storage tank area (referred to as the North Tank Area) at building 3001.

Groundwater Technology, Inc. has conducted a review of government furnished data in order to design a remedial system to recover the phase-separated and vapor-phase hydrocarbons in the North Tank Area.

The purpose of this investigation was to:

* Determine the physical characteristics of the North Tank Area;
* Identify local geological and hydrogeological conditions;
* Determine the presence and significance of phase-separated and vapor phase hydrocarbons;
* Evaluate the degree of hydrocarbon contamination and identify any potential receptors; and
* Design a recovery system to remove phase-separated and vapor-phase hydrocarbons from the perched aquifer and soils in the North Tank Area.

2.0 SITE LOCATION/DESCRIPTION

Tinker Air Force Base (TAFB) is located in the Central Lowlands, physiographic province of Oklahoma, in the southeast portion of Oklahoma City. The base is bounded by Sooner Road to the west, Douglas Blvd. to the east, Interstate 40 to the north, and Southeast 74th Street to the south. Building 3001 is located in the northeast portion of the base. The large underground storage tank area is immediately north of Building 3001 beneath a grass area (North Tank Area).

The North Tank Area contains an underground 235,000 gallon fuel oil tank, an active underground 20,000 gallon diesel tank, and a 500-600 gallon tank used to pump waste liquid from pump pits. A 13,000 gallon gasoline tank was removed from the North Tank Area in 1985 due to known leaks in the system. The 235,000 gallon fuel oil tank has been emptied and cleaned and will be decommissioned this year. Due to leaking tanks and/or spills, fuel product has contaminated the soil and perched groundwater in the North Tank Area (see Figure 1).

TINKER AIR FORCE BASE
NORTH TANK AREA

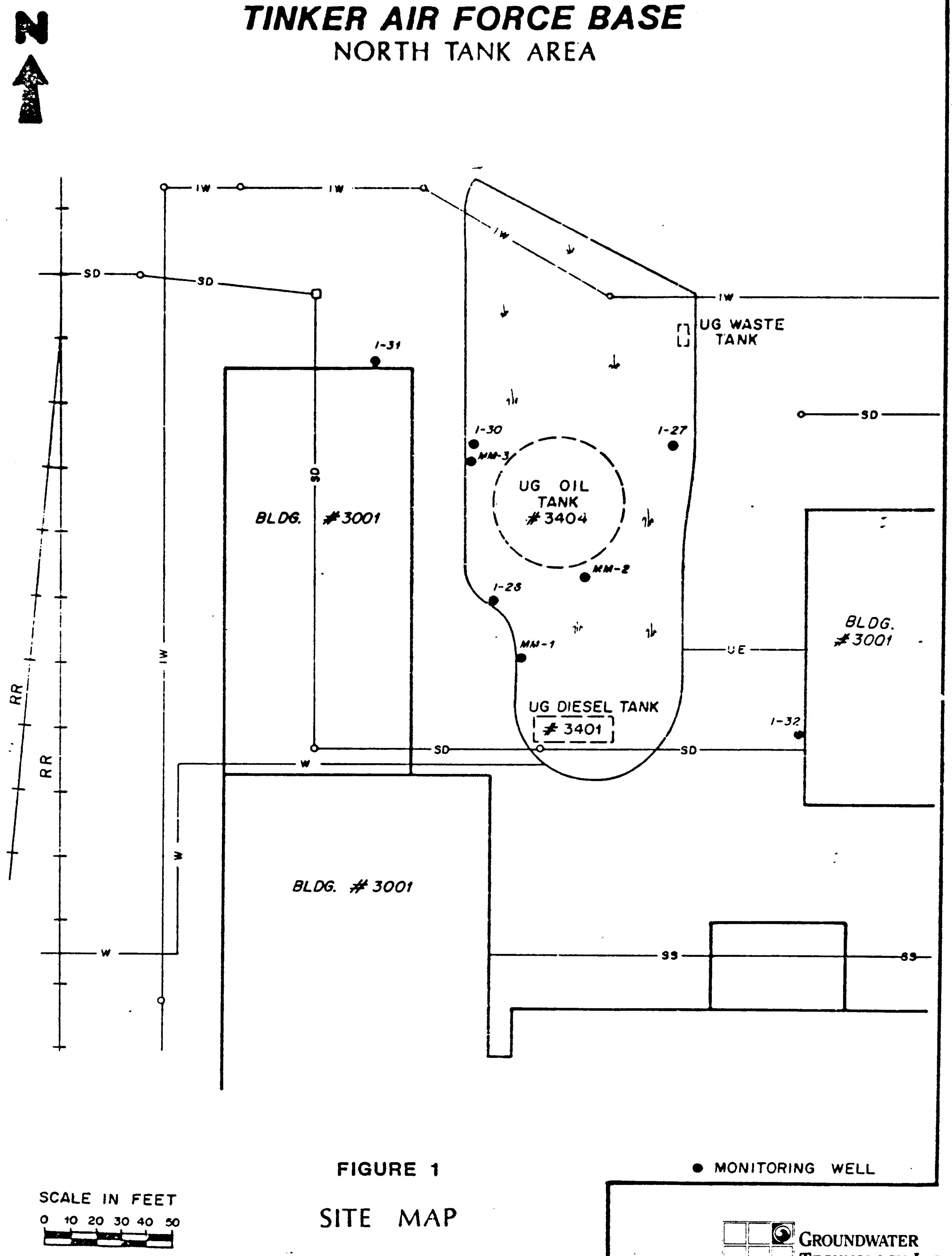

FIGURE 1

SITE MAP

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3.0 SITE HISTORY

As noted in the United States Army Corps of Engineer's report "Building 3001 Remedial Investigations, Volume I", the source of soil and groundwater contamination in the North Tank Area is due, in part, to occurrences of leaks and/or spills from the underground fuel storage tanks.

Monitor wells installed around the fuel tanks indicate phase-separated hydrocarbons floating on the shallow perched water system. Thickness of phase-separated hydrocarbons range from 15.0 feet in monitor well MM-3 to 0.04 feet in monitor well 1-31 (see Figure 2).

According to the Volume I report, fuel product thicknesses were recorded in January 1987 for monitor wells MM-1, MM-2, and MM-3. The product thicknesses in monitor wells 1-30 and 1-31 were recorded in March, 1987.

Due to vertical and lateral migration of the leaking fuel oils, the upper soil horizon at the North Tank Area has been contaminated.

According to the report, sample analysis of phase-separated hydrocarbons found in monitor well 1-30 indicated that they were primarily fuel oil. Hydrocarbon samples collected from monitor well MM-3 were fuel oil and diesel fuel. Since diesel fuel has been identified floating on the perched water table, either the active 20,000 gallon diesel fuel tank is leaking, or occasional diesel spills have caused its accumulation on the water table.

4.0 GEOLOGY

4.1 Regional Geology

The Garber-Wellington Formation crops out in central Oklahoma and dips to the west at approximately 15 feet/mile. Although the Garber Sandstone and Wellington Formation are different formations, they are not easily distinguished from each other based on rock type or fossil assemblage. The Garber-Wellington Formation typically consists of sandstone, interbedded with siltstone and mudstone. The sandstone is orange-red to reddish-brown, fine grained, quartzose, and poorly cemented; the sandstones comprise approximately 65% of the formation. The siltstone and mudstone are reddish-brown in color and occur in the formation as discontinuous, interbedded units. The Hennessey Group overlies the Garber-Wellington Formation and is composed of shale and siltstone formations.

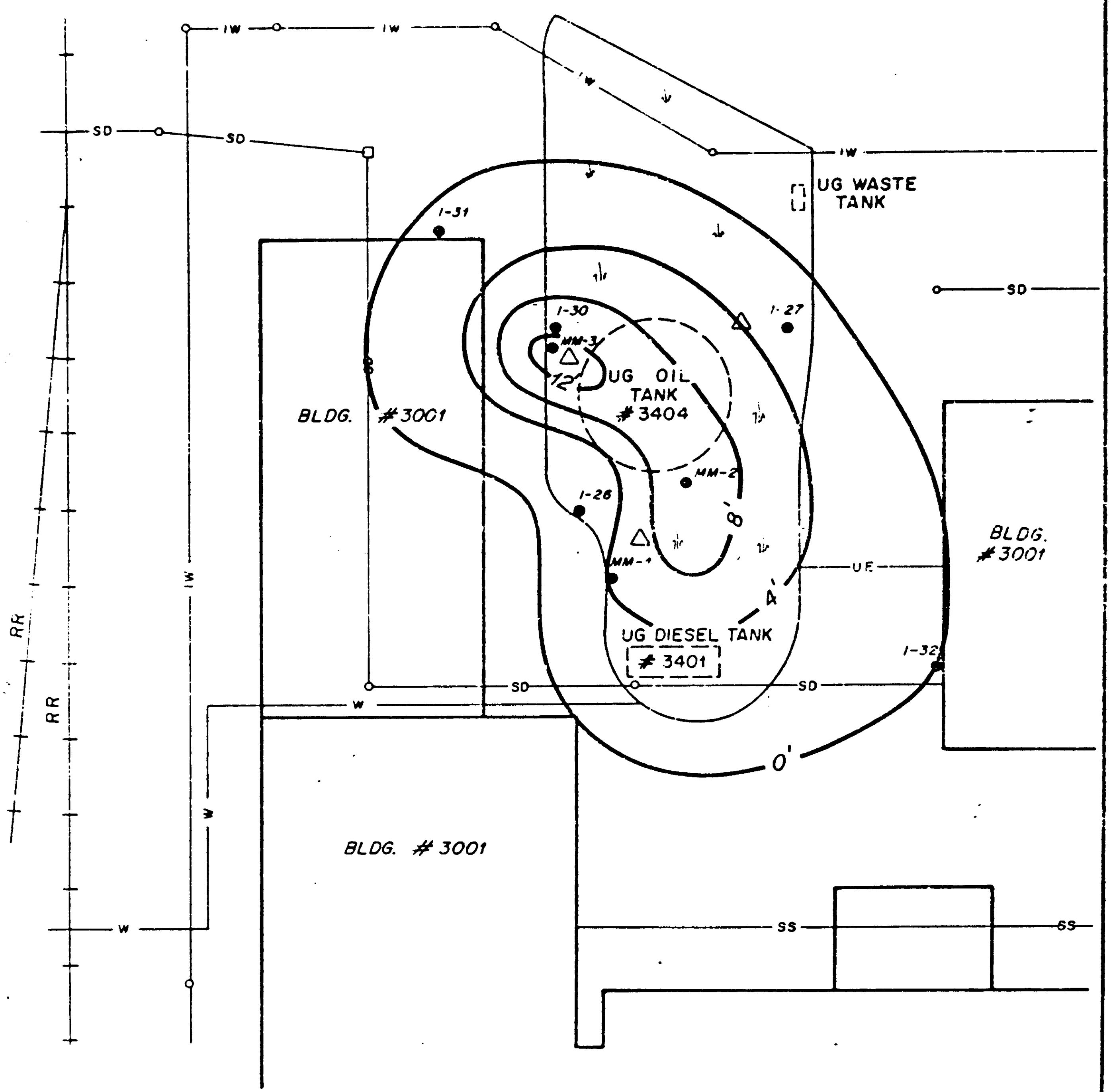
4.2 Site Geology

Tinker Air Force Base lies primarily on the Garber-Wellington Formation; the formation averages 500 feet in thickness here. The southern portion of the base, as detailed on the Oklahoma City Quadrangle Geologic map, lies on the Fairmont Shale, a member of the Hennessey Group.

Building 3001 lies directly on the Garber-Wellington Formation. At the North Tank Area the Garber-Wellington Formation is composed of sandstone, interbedded with thin lenses of blocky shale. The sandstone is composed of fine to coarse grained, reddish-brown, poorly cemented sand. The shales are red-brown in color.

The sandstone units are approximately 4-6 feet thick between thin shale layers. The sandstone units are the major medium of groundwater flow within the perched system.

TINKER AIR FORCE BASE
NORTH TANK AREA



△ PROPOSED RECOVERY WELL LOCATION

● MONITORING WELL

FIGURE 2

FUEL ISOPACH MAP
with
PROPOSED RECOVERY WELL
LOCATIONS

SCALE IN FEET
0 10 20 30 40 50

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5.0 HYDROGEOLOGY

5.1 Regional Hydrogeology

Tinker Air Force Base lies within the Garber-Wellington groundwater basin. The Garber Sandstone and Wellington Formation are the main sources of groundwater in Oklahoma County and are considered to be a single aquifer. Recharge to the Garber-Wellington aquifer results from precipitation and stream infiltration. Groundwater produced from public supply wells is derived primarily from lenticular sandstone beds, interbedded with shale layers.

The Garber-Wellington aquifer crops out in the northern one-half of TAFB. Groundwater conditions vary from unconfined to confined. Fluid depths in the several aquifers range from 30 to 100 feet below grade. At the southern portion of TAFB, the Garber-Wellington aquifer is overlain by members of the Hennessey Group. In this portion, the Garber-Wellington is considered to be confined, since the less permeable Fairmont Formation overlies the Garber-Wellington aquifer.

5.2 Site Hydrogeology

Data collected from monitor wells located around the North Tank Area indicate the presence of a perched aquifer, on which phase-separated hydrocarbons are floating. Depth to the fluid levels in the wells at the North Tank Area range from 15.0 to 16.0 feet below grade.

Hydraulic gradients are very low in the North Tank Area. Primary flow directions of the perched system are to the southeast, towards East Soldier Creek, and toward the west. Groundwater contours of the perched system around the North Tank Area indicate an area of recharge underneath Building 3001. The recharge to the system is apparently caused by discharge of West Soldier Creek, storm drains, and possible leaks in sewer lines.

From well geologic logs and schematics of wells drilled at the North Tank Area, a saturated thickness of at least 20.0 feet is identified in the area of interest. According to geologic cross-sections from the Corps of Engineers (COE), there is a confining shale layer, averaging 10.0 feet in thickness, approximately 35 feet below grade.

Slug tests were performed on wells completed in the perched system to calculate hydraulic conductivities of the formation. Although the test wells are not located at the North Tank Area, geologic logs of wells at the North Tank Area are comparable to logs of test wells. Therefore, data collected in the test wells can be extrapolated to the North Tank Area. Results from the well tests indicate a range of hydraulic conductivity values, a high of $1X10^{-3}$, with a transmissivity of 513 gpd/ft, and a low of $6X10^{-4}$, with a transmissivity of 72 gpd/ft. From these hydraulic conductivity and transmissivity values, estimates of specific capacities were calculated.

The large underground storage tank extends below the water table approximately seven (7) feet. This creates a boundary to groundwater flow and complicates recovery operations. Therefore, the recovery efficiency of a single recovery well would be severely decreased, necessitating the use of multiple recovery wells.

Static recovery, the second approach, is a viable recovery option in areas where thick accumulations of phase-separated hydrocarbons are present. The method allows initial rapid recovery of phase-separated hydrocarbons in areas of high product thickness and also precludes the generation of groundwater containing dissolved hydrocarbons. It decreases the initial expense of recovery equipment, as well as later operation and maintenance expenses.

Using this approach at TAFB, product only pumps would be deployed in areas where phase-separated hydrocarbon thickness is greatest and in areas, where needed, to minimize boundary effects of the underground storage tank. The recovery rate of phase-separated hydrocarbons and system efficiency are based partially on aquifer parameters, phase-separated hydrocarbon distribution, and recovery system design. Static recovery of phase-separated hydrocarbons with hydrocarbon only product pumps will be rapid initially, but will decrease through time. As phase-separated hydrocarbon thicknesses decrease, water levels will rebound, necessitating adjustment of the product pump. This will result in a decreased cone of depression within the phase-separated hydrocarbon column and a decrease in the driving force which moves phase-separated hydrocarbons to the recovery wells. Once phase-separated hydrocarbon thicknesses are lowered across the entire plume, the ability to pull phase-separated hydrocarbons to the recovery wells will become severely limited. Static recovery also may not allow recovery of phase-separated hydrocarbons near the plume perimeter.

6.2 Recovery System

Several factors apparent at Tinker Air Force Base lead GTI to recommend the third recovery option. The dual fluid approach will allow the development of a substantial cone of depression, with the production of a minimal volume of groundwater. Other factors leading to this recommendation include recovery boundaries generated by the underground storage tank, the lateral extent of the phase-separated hydrocarbon plume, and aquifer properties that are conducive to this system. In this system three 8" diameter, .020 slot, stainless steel recovery wells would be located throughout the plume, taking into consideration the tank location and prevailing aquifer properties. Wells will be installed to approximately 34 feet in depth and would allow for drawdown of at least 10 feet at the well bore (see Figure 3).

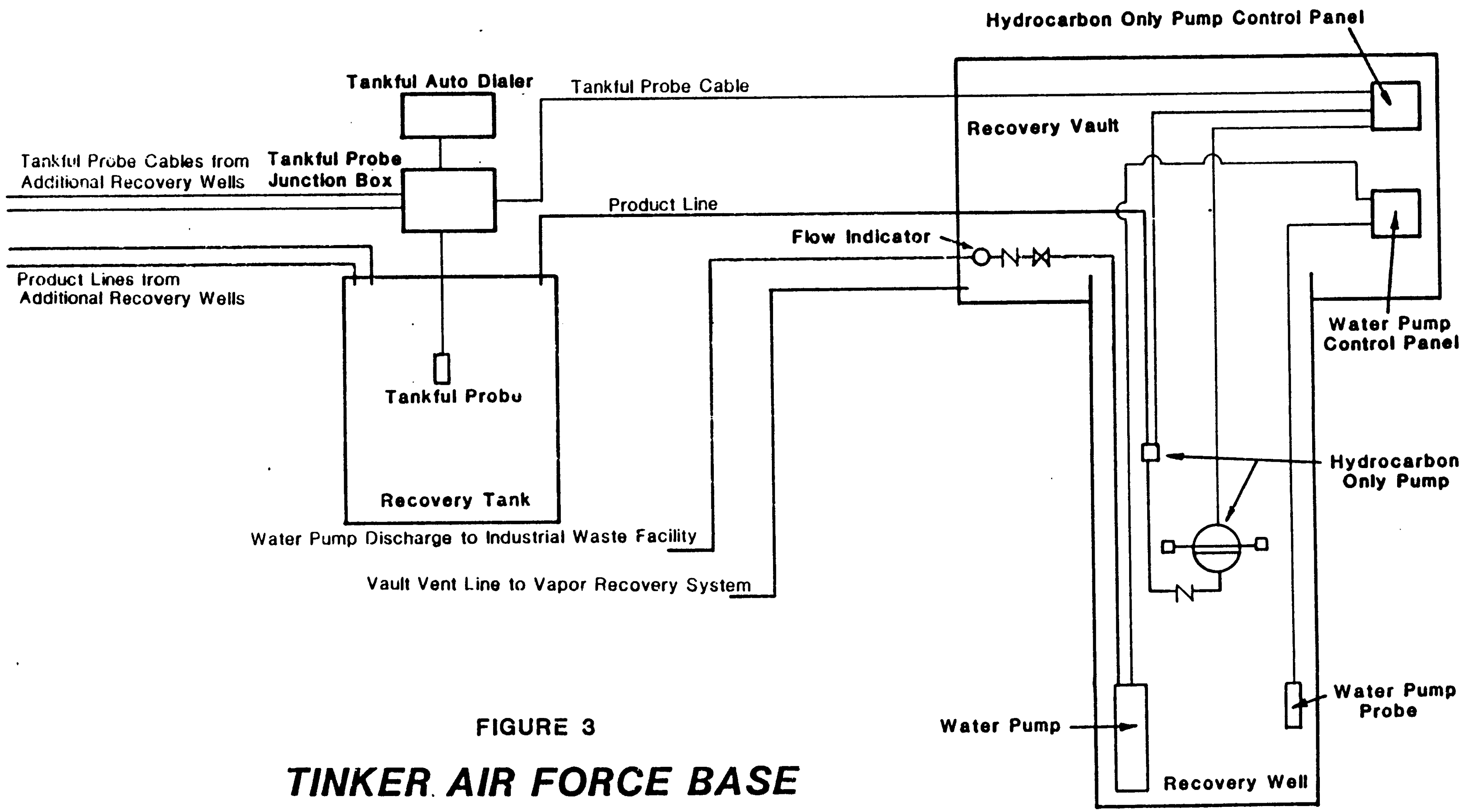

FIGURE 3

TINKER AIR FORCE BASE

NORTH TANK AREA

SCHEMATIC DRAWING of
PHASE SEPARATED HYDROCARBON RECOVERY SYSTEM

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7.0 VAPOR PHASE HYDROCARBON RECOVERY SYSTEM CONCEPTUAL DESIGN

7.1 General

Appropriate remediation at the Tinker Air Force Base North Tank Area will require treatment of vadose zone contamination, as well as phase-separated hydrocarbon removal. The area addressed by this vapor recovery system is the contaminated zone within a radius of approximately 250 feet from underground oil tank # 3404.

Spilled petroleum products tend to chemically adsorb to soil particles. Significant volumes of phase-separated hydrocarbons can be removed; however, up to 60 percent of the spill can remain adsorbed on the soil. This remaining product can continue to contaminant water for years and/or can become a health hazard by creating explosive vapor concentrations in basements or buildings.

7.2 Recovery System

The system would utilize a series of vapor extraction points distributed throughout the area. These points are to be two-inch diameter wells extending to the water table, approximately 15 feet. The vapor recovery plan would utilize one hundred (100) such wells specifically for vapor recovery and would also tie into the product recovery well vaults (see Figure 4). To obtain proper extraction rates from each well, a maximum of twenty wells would be manifolded together to one vacuum blower. Each well would be fitted with a valve and a sample port (see Figure 5). All of the blowers and vapor control equipment would be located in a single recovery compound northeast of tank # 3404.

Due to concurrent contamination by chlorinated solvents, fiberglass well materials must be used. The wells would be two-inch diameter, slotted 0.020-inch, with three feet of blank riser pipe at the top. The extraction wells would extend to the water table, however, standardization can allow all wells to extend to fifteen feet in depth. The wells would be sand packed to three feet below grade. The remainder would be backfilled with native material. Wells would be spaced on 30 foot centers, connected by manifold piping.

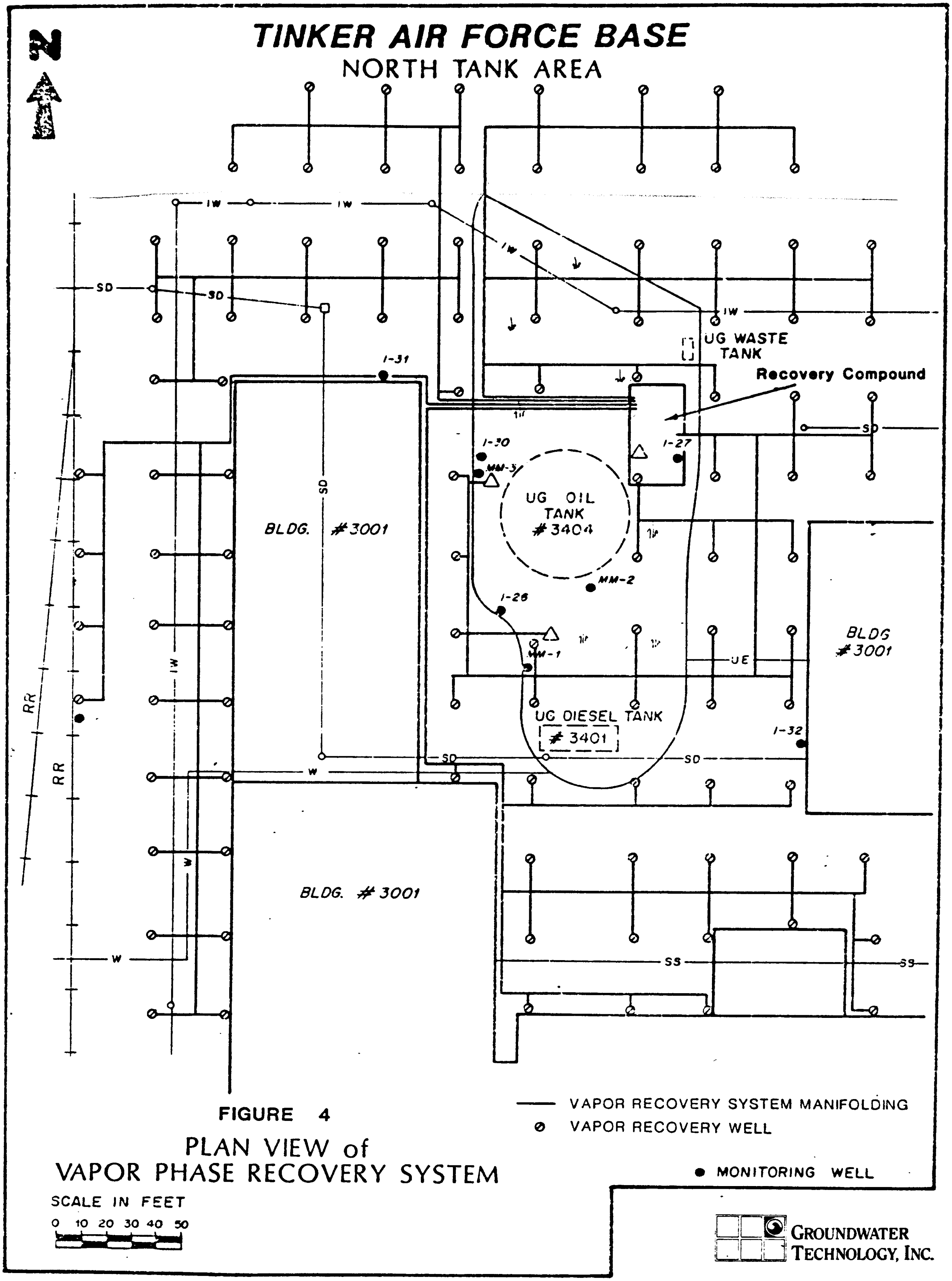

FIGURE 4

PLAN VIEW of
VAPOR PHASE RECOVERY SYSTEM

TINKER AIR FORCE BASE
NORTH TANK AREA

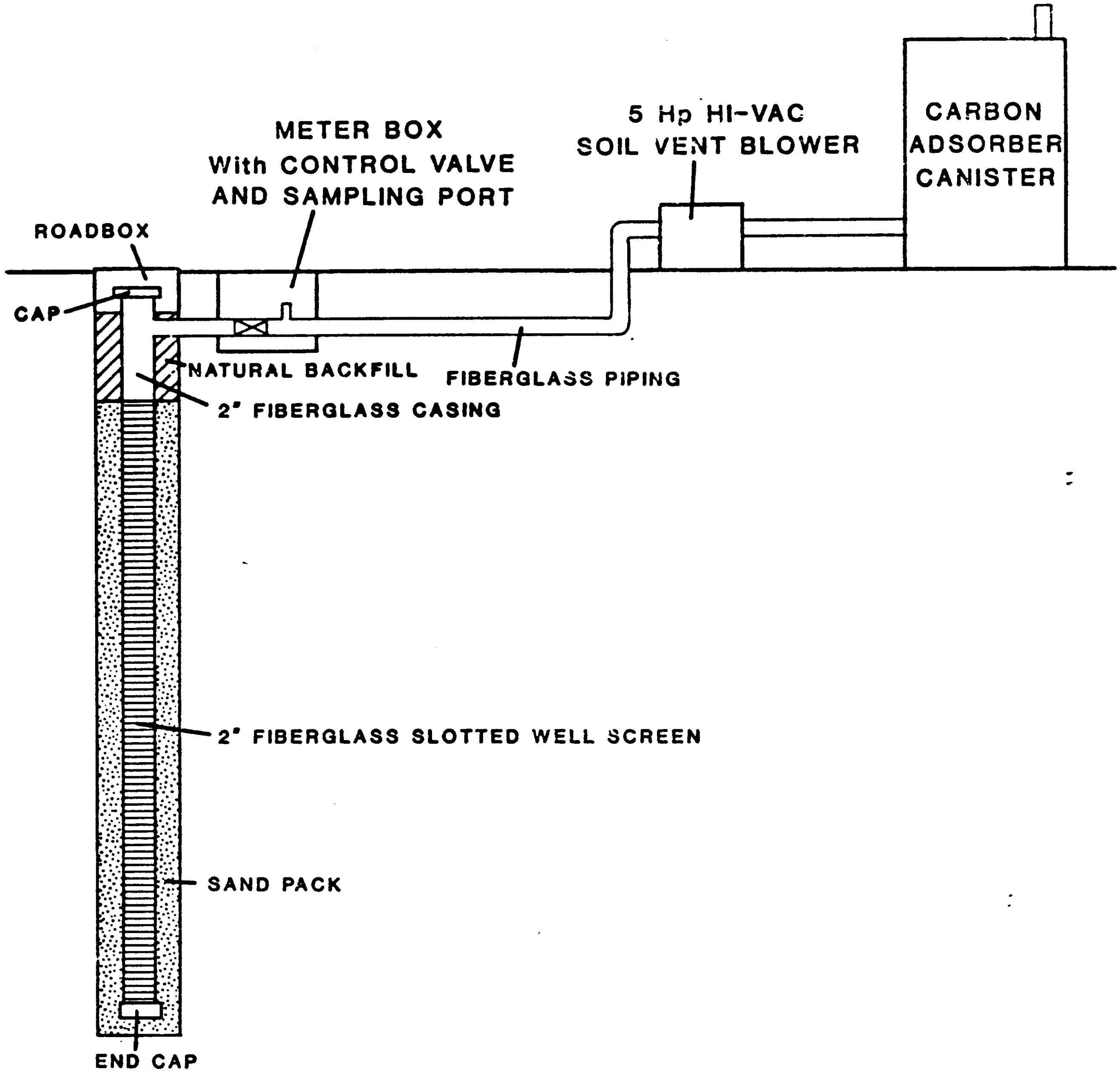

FIGURE 5

SCHEMATIC DRAWING of VENT RECOVERY SYSTEM

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Each well would be equipped with a solvent resistant valve and fitted with a 5/16" sample port. The wellhead valve and sample port would be enclosed in a valve box. The manifold piping would be two-inch fiberglass and would be installed underground to the recovery compound.

Accurately predicting the concentration from a soil venting system requires a vapor pump test. In lieu of a vapor pump test, this site can be compared with similar sites. Other soil venting systems with phase-separated hydrocarbons typically yield vapor concentrations between the lower explosive limit and the upper explosive limit. These high concentrations, coupled with the fact that many of the compounds are carcinogenic, necessitate vapor controls. Chlorinated solvents in the vapor stream preclude use of a catalytic incinerator. The other viable control technology is a regenerable carbon adsorption unit. Base steam would be required for such a unit, with the condensate being pumped to the base industrial waste facility.

The vapor recovery system would remove high concentrations of contaminants as long as phase-separated hydrocarbons are in the ground. Once the phase-separated hydrocarbons have been removed, a decrease in concentration should be noted. The lighter hydrocarbons, including chlorinated solvents, can be remediated in a two to three year time frame. Hydrocarbons equal to or heavier than diesel have a low vapor pressure, which makes soil venting an ineffective treatment strategy. These compounds would not be removed by this system.

8.0 PUBLIC HEALTH AND SAFETY

Groundwater Technology, Inc. recognizes the potential health risks for exposure to physical and chemical hazards during site investigation, treatment, storage, and disposal operations associated with remedial activities. The degree of exposure is variable, site specific, and primarily dependent upon the phase and type of waste or materials handled. The specific components of the Health and Safety Program, for remedial activities associated with the North Tank Area, are as follows:

Task I Drilling

Since concentrations of tetracloroethylene and adsorbed concentrations of fuel oil exist within the soil at the North Tank Area, level C equipment is required for drilling activities.

The establishment of work zones will help ensure that personnel are properly protected against the hazards present. Work activities and contamination are confined to the appropriate areas, and personnel can be located and evacuated in an emergency. The three zones are: the Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support Zone (SZ) (see Figure 6).

The Exclusion Zone (EZ) is an designated area where workers may be exposed to hazardous conditions. In this zone (marked EX on Figure 6), Level C equipment with full face purifying respirators and Tyvek suits will be used. Drilling operations will occur in this area. The outer boundaries of the Exclusion Zone should be clearly marked with "Hazard Tape" or a barricade system. Personnel moving into the Exclusion Zone should be wearing all appropriate personal protective equipment specified.

The Contamination Reduction Zone (CRZ) is a transition area between the contaminated/operational area and the "clean" area (Support Zone). All decontamination of clothing, equipment, and drill cuttings will occur in the CRZ. The personal protection equipment will be drummed and marked hazardous after use. The drilling rig and equipment will be decontaminated in a 15 X 30 X 3 foot deep decontamination sump, lined with 30 ml polyethylene and filled with gravel, within the boundaries of the CRZ (see Figure 7). A steam cleaner will be used to decontaminate the drilling equipment, hence water will be trapped in the decontamination sump. After use the water will be transferred to

TINKER AIR FORCE BASE
NORTH TANK AREA

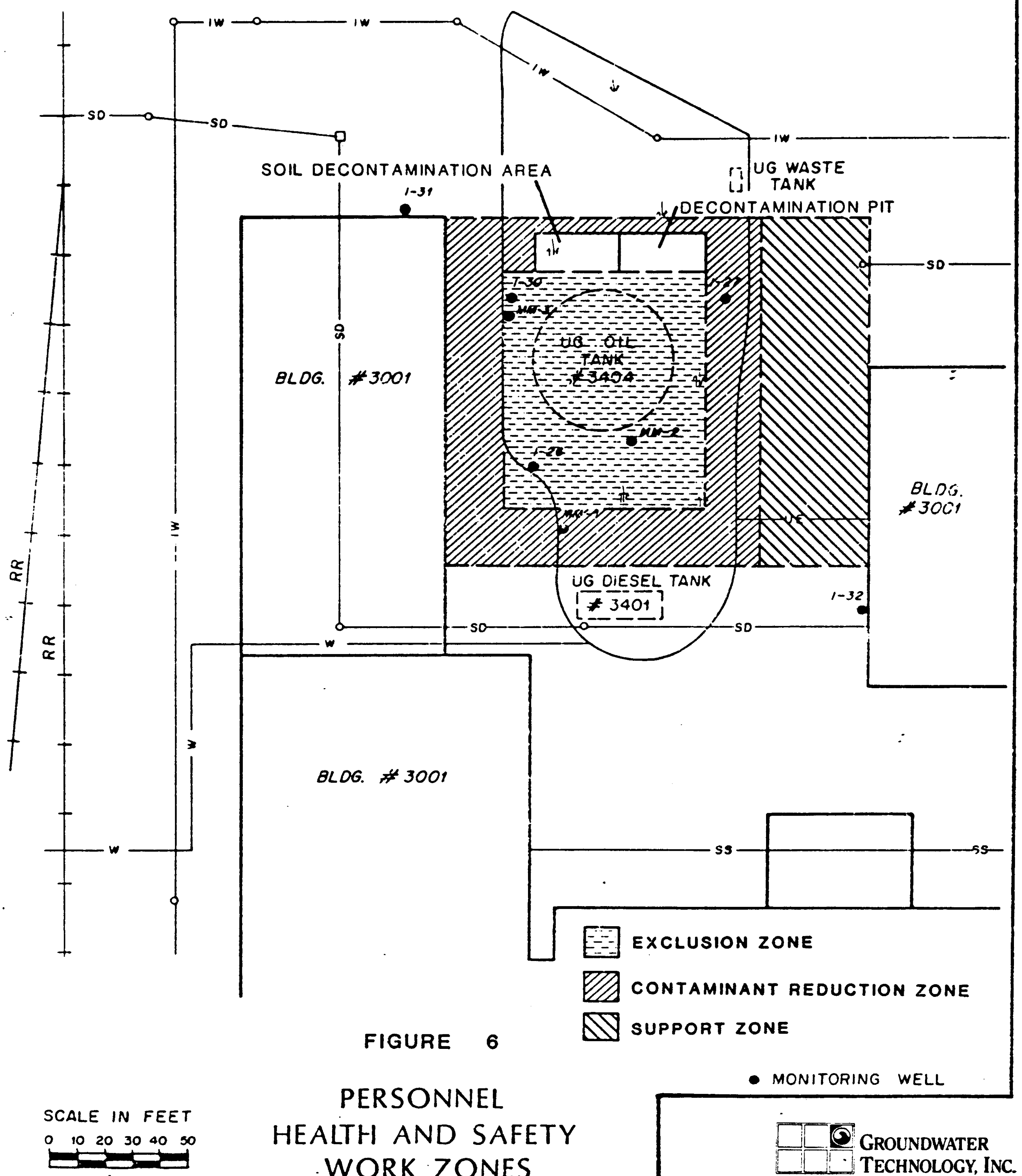

FIGURE 6

PERSONNEL
HEALTH AND SAFETY
WORK ZONES

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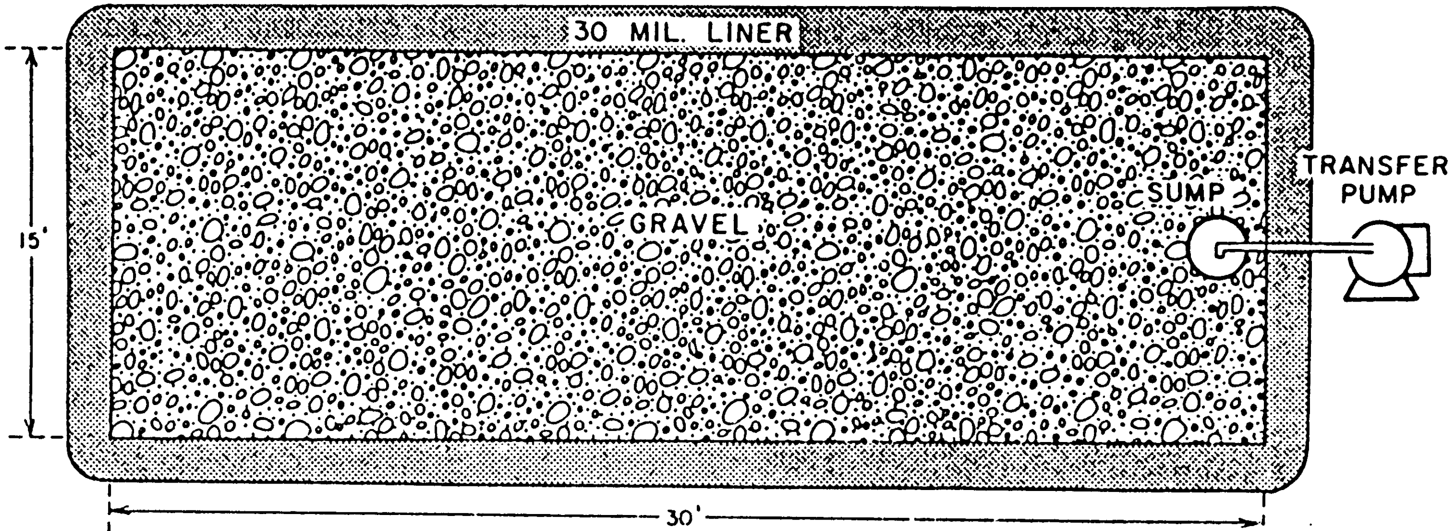
PLAN VIEW:



SIDE VIEW:

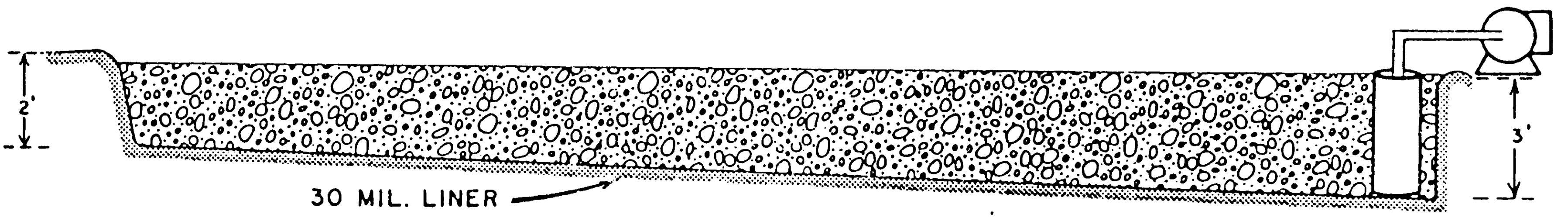


FIGURE 7

TINKER AIR FORCE BASE

NORTH TANK AREA

DECONTAMINATION TRENCH

NOTE: DRAWINGS NOT TO SCALE.

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TINKER AIR FORCE BASE
NORTH TANK AREA

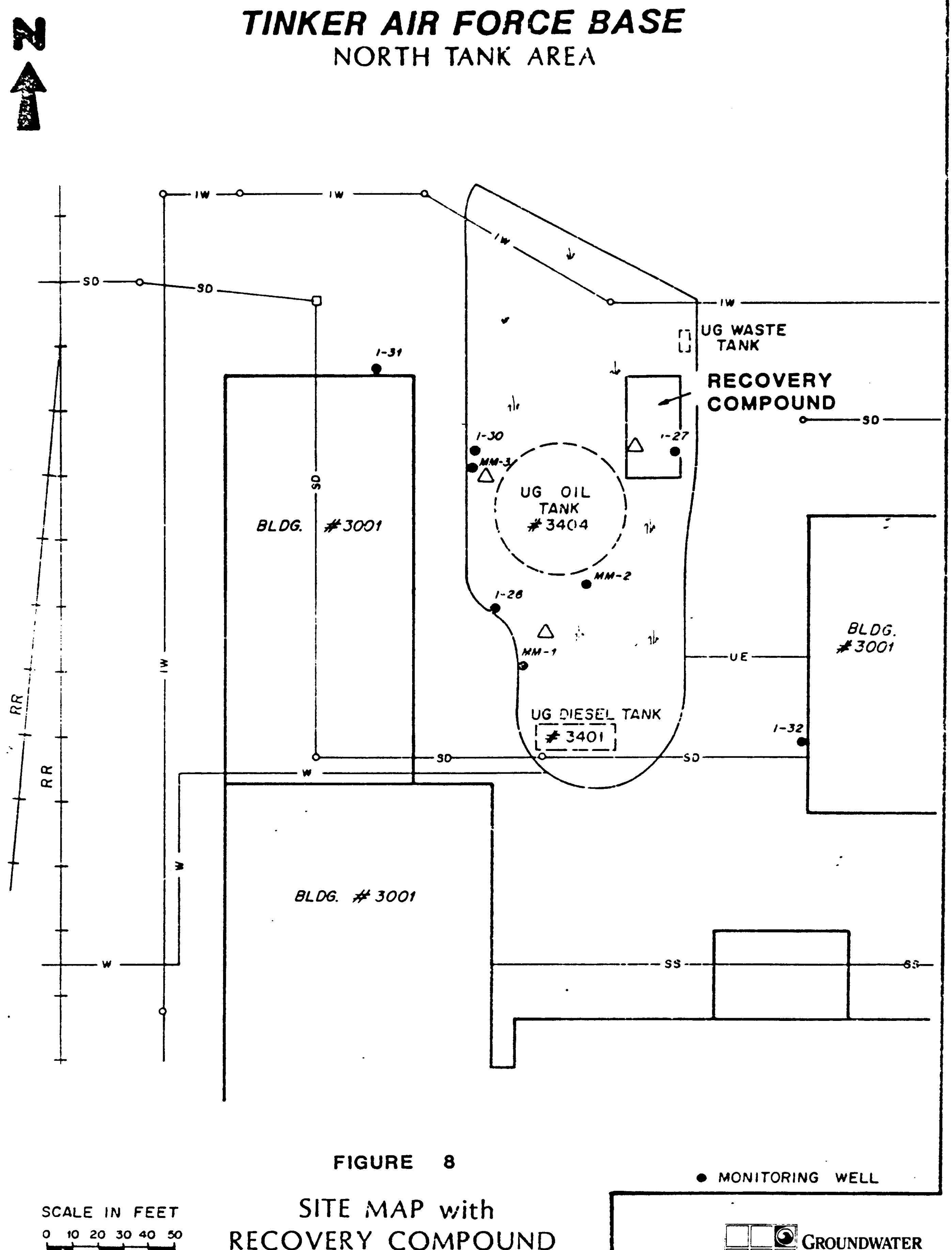

FIGURE 8

SITE MAP with RECOVERY COMPOUND

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9.0 RECOMMENDATIONS

* Gauge existing monitor wells at North Tank Area;

* Remap fuel isopach of North Tank Area utilizing new data;

* Perform tank test on active 20,000 gallon diesel tank #3401 and perform any necessary repairs or tank removal;

* Install three 8" diameter stainless steel .020" slot wells strategically within the phase-separated plume around the fuel oil tank;

* Emplace hydrocarbon only pumps in the recovery wells, to produce phase-separated hydrocarbons under static conditions; system will be set up to allow water table depression pumps to be installed at a later date, if necessary;

* Weekly, gauge monitor wells and recovery wells located in and around the hydrocarbon plume; and

* Monthly, sample water discharge for quality assurance of dissolved concentrations to discharge point.

10.0 SCOPE OF COST

The following represents Groundwater Technology, Inc.'s estimate of time and materials required to accomplish the scope of work detailed in this proposal. The prices quoted therein are valid for a period of 60 days from the date of submittal. These costs reflect all administrative and handling charges associated with this project. A handling charge of 20% is added to all subcontracted work billed through Groundwater Technology, Inc. Mileage is charged at 22.5 cents/mile for cars, 40 cents/mile for trucks. Out-of-town travel (meals, lodging, car rentals and airfare) and other direct expenses are billed with a 15% handling charge.

Task I Project Organization

Professional Fees

Professional Hydrogeologist		$ 704.00
Hydrogeologist		496.00
Geologist		912.00
Geotechnician		624.00
	Subtotal	$ 2,736.00

Task II Regauge Monitor Wells and Remap Plume

Professional Fees

Professional Hydrogeologist		$ 176.00
Geologist		1,368.00
Geotechnician		936.00
	Subtotal	$ 2,480.00

Other Direct Costs

Rentals EIP Survey		$ 150.00
Mileage		250.00
Lodging and Meals		300.00
	Subtotal	$ 700.00

Task IV Installation of Phase-Separated Hydrocarbon Equipment

Professional Fees

Professional Hydrogeologist	$ 704.00
Geologist	1,368.00
Geotechnician	936.00
Subtotal	$ 3,008.00

Other Direct Costs

Probe Scavenger (3)	22,050.00
Water Table Depression Pump (3)	18,000.00
Vaults (2)	2,760.00
Electrical Materials	1,440.00
Electrical Contractors	6,000.00
Plumbing Materials	1,800.00
Lodging and Meals	450.00
Mileage	250.00
Rental EIP 3 days	115.00
Subtotal	$52,865.00

Task V Installation of Vapor Abatement System

Professional Fees	
Professional Hydrogeologist	$ 1,408.00
Geologist	13,680.00
Engineer	12,960.00
Subtotal	$28,048.00
Other Direct Costs	
Drilling Contractor	$ 18,000.00
Well Materials	14,400.00
Piping Materials	30,000.00
Blowers	25,000.00
Regenerable Carbon System	100,000.00
Trenching and Concrete Cutting	12,000.00
Electrical Contractor	6,000.00
Travel, Lodging and Meals	5,400.00
Mileage	250.00
	$211,050.00

Task VI Calibration and Clean Up

Professional Fees

Professional Hydrogeologist	$ 2,112.00
Geologist	4,560.00
Engineer	4,320.00
Subtotal	$10,992.00

Other Direct Costs

Lodging and Meals	$ 2,100.00
* Phone	500.00
* Reproduction	300.00
* Safety Equipment	1,000.00
Mileage	500.00
Subtotal	$ 4,400.00
GRAND TOTAL	**$332,715.00**

* Includes costs for entire project

11.0 CONCLUSIONS

* There is an extensive phase-separated hydrocarbon plume floating on the perched aquifer system beneath the North Tank Area, approximately 15.0 feet below grade.

* Fuel samples of the plume indicate a mixture of fuel oil and diesel.

* The North Tank Area directly overlies the Garber-Wellington Formation, which is composed mostly of reddish-brown sandstone and lenticular shales.

* The Garber-Wellington Formation, at depths greater than 300 feet below grade, is the major aquifer for public water supply for Oklahoma County and Tinker Air Force Base.

* The Garber-Wellington Aquifer at the North Tank Area is an unconfined perched system.

* The saturated thickness of the perched system thins towards the east with an average thickness at the North Tank Area of 17.0 feet.

* The fuel oil tank will act as a barrier for migration of phase-separated hydrocarbons to a single recovery well.

* Vapor phase hydrocarbons can be removed from the subsurface by using a subsurface abatement system.

* The estimated time of recovery for the phase-separated hydrocarbon plume at the North Tank Area under static conditions is a minimum of 3 years.

(Draft)

Clarification Sheet For Nova Engineering

on the

"Hydrocarbon Abatement Proposal
North Fuel Tank Area
Tinker Air Force Base
Building 3001".

I. Section 6, Phase Separated Recovery System.

A. The system should be designed so that it can accommodate groundwater depression pumps and flowlines, but only the product pumps and flowlines are to be installed under this contract.

B. The vent lines from the vaults should discharge to the atmosphere rather than to a carbon adsorption unit.

C. Mechanical loading requirements for the vaults should be coordinated with Base Civil Engineering.

D. The requirements for handling the well cuttings will be revised such that their storage on base at the industrial waste treatment plant is allowed.

E. Phase separated recovery well locations are given on Figure 2 page 5, but are not referenced in the report.

F. System operation will be performed by TAFB and/or COE personnel.

II. Section 7, Vapor Phase Recovery System.

A. The installation of this system as described in section 7 should be include in the construction contract documents.

B. Vapors collected by this system should be vented to the atmosphere instead of to a carbons adsorption unit.

C. The worker protection requirements and work zone designations for the installation of this system will be clarified.

III. Section 8, Public Health and Safety.

A. The decontamination sump described on page 17 will not be required. The handling requirements for well cuttings will be revised such that no polyethylene liners will be required.

B. Vapors will not be collected from the well cuttings.

C. The activated carbon air unit described on page 20 will not be required.

IV. Section 9, Recommendations.

A. Gauging the wells and remapping the fuel plume will be done by COE