DRAFT

Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Site 17 Altus Air Force Base, Oklahoma

Prepared For

Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base, Texas

December 1998

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

Aug. 6, 2001

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1. Draft: Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Site 17.
   Altus AFB, OK Dec 1998

DRAFT

WORK PLAN FOR THE DEMONSTRATION OF PHYTOSTABILIZATION AT SITE 17 ALTUS AIR FORCE BASE, OKLAHOMA

DECEMBER 1998

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE, TEXAS

AND

97TH CES/CEV
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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS AND ABBREVIATIONS

$\mu g/L$	micrograms per liter
1,2-DCE	1,2-dichloroethene
AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
atm	atmospheres
bgs	below ground surface
CAH	chlorinated aliphatic hydrocarbons
CO^2	carbon dioxide
DOC	dissolved organic carbon
ft/d	foot per day
ft/ft	foot per foot
ft^2	square foot
gal/d	gallons per day
L/m^2-d	liters per square meter per day
L/m^2-yr	liters per square meter per year
log K_{ow}	octanol-water partition coefficient
m^2	square meters
mm/yr	millimeters per year
OM&M	operations, maintenance, and monitoring
Parsons ES	Parsons Engineering Science, Inc.
POC	particulate organic carbon
QA	quality assurance
SCAPS	Site Characterization and Analysis Penetrometer System
SWL	static water level
TCE	trichloroethene
TOC	total organic carbon
US	United States
USEPA	US Environmental Protection Agency
VC	vinyl chloride

SECTION 1

INTRODUCTION

This work plan was prepared by Parsons Engineering Science, Inc. (Parsons ES) for the Air Force Center for Environmental Excellence (AFCEE) as part of an overall demonstration of engineered tree plantings to hydraulically control (phytostabilize) groundwater contaminated with chlorinated aliphatic hydrocarbons (CAHs). The activities outlined in this work plan will be performed at Altus Air Force Base (AFB), Oklahoma.

Two primary objectives exist for this project:

1. Demonstrate the ability or inability of engineered tree plantings to hydraulically control groundwater through field measurements; and

2. Utilizing the field measurements, refine and calibrate a water balance model to be used as a screening and evaluation tool for phytostabilization at other Air Force sites (to be completed by others).

These two objectives provide the basis for the activities outlined in this work plan.

1.1 PHYSTOSTABILIZATION OVERVIEW

The extensive use of CAHs, such as trichloroethene (TCE), as cleaning solvents has resulted in their inappropriate disposal and subsequent soil and groundwater contamination. Highly engineered systems (i.e., pump and treat, zero-valent metal barrier walls) currently used for control and treatment of groundwater contaminated with CAHs are expensive to install and operate. Phytoremediation is a potentially more efficient and/or less costly alternative for shallow groundwater remediation.

Phytoremediation is defined as the use of plants to remove, degrade, or sequester pollutants in contaminated soil or groundwater. One application of phytoremediation is phytostabilization. Phytostabilization can be defined as the use of plants to hydraulically control the migration of a contaminant plume through transpiration and to aid in the remediation of the dissolved phase contaminants through the rhizosphere degradation or gradual volatilization. Plants have profound effects on physical, chemical, and biological processes in soils, and can significantly impact the environmental fate of organic chemicals in soil systems. Plants increase microbial and chemical activity on and around their root surfaces, thereby potentially accelerating the microbial degradation of organic contaminants. Root exudates may act as electron donors for organic contaminants that are biodegraded through reductive dechlorination.

Uptake, transpiration, and/or metabolism of organic chemicals may be important in some cases. These processes are accelerated by the mass flow of solution to the root surface induced by the transpiration flux of water from plant leaves.

If the water being used by the vegetation for transpiration is being supplied by the groundwater, plants may have the ability to control the migration of contaminant plumes and possibly enhance transfer of contaminated groundwater into the microbially rich rhizosphere (Davis *et al.*, 1996). The relative impact of vegetation on groundwater is dependent on many factors including groundwater aquifer depth and soil conditions. In low permeability areas where the recharge is low, groundwater use by plants may depress the groundwater table significantly. Where the recharge rate is high, such as sandy soil conditions near a surface water, the impact may not be as great. An annotated bibliography for watersheds in the western U.S. indicates that annual water use by cattails, cottonwoods, rushes, reeds, sedges, and tamarix can exceed 60 inches of water. A 10-ft by 50-ft planted strip of this vegetation could remove over 18,700 gallons per year from the subsurface.

In certain cases, plant uptake and metabolism of CAHs also may be important. Plant membranes are composed of a lipid bi-layer that prevents the uptake of almost all highly water-soluble compounds except plant nutrients, which are actively absorbed via specific ion pumps. The plant uptake of organic compounds tends to increase with the lipid solubility of the compounds up to a log of their octanol-water partition coefficient (log K_{ow}) of about 2 (Briggs *et al.*, 1982). Highly lipophilic compounds (log K_{ow} greater than 3) are thought to cross plant membranes more slowly than compounds of intermediate lipophilicity (log K_{ow} 1 to 3) because highly lipophilic compounds are tightly bound to the lipid membranes and are insoluble in the aqueous cytoplasm inside the cell. Translocation from roots to shoots also is optimal for chemicals with intermediate lipophilicity, and translocation appears to increase with transpiration (Ryan *et al.*, 1988). TCE is considered to be a compound of intermediate lipophilicity having a log K_{ow} of 2.5. However, while TCE uptake into plants has been observed, the quantitative relationship between groundwater concentration and the overall plant removal rate has not been established (Anderson and Walton, 1992; Newman *et al.*, 1997; Schnable *et al.*, 1996). Metabolism of TCE in plant tissue has also been described, with chlorinated alcohols and aliphatic acids being reported as byproducts (Newman *et al.*, 1997; Edwards *et al.*, 1997).

Microbial degradation of CAHs occurs under both anaerobic and aerobic environmental conditions. Anaerobic micro-sites are commonly found throughout aerobic rhizosphere (root-zone) regions. Saturated soil conditions can increase the likelihood of anaerobic sites because oxygen diffusion is reduced when soil pores are filled with water.

Under aerobic conditions, a variety of bacteria, including methane and propane oxidizers, ammonia oxidizers, and toluene (aromatic) oxidizers, have been shown to oxidize CAHs cometabolically. Although optimal conditions are uncommon, comparisons of TCE mineralization in planted versus unplanted soil suggest that vegetation may accelerate TCE degradation (Walton and Anderson, 1990).

The plant rhizosphere contains an abundance of organic compounds, originating from both plant deposition and microbial metabolism. Anaerobic conditions in the rhizosphere may therefore favor reductive dechlorination of CAHs. Under anaerobic conditions, TCE undergoes reductive dechlorination to 1,2-dichloroethene (1,2-DCE), and then to vinyl chloride (VC). Although the breakdown of TCE to VC is an undesirable process, many studies have indicated that VC can be further dechlorinated to ethene and then mineralized to carbon dioxide (CO_2). A metabolic process has been proposed linking reductive dechlorination to methanogenesis, which requires an electron-donating substrate. VC is also very volatile and is rapidly oxidized aerobically as it passes through the upper levels of the soil column.

In summary, phytostabilization has the potential to aid in the remediation or hydraulic control of CAH contaminant plumes by the following mechanisms:

1. Groundwater removal via transpiration could act to hydraulically control the migration of contaminants similar to groundwater extraction wells;

2. Contaminants in the groundwater that are removed via transpiration could be metabolized within the plant or translocated to the atmosphere; and

3. The rhizosphere could enhance the biodegradation of contaminants by altering the subsurface through the production of aerobic/anaerobic micro-sites, the natural production of low molecular weight carbon sources by plants could enhance aerobic/cometabolic degradation or reductive dechlorination.

SECTION 2

SITE CHARACTERISTICS

A detailed report regarding the characteristics at Site 17 can be found in the *Revised Description of Current Conditions RCRA Facility Investigation, Altus Air Force Base, Oklahoma* (URS, 1997). The following sections provide a summary of information found in that report in addition to a description of recent investigative activities (November 1998) performed by the United States (US) Army Corps of Engineers; details of which can be found in Appendix A.

2.1 GENERAL DESCRIPTION AND TEST SITE LOCATION

Altus AFB is located in southwestern Oklahoma, just east of the city of Altus in Jackson County. Oklahoma City is approximately 140 miles to the northeast. Altus AFB encompasses approximately 5,900 acres. The Base is organized around a primary north-south runway with the support facilities to the west. Additional runways and taxiways have been constructed to the east of the primary runway. The primary mission of Altus AFB is to conduct training for strategic airlift and air refueling crews. In addition, Altus AFB maintains a worldwide air refueling capability to support the Air Forces's mission of providing global reach and power. Altus AFB provides instruction to the Air Force Reserve, National Guard, US Navy, Marines, Coast Guard, and Air Forces of allied nations.

A preliminary screening of the site and the field investigation indicated contaminant locations, site restrictions, and underground utilities limit the area available for the tree planting. Based on the screening, the proposed planting area is an area bounded by a paved road to the east, Buildings 507 and 508 to the west, and two east/west access roads to Facilities 507 and 508 to the north and south. Underground fuel and water lines run parallel to the paved road to the east, overhead electrical line runs at a diagonal to the west of the planting area running northwest to southeast, and the tree planting straddles an underground sewer line which runs parallel to the paved road. Descriptions of soil and groundwater conditions is limited to that information pertaining to this demonstration project.

2.2 PRECIPITATION

As summarized in Table 2.1, rainfall in the vicinity of Altus AFB occurs primarily in the spring with May being the wettest month. Annual precipitation averages approximately 25 inches (657 mm) per year.

TABLE 2.1
PRECIPITATION DATA (mm) FOR ALTUS, OKLAHOMA

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
1993	NR [a/]	55.8	63.5	86.1	199.9	55.6	43.9	118.9	83.6	23.9	25.9	30.0	787.2
1994	4.8	29.7	53.6	103.1	63.0	30.0	41.9	15.5	39.4	46.5	130.3	6.9	564.6
1995	16.0	3.3	31.0	88.4	132.6	235.2	110.0	184.2	158.2	14.5	4.3	22.9	1000.5
1996	0.5	0.8	24.4	0.8	NR	103.6	189.8	170.9	118.6	46.5	36.1	1.2	697.5
1997	6.4	115.3	0.5	187.4	95.5	133.4	74.4	140.5	155.7	NR	14.5	NR	923.5
Avg. [b/]	20.8	23.7	37.5	63.0	106.7	93.5	46.6	64.0	73.1	70.5	32.3	24.6	657.4

[a/] NR = not reported.
[b/] Average precipitation compiled from 66 years of data between 1914 and 1995.

Source: Altus Irrigation Reservoir NCDC Station, Jackson County, Oklahoma (www.worldclimate.com).

2.3 TOPOGRAPHY

The land surface at Altus AFB is nearly level to gently sloping and generally lacks distinct features. Local relief is mostly the result of stream erosion. Surface elevations range from 1,330 feet to the south of the Base and 1,390 feet to the north end of the Base (separated by approximately 3 miles).

2.4 SUBSURFACE CONDITIONS

2.4.1 Soil Conditions

Surface soils near the proposed planting area consist generally of the Tillman and Hollister series. These series are characterized by clay soils with Permian red parent material.

Two primary geologic units are present below the site:

- Fill soils; and
- Hennessey shale (and its residual mantle).

The fill soils consist mainly of silty clay and sandy clay. The thickness of the fill is variable but averages about 5 to 8 feet. Thicker fills (10 to 15 feet) are found adjacent to subsurface structures such as the utility trenches that are present to the east and west of the planting area. Underlying the fill soils is the Hennessey shale and associated residual soil cover. The uppermost 5 to 20 feet of the unit generally consists of dark red clay/silty clay. Deposits below 10 to 20 feet in depth are generally described as red shale or silty shale. The shale contains various sized carbonate concretions and thin seams of gypsum.

These descriptions are consistent with the lithological data collected by the US Army Corps of Engineers during investigative activities in support of this demonstration (Appendix A). Soil classification based on cone penetrometer readings to a depth of 13 feet below ground surface (bgs) in the middle of the proposed planting area is described as red silty clay. The top of the weathered shale appears to be approximately 18 feet bgs.

No residual soil contamination has been identified near the planting area.

2.4.2 Groundwater Conditions

Two water bearing zones have been identified below the planting area, which correlate to the residual clay and shale of the Hennessey Group. The upper water-bearing zone consists of the geologic material between 0 and 20-feet bgs and the lower water-bearing zone consists of material encountered below 20-feet bgs. Based on similar hydrogeologic characteristics identified in previous investigations, it is not believed that these two units are distinct, but are part of the larger regional hydrogeological unit.

Groundwater is generally less than 10 feet bgs under the planting area. Groundwater flow is to the south-southeast at a horizontal gradient of approximately 0.0009 to 0.003 foot per foot (ft/ft). Both upward and downward vertical gradients have been identified between the upper and lower water-bearing material.

Aquifer tests performed during previous investigations resulted in hydraulic conductivity values of 3 to 5 feet per day (ft/d) for the upper zone and 1 to 2 ft/d for the lower zone. Using a hydraulic gradient of 0.002 ft/ft, a hydraulic conductivity of 3 ft/d and an effective porosity of 35 percent, the velocity of groundwater flow is expected to be approximately 6 feet per year.

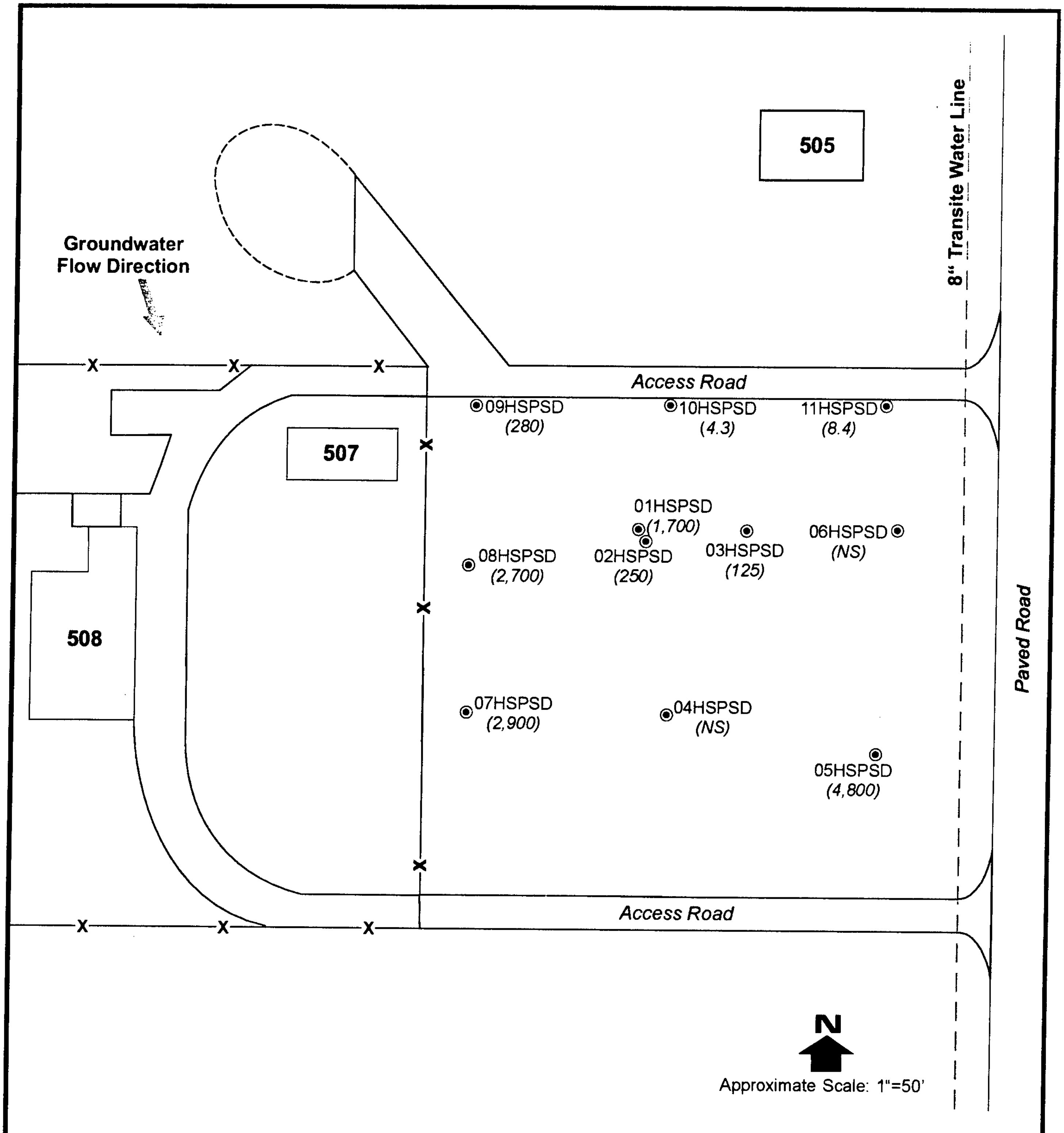
Recent investigations performed by the US Army Corps of Engineers using a Site Characterization and Analysis Penetrometer System (SCAPS) in support of this demonstration indicate that dissolved phase TCE concentrations below the proposed planting area range from 4.3 to 4,800 micrograms per liter (μg/L) (Figure 2.1, Table 2.2, and Appendix A). The highest concentrations were detected to the north of the east/west access road leading to Building 508 (05HSPSD). Based on previous investigations, the source of TCE in this location is most likely Facility 424 to the north and the storm sewer line which runs parallel to the paved road to the east of the proposed planting area (URS, 1997).

2.5 CANDIDATE PLANT SPECIES

The selection of plant species for phytostabilization at Altus AFB should be assessed using several criteria, including:

1. Potential for deep roots and potential to utilize groundwater;
2. Potential for phreatophytic, freely transpiring leaves;
3. Potential for transpiration during winter months (evergreen species);
4. Tolerance of anaerobic root-zone environments;
5. Rapid growth rates to maximize interception of solar radiation;
6. Reduced potential to spread and become problem weed species; and
7. Reduced attractiveness to birds.

The local species with the greatest potential for accelerating the attenuation of TCE-contaminated groundwater at Altus AFB are those with a capacity to access and utilize groundwater on a year-round basis. The use of groundwater by vegetation is primarily determined by the environment rather than by the type of plant. Atmospheric factors that can lead to groundwater utilization include a period of low rainfall during a period of high evaporative demand. Therefore, the meteorological conditions during the summer months at Altus AFB (Section 2.2) are very favorable for groundwater utilization. Equally important are the soil characteristics. A coarse-textured, permeable soil that facilitates oxygen transfer is critical to good root growth in lower



Legend

◉ 07HSPSD (2,900)	**Monitoring Point Location (TCE Concentration in µg/L in November 1998)**
——x——	**Fence**
————	**Road**
(NS)	**Not Sampled (Dry at Time of Sampling)**
507	**Facility**

FIGURE 2.1

SITE LAYOUT

Phytostabilization Demonstration
Work Plan
Site 17
Altus Air Force Base, Oklahoma

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Corel/draw/733923b.cdr p2 nap 12/21/98

TABLE 2.2
MONITORING POINT DATA

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Location	Depth (ft bgs)[a/]	Static Water Level (ft bgs)[b/]	TCE (μg/L)[c/]	DCE (μg/L)[c/]	PCE (μg/L)[c/]
01HSPSD	16.8-19.8	8.0	1,700	350	510
02HSPSD	9-12	8.0	250	200	190
03HSPSD	9-12	7.9	125	79	87
04HSPSD	9-12	8.0	not sampled (dry at time of sampling)		
05HSPSD	7-12	8.2	4,800	2,200	4,800
06HSPSD	9-12	9.7	not sampled (dry at time of sampling)		
07HSPSD	9-12	8.3	2,900	1,900	2,000
08HSPSD	8-11	8.5	2,700	1,700	5,500
09HSPSD	7.9-17.5	8.4	280	70	110
10HSPSD	9-18.6	8.4	4.3	<5	2.4
11HSPSD	9-18.3	8.0	8.4	<5	2.0

a/ ft bgs = feet below ground surface.

b/ Static water level on November 10, 1998.

c/ Sampled in November 1998 by the US Army Corps of Engineers (Appendix A); μg/L = micrograms per liter.

soil layers. In low permeability soils, passive air vents can be used to create aerobic conditions.

Because there is little information on differences among plant species for the uptake of organic compounds, the selection of species for phytoremediation should be based primarily on maximizing the uptake of groundwater. Phreatophytic species (also called phreatophytes) are defined as those species that are freely transpiring. This means that the stomates (pores in the leaves that exchange water vapor and CO_2 with the atmosphere) are open in a wide range of environmental conditions. Most plant species partly close their stomates during hot dry periods so that the plant can conserve water. In order for phreatophyte species to be freely transpiring they must also have the ability to access significant amounts of water through their root systems. This means that they have vigorous root systems. These root systems can grow laterally for great distances or have deep roots, which can proliferate in the capillary fringe above the groundwater. Selection of phreatophyte species should potentially increase the utilization of groundwater when environmental factors (periods of drought) place stress on the plant.

Several plant species are known to grow well in areas that have shallow groundwater and these species are generally considered to be phreatophytes. These species include many species in the Saliceae (willow) family, particularly plants in the *Populus* genus (cottonwood and poplar) and the *Salix* genus (willows). These species commonly grow along streams and are thought to access water in low-oxygen root-zone environments. Unfortunately, all of these species are deciduous (drop their leaves in the winter) and would not use groundwater in the winter months. Because of their year-round water uptake, evergreen species are often better choices than deciduous species for phytoremediation. However, transpiration rates in evergreen species would be significantly lower in the winter, because of the dormant state of the trees.

Although we have a limited understanding of the ability of specific types of trees to access groundwater, there is some information available on the ability of species to tolerate the anaerobic conditions associated with flooding. If deep rooting of these species can be encouraged, they should have the potential for root growth into the anaerobic groundwater region. Flood tolerance implies that the plants can survive in flooded (i.e., low oxygen) environments. The rooting pattern of the plants will be dependent on environmental conditions (i.e., soil type, rainfall patterns). The roots will be found in both anaerobic and aerobic zones. Roots in the anaerobic zone will be depleted of oxygen and become stressed. Roots in the aerobic zones would be able to supply oxygen to the root cells only as necessary for growth and survival. Oxygen for the remaining portions of the plant is obtained primarily above grade. Broad-leaf trees generally tolerate flooding better than most conifers, but there are exceptions.

Transpiration rates are largely determined by interception of solar radiation by the surface of leaves. Radiation falling on the ground does not cause transpiration and does little to increase surface evaporation because the soil surface usually quickly dries out. Thus species with rapid growth rates in the semi-arid environment at Altus AFB are crucial to maximizing the use of groundwater. Rapidly growing trees have fragile branches, but they form new leaves quickly. This leads to rapid interception of solar radiation, which leads to high transpiration rates. Many tree species have rapid growth rates. The growth rates and proliferation of some of these species are so rapid that they are considered to be problem weed species in most states. These species include tamarisk (*Tamarix chinensis*) and siberian elm (*Ulmus pumila*). These species are not recommended because of the potential to spread beyond the planted area and become problem weeds.

Other deciduous species with fairly rapid growth rates that are adapted to various soil conditions (e.g., moist or dry) and would probably utilize groundwater are Eastern cottonwood (*Populus deltiodes*), silver maple (*Acer saccharinum*), river birch (*Betula nigra*), and sandbar willow (*Salix exigua*). Evergreen species that prefer or are adaptable to moist and poorly drained soils include loblolly pine (*Pinus taeda*) and Austrian pine (*Pinus nigra*).

Based on the preceding discussion, the following attributes should be considered in selecting the type of vegetation to be used in a phytoremediation system:

- Trees that are considered phreatophytic or freely transpiring (e.g., willows, cottonwoods, poplars);
- Trees that can maximize transpiration throughout the year (e.g., evergreens as opposed to deciduous trees that drop their leaves);
- Trees that are considered flood and drought tolerant; and
- Trees that are rapidly growing.

It is apparent that there are many contributing factors to selecting possible types of vegetation to be used. As stated earlier, little information on differences among species for the uptake of organic compounds is available. Therefore, a rapidly growing tree, which is adapted to the region, should be used. Keeping this in mind it is recommended that the Eastern cottonwood (or one of its hybrids) be used. Characteristics of these species are detailed below.

Eastern cottonwood or one of its hybrids would be a good choice to use at Altus AFB; however, a seedless (i.e., cottonless) cultivar should be chosen to eliminate problems with flying cotton on the runways. Some hybrid crosses, such as Eastern cottonwood and black cottonwood (*Populus trichocarpa*) produced leaves that are four times larger than the parent plants, increasing transpiration rates. Advantages of using Eastern cottonwood include: 1) grows quickly, 4 to 5 feet per year; 2) has high transpiration rates; 3) extends taproots and lateral root systems quickly; 4) tolerates pollutants and saline conditions, which occur with frequent irrigation; and 5) degrades organics, such as TCE, by enzymes in plant membranes. One disadvantage of using cottonwoods is that transpiration will cease during the winter months.

Eastern cottonwoods grow to a height of 60 to 100 feet (18 to 30 meters) and a width of 40 to 75 feet (12 to 23 meters). The tree form is upright spreading with an oval to rounded crown. It is a short-lived species and trees over 70 years old deteriorate rapidly. A fast growth rate of 4 to 5 feet (1.2 to 1.5 meters) per year in rich, moist soil is not uncommon for the Eastern cottonwood, and two-year-old trees may attain heights of 30 feet (9 meters). Male cottonwood (i.e., cottonless) cultivars grow slower; between 2 to 4 feet (0.6 to 1.2 meters) per year. On preferred sites, 35-year-old Eastern cottonwood trees may average 20 inches (51 centimeters) in caliper and 130 feet (40 meters) in height. Eastern cottonwood prefers growing in moist, well-drained soil. However, it tolerates a wide range of soils.

Cottonwoods are prone to disease and insects, so locally-grown native trees should be used. Cottonless cottonwood varieties that are available from nurseries in Oklahoma include the cultivars 'Siouxland,' 'Robusta,' and 'Noreaster.' All of these cultivars are seedless and grow quickly. Many Oklahoma nurseries carry 5-gallon container stock (6- to 8-foot tall trees); however, 1.25- to 3-inch caliper trees (e.g., 10- and 15-gallon container, ball and burlap) may be available. Planting is usually done from November to March. Young cottonwood trees are highly susceptible to deer browsing, so appropriate precautions should be taken to limit damage. Based on current availability from local nurseries, the 'Noreaster' will be specified for use during this project.

SECTION 3

PROPOSED PLANTING

3.1 BASIS OF DESIGN

The field objective of this demonstration project is to establish whether engineered tree plantings can hydraulically control the movement of contaminated groundwater. Therefore, the basis of design for the tree plantings needs to be developed with the intent of providing a system conducive to deep root penetration and the use of contaminated groundwater for transpiration. The following sections provide additional detail with respect to the rationale used to design and configure the plantings with these objectives in mind.

3.1.1 Groundwater Interception

3.1.1.1 Simplified Transpiration Model

Transpiration is fundamentally driven by the input of solar radiation. Transpiration is a physical process that follows the first law of thermodynamics: energy use equals energy output. A reasonable estimate of the maximum potential transpiration rate can be made for Altus AFB by assuming that 100 percent of the solar energy per plant (leaf) unit area is used to evaporate water.

Thus:

TRANSPIRATION = (Daily incident solar radiation in Megajoules [MJ] per square meter of leaf surface per day [25 MJ/m²-d])/(The latent heat of vaporization of water [2.45 MJ/L])

Substituting typical values for solar radiation in the Altus region indicates a potential transpiration rate of about 10 liters per square meter per day (L/m^2-d) (3,650 liters per square meter per year [L/m^2-yr]) during the summer months (Oklahoma Climatological Survey, 1998). This decreases to about 4 L/m^2-d in the spring and fall (1,460 L/m^2-yr), and to about 2 L/m^2-d (730 L/m^2-yr) in the winter (for non-dormant species only).

Evapotranspiration rates for the Altus region range from 600 L/m^2-yr (dry land) to 1,950 L/m^2-yr (potential evapotranspiration) (Hauser, 1998). This high transpiration rate would be achieved only when vegetation covers more than about 95 percent of the soil surface. With a dense planting of young, fast-growing trees, this 95-percent interception of incoming radiation might be achieved in about 3 years. With a less dense planting of trees, good radiation interception would take 4 to 5 years.

Vegetation with ready access to water in the top 1 foot of soil would typically reach these potential transpiration rates. However, forcing the vegetation to utilize groundwater means that the plants would have a lower water potential and may not achieve this high potential transpiration rate. This is true even with the freely transpiring phreatophytic vegetation, because the stomates would close to prevent water loss from exceeding the rate at which water can be taken up by the roots. The transpiration rate could be reduced by 40 to 50 percent if the plants must draw water from capillary fringe above the groundwater table. This would result in a transpiration rate of about 1,000 L/m^2-yr. With annual precipitation averaging around 660 millimeters per year (mm/yr) (equivalent to 660 L/m^2-yr) (Table 2.1), the amount of groundwater transpired would equal approximately 340 L/m^2-yr (groundwater utilization rate = transpiration - precipitation).

3.1.1.2 Groundwater Flow Estimates

In order to estimate the volume of contaminated groundwater that must be intercepted by a strip of trees planted perpendicular to the plume flow line at Site 17 the plume geometry was assumed to have a width of 300 feet (see Section 2.4.2). A depth of 10 feet was assumed to be the maximum depth to which vegetation may influence the system below the current groundwater table. Actual influence may be higher or lower than this value. This demonstration project will attempt to elucidate this value. With this geometry, the volume of contaminated groundwater passing through the aquifer cross-section at the location of the planted strip can be estimated using Darcy's Law to estimate groundwater velocity at the site. Input for the calculation of groundwater velocity includes hydraulic gradients (i) of 0.0009 to 0.004 ft/ft, aquifer conductivity (K) of 1 to 5 ft/d, and aquifer effective porosity (θ) of 0.35 (URS, 1997). With these input values, a range of groundwater velocities can be estimated for the measured K values that apply to the silty clays present below the site. Using these calculated groundwater velocities, the volumetric groundwater flow rate passing through the plume cross-section, assumed to be 300 feet wide and 10 feet thick, can be estimated as the product of the groundwater velocity and the 3,000-square-foot (ft^2) cross-sectional area. Table 3.1 summarizes the results of groundwater velocity and flow rate estimates using a range of hydraulic gradients and hydraulic conductivities.

Using these groundwater flow rate estimates and the estimated groundwater utilization rate of trees at Altus AFB of 340 L/m^2-yr, the planting area required to intercept this groundwater flow can then be calculated. These calculations are summarized in Table 3.2. It should be noted that during the winter months, transpiration rates will decrease significantly or stop entirely, depending on the dormancy of the vegetation. Thus, hydraulic control of the contaminant plume may not be as effective during the winter months.

From these planting area estimates, a planting configuration footprint can be estimated. These calculations are summarized in Table 3.3. The Width of Planting Area values were calculated assuming that plantings would occur across the entire 300-foot width of the plume. The Number of Trees Required values were calculated assuming that plantings would occur on 10-foot centers (used for number of trees per row [i.e., 30 trees]) and have a 20-foot-diameter coverage (used for row numbers)

TABLE 3.1
ESTIMATED GROUNDWATER VOLUMETRIC FLOW RATES

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Average Groundwater Gradient (ft/ft)[a/]	Hydraulic Conductivity (ft/d)[b/]	Effective Aquifer Porosity	Total Plume Cross-Section (ft^2)[c/]	Effective Plume Cross-Section (ft^2)	Groundwater Velocity (ft/d)	Volumetric Groundwater Flow Rate (gal/d)[d/]
Low Estimate						
0.0009	1	0.35	3,000	1,050	0.003	24
Average						
0.002	3	.0.35	3,000	1,050	0.02	160
High Estimate						
0.004	5	0.35	3,000	1,050	0.06	470

a/ ft/ft = foot per foot.
b/ ft/d = feet per day.
c/ ft^2 = square feet.
d/ gal/d = gallons per day.

TABLE 3.2
ESTIMATED PLANTING AREA REQUIRED TO INTERCEPT VOLUMETRIC FLOW

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Groundwater Flow Rate (gal/d) [a/]	Groundwater Flow Rate (L/yr) [b/]	Plant Transpiration Rate (L/m^2-yr) [c/]	Required Plant Area (m^2) [d/]	Required Plant Area (ft^2) [e/]
Low Estimate				
24	33,000	340	97	1,000
Average				
160	220,000	340	650	7,000
High Estimate				
470	650,000	340	1,900	20,000

a/ gal/d = gallons per day.

b/ L/yr = liters per year.

c/ Average rate; plant transpiration rates will decrease significantly or stop entirely during the winter months. L/m^2-yr = liters per square meter per year.

d/ m^2 = square meters.

e/ ft^2 = square feet.

TABLE 3.3
CONFIGURATION OF PLANTING AREAS AND CORRESPONDING NUMBER OF TREES REQUIRED TO INTERCEPT VOLUMETRIC FLOW

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Required Plant Area (ft^2)[a/]	Width of Planting Area (feet)	Number of Tree Rows	Number of Trees
Low Estimate			
1,000	3	1	30
Average			
7,000	23	1-2	30-60
High Estimate			
20,000	67	3-4	90-120

[a/] ft^2 = square feet.

area when mature. Once established, the number of trees could be thinned if unhealthy overcrowding was evident.

As can be seen from the calculations in Table 3.3, a range of planting requirements with up to 4 rows of trees, 300 feet long (or a total plant coverage area of 20,000 ft^2), would be required to intercept the contaminated groundwater flowing below the site (using a transpiration rate of 340 L/m^2-yr and a groundwater flow volume as high as 650,000 L/yr (470 gal/d). Based on the preliminary screening, the final configuration of the planting area is limited by contamination location and site restrictions.

3.2 PLANT SPECIES

Based on the discussion presented in Section 2.5, a cottonwood hybrid (specifically the cultivar 'Noreaster') will be used.

3.3 LAYOUT AND PLANTING PIT DESIGN

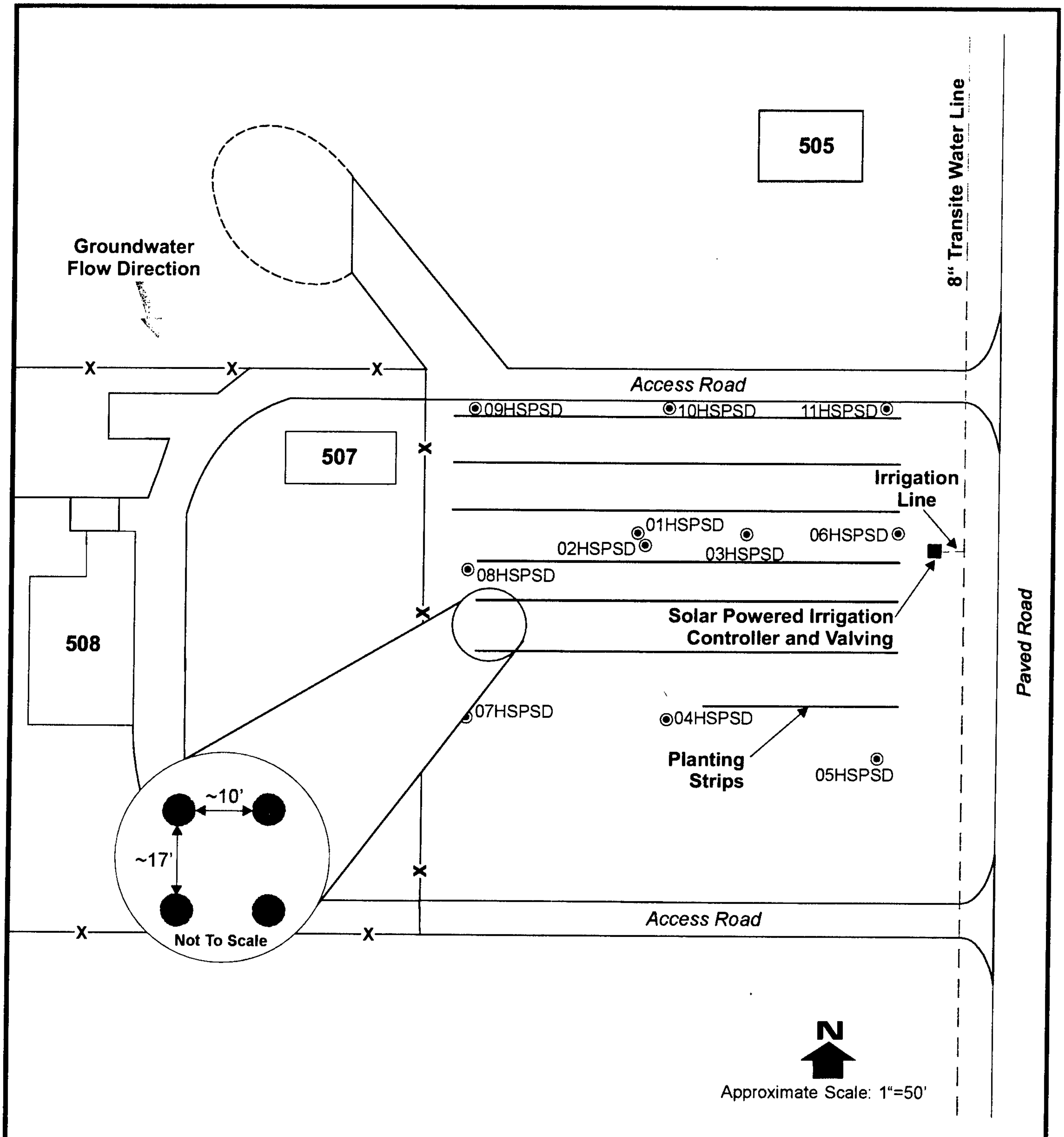
The ability of plants to directly utilize groundwater depends mainly on environmental conditions (e.g., a period of low rainfall during a period of high evaporative demand). A permeable soil that facilitates oxygen transfer also is critical for good root growth in deeper soil layers.

Section 3.1.1.2 and Figure 3.1 provide a detailed description of the proposed layout of the engineered plantings. Site restrictions due to underground and above ground utilities requires a non-uniform planting be established. The following configuration is illustrated on Figure 3.1 (each tree on 10-foot centers with rows spaced approximately 17-feet apart):

- Row 1 (R1) - 16 Trees (T1 - T16)
- Row 2 (R2) - 16 Trees (T1 - T16)
- Row 3 (R3) - 16 Trees (T1 - T16)
- Row 4 (R4) - 15 Trees (T1 - T15)
- Row 5 (R5) - 15 Trees (T1 - T15)
- Row 6 (R5) - 15 Trees (T1 - T15)
- Row 7 (R7) - 7 Trees (T1 - T7)

This planting configuration maximizes the use of available space and is placed as closely as possible to the storm sewer to the east of the site presumed to be a preferential conduit for the transport of contamination. A total of 100 trees will be planted which will result in coverage of approximately 15,600 ft^2.

This will also provided added distance (100 feet from first row to last row) to intercept groundwater which has migrated during periods of low transpiration (approximately 4 to 6 months during the winter). Groundwater will move approximately 30 to 40 feet during this time period without treatment. Designing the planting width at a total of 100 feet (seven rows separated by 17 feet each), allows for the possibility of groundwater interception and treatment after the period of low transpiration (winter season).



Legend

07HSPSD Monitoring Point Location

—X— Fence

—— Road

507 Facility

FIGURE 3.1

MONITORING POINTS AND PLANTING STRIP LOCATIONS

Phytostabilization Demonstration Work Plan
Site 17
Altus Air Force Base, Oklahoma

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Corel/draw/733923b.cdr p3 nap 12/21/98

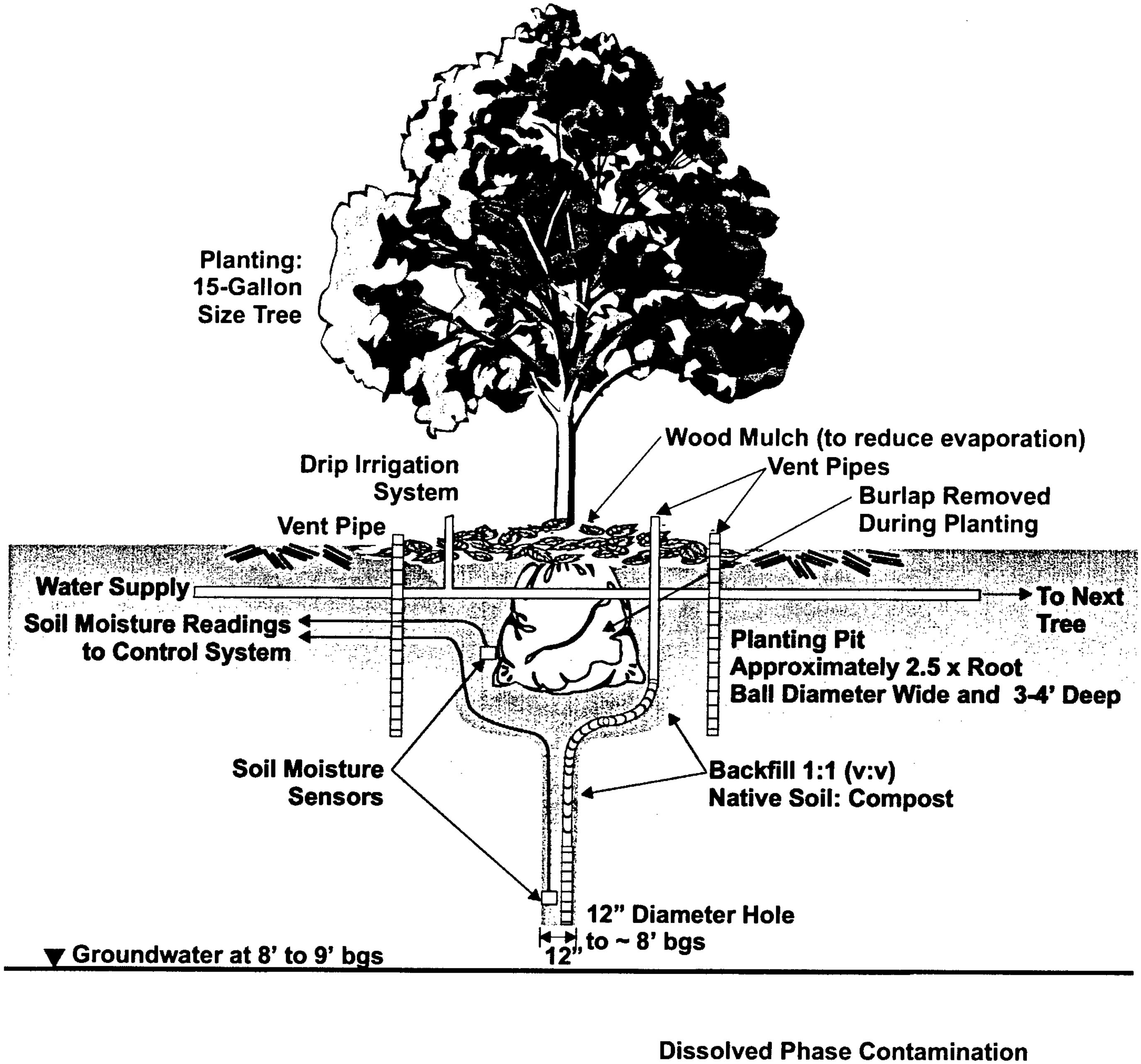
To increase the potential use of groundwater by planted trees, an engineered approach is to be used to modify the planting pit for each tree in the planting strip. A planting pit approximately 2.5 times the diameter of the root ball will be excavated to a depth of approximately 3 to 4 feet bgs. This will be the main hole for tree planting. To enhance the vertical migration of roots, a 12-inch diameter hole will be augured to a depth of approximately 8 feet bgs (approximately 1 feet above the water table) starting at the base of the main planting pit. The entire planting pit will be backfilled with a equal volume of native soil and compost which is suitable for good plant growth and will increase the permeability of the planting pit compared to the surrounding area. Passive air inlet wells (3-inch diameter) will be placed in each planting pit with perforations from 3 to 8 feet bgs to provide oxygen to the subsurface directly below the trees. Additional aeration holes will be placed 3 feet to the west and east of each planting pit to a depth of 5 feet bgs. Passive air inlet wells (3-inch diameter perforated pipe) will be placed in each hole to provide oxygen to the subsurface to promote lateral and vertical root growth. An illustration of this design has been provided as Figure 3.2. Additional details can be found in Appendix B.

3.4 IRRIGATION SYSTEM

An irrigation system will be required for a minimum of three years after the initial planting to supply water to the growing trees. It is anticipated that the amount of water added to the system will decrease with increasing age of the tree to enhance the migration of the roots to the groundwater table. It is necessary that this system supplies sufficient water to ensure the health of the trees during the first three years while minimizing the amount of water added to the groundwater system to avoid displacement/dilution of the dissolved contaminants.

Initially, it is estimated that each tree will required approximately 1 to 1.5 gallons of water per day for irrigation (100 to 150 gallons of water per day for 100 trees) (Hauser, 1998). The water will be provided by tapping into a potable water line approximately 30 feet to the east of the tree plantings (see Appendices B and C and Figure 3.1). Based on conversations with local service providers, the most efficient means of irrigation water delivery to individual plants is through drip irrigation with multiple emitters on or near the surface of each tree basin. The design of the planting pits is such to increase the vertical flow of irrigation water applied at the surface to the deeper regions below the root ball. The tree plantings will be divided into four zones for more discrete control of watering (see Appendix C).

The application of water will be controlled by a programmable solar powered controller (Appendix C). The amount of irrigation water applied to the trees will be dependent on physical inspection of the trees by a local service provider. Current and anticipated weather conditions will be taken into account when scheduling the irrigation frequencies. It is anticipated that the amount of irrigation water applied to the plantings will be substantially reduced in years 2 and 3 of the project to facilitate the trees use of groundwater.



Not To Scale

FIGURE 3.2

PLANTING DESIGN

Phytostabilization Demonstration
Work Plan
Site 17
Altus Air Force Base, Oklahoma

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

Corel/draw/733923b cdr p1 nap 12/21/98

3.5 MAINTENANCE ACTIVITIES

Maintenance activities for the tree plantings will be provided by a local service provider. Details regarding the maintenance activities to be performed can be found in Appendices B and C. Watering of the trees will be completed automatically as described in Section 3.4. The schedule of maintenance activities is required to be submitted by the local provider prior to beginning field activities. This will be distributed to AFCEE and Base upon receipt. In summary, maintenance activities will consist of the following activities:

- Periodic walk throughs observing the general condition of the plant material and irrigation system noting any concerns;
- Pruning of the trees as necessary
- Inspections of the stakes and guys;
- Weed control within the tree basins; and
- Insect and disease control.

Replacement of any dead trees will be provided on an as need basis by the local service provider.

SECTION 4

MONITORING ACTIVITIES

Numerous activities will be occurring over the first three years of operations, maintenance, and monitoring (OM&M). A large portion of the monitoring activities will be automated using a data acquisition system integrated with the irrigation controller. A smaller portion of the monitoring will take place annually during schedule site visits. A summary of these monitoring activities is provided in Table 4.1. The following sections briefly describe these activities. All activities will be conducted under the guidelines of the project *Health and Safety Plan* found in Appendix D.

4.1 SOIL

4.1.1 Soil Moisture

Plant growth, soil temperature, chemical transport, and groundwater recharge are all dependent on the state of water in the soil. The best measure of the state of water in the soil for irrigation purposes is the soil's water potential. The water potential is an expression of the energy state of the water in the soil and the ease with which plants can utilize such water. Free water or gravitational water will drain from a soil until the soil water potential reaches approximately -0.3 atmospheres (atm). This is called the field capacity. As the soil continues to dry (i.e., used by plants), more and more energy is needed by the plants to remove the water. The wilting point is the water potential at which a plant can no longer remove water and usually occurs around -15 atm. Thus, the water potential in the soil is an important variable in understanding the plant-soil-groundwater relationship.

Soil moisture will be measured with granular matrix sensors, which use electrical conductance as an indirect measure of water potential. Soil moisture will be monitored at two depths (10 inches [mid-point of root ball depth] and 6 feet bgs) within each of four pits at the site. Soil moisture readings will be measured and recorded at a frequency of once per hour for three years after the initial planting.

4.1.2 Root Distribution

Roots typically take up more water per unit surface area from shallow roots than from deep roots (Thornley and Johnson, 1990). However, during periods of drought the surface water is depleted more rapidly than the deep water and water uptake per unit surface area from deep roots can be greater than from shallow roots (Thornley and Johnson, 1990). The relative advantage of shallow roots (per unit surface area) may not be as great in regions with prolonged droughts. Conversely, in drought conditions,

TABLE 4.1
SUMMARY OF MONITORING ACTIVITIES

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Medium	Type	Number	Frequency
Soil	Soil Moisture	4 locations at 2 depths each	1/hr[a/] in OM&M[b/] Years 1, 2, and 3
	Root Distribution	2 locations	1/Year in OM&M Years 2 and 3
	pH	6 locations at 2 depths each	1/Year in OM&M Year 3
	TOC[c/]	6 locations at 2 depths each	1/Year in OM&M Year 3
	Chloride	6 locations at 2 depths each	1/Year in OM&M Year 3
	Moisture Content	6 locations at 2 depths each	1/Year in OM&M Year 3
Groundwater	SWL[d/]	2 locations	1/Day in OM&M Years 1, 2, and 3
	SWL	10 locations	1/Year in OM&M Years 1, 2, and 3
	CAHs[e/]	10 locations	1/Year in OM&M Years 2 and 3
Tree	Growth	10 locations	1/Year in OM&M years 1, 2, and 3
	Sap Flow	2 locations	1/Week in March, July, and September in OM&M Years 1 and 2

a/ 1/hr = once per hour.
b/ OM&M = operation, maintenance, and monitoring.
c/ TOC = total organic carbon.
d/ SWL= static water level.
e/ CAHs = chlorinated aliphatic hydrocarbons.

the deep roots typically allow the plant to maintain only a minimum hydration state rather than supply a significant amount of water for transpiration. Even if the water uptake of the deep roots was double that of the surface roots on a surface area basis, they would still contribute only a small portion of the annual plant water supply. During periods of increased rainfall, the surface roots typically contribute a disproportionately large fraction of the plant water supply because it requires less energy to draw water from shallow soil than from deep soil layers. This could limit the interaction of the vegetation with the contaminate media.

To evaluate the root distribution in the subsurface during this demonstration, a limited intrusive survey will be conduced in years 2 and 3 of OM&M. The limited intrusive survey will be completed by hand coring or augering through two planting pits to qualitatively evaluate the total depth and density of the roots. Field logs will be maintained at each borehole describing the general density of roots with depth and will record the characteristics of the roots (e.g., size, color, etc.).

4.1.3 Soil Quality

The most important process for the natural biodegradation of the more highly chlorinated solvents is reductive dechlorination. During this process, the CAHs are used as electron acceptors, not as a source of carbon, and a chlorine atom is removed and replaced with a hydrogen atom. This results in chloride concentrations in the system which are elevated relative to background concentrations. As was indicated in the overview, microbial degradation of TCE occurs under both anaerobic and aerobic environmental conditions. The plant rhizosphere contains an abundance of organic compounds, originating from both plant deposition and microbial metabolism. Anaerobic micro-sites are commonly found throughout aerobic rhizosphere (root-zone) regions. Although optimal conditions are uncommon, comparisons of TCE mineralization in planted versus unplanted soil suggest that vegetation may accelerate TCE degradation (Walton and Anderson, 1990). Conditions in the rhizosphere may therefore favor reductive dechlorination of TCE using natural organic matter deposited by the vegetation as electron donors. Thus, the conditions in the rhizosphere may result in elevated degradation of CAHs compared to non-vegetated areas which would cause localized, elevated regions of chloride concentrations. Newman *et al.* (1998) observed this phenomenon in pilot-scale systems planted with hybrid poplar, native western poplar, and black locust.

Because the CAH is used as an electron acceptor, an electron donor is needed. This can be anthropogenic compounds (e.g., landfill leachate, fuel hydrocarbons) or it can be from natural sources (e.g., vegetation). As subsurface biomass of the vegetation degrades or the vegetation exudes low molecular weigh organic compounds, the dissolved or particulate organic carbon (DOC [< 0.45 μm] or POC [> 0.45 μm]) is transported to the groundwater adding natural carbon to system. In systems where the conditions for reductive dechlorination are favorable, this carbon addition may act to locally increase the biodegradation of the contaminants. A stand of trees may serve as a large enough source of organic carbon to impact the migration of contaminants through mineralization. Lee *et al.* (1998) observed this below a mature cottonwood tree in Texas. In this study it was concluded that a microbially mediated iron-reducing environment capable of degrading TCE had developed from the natural organic carbon being released from the rhizosphere.

Soil quality measured as chloride content and total organic carbon (TOC) content will be collected in year 3 of OM&M to evaluate the potential effect of the rhizosphere on the system. Six samples will be collected within (three locations at two depths each) the planted area and six samples (three locations at two depths each) outside the planted area for comparison purposes. Samples will be collected via hand coring or augering techniques and analyzed in a commercial laboratory.

4.2 GROUNDWATER

4.2.1 Water Level Measurements

The most direct evidence of a plant use of groundwater and potential effectiveness at controlling the migration of a contaminant plume is a localized depression of the groundwater table. As in pump-and-treat remediation schemes, the cone of depression developed by groundwater extraction wells serve to locally reverse the hydraulic gradient of the groundwater thereby stopping or minimizing the downgradient migration of contaminants in that area. This is the ultimate goal of this phytostabilization project.

To assess the impact of the tree plantings on the groundwater table, static water level (SWL) of the groundwater will be measured continually utilizing pressure transducers within two monitoring points at the site. These two monitoring points are intended to establish whether localized depressions exist due to the trees transpiration of groundwater and whether the trees create daily cycles of groundwater elevation change. One location will be within the planted area (02HSPSD) and one location will be outside the planting area (09HSPSD). Measurements will be collected at a frequency of once per hour for the first three years after the initial planting via the data acquisition system. These measurements will be stored in a data logger location in the field and downloaded in computer compatible form at least four times per year.

Once each year, water levels will be measured in all available wells surrounding the trees to assess groundwater depression on a larger scale, flow direction, and rate in the portion of the plume beneath the tree planting.

4.2.2 Ground Water Quality

Groundwater quality changes due to the presence of vegetation is important aspect when evaluating the effectiveness of phytostabilization. These changes can be measured by collecting samples upgradient and downgradient of the planting area and comparing the results. To this end, groundwater samples will be collected upgradient (09, 10, 11HSPSD), within (01, 02, 03, 06, 08HSPSD), and downgradient (04, 05, and 07HSPSD) of the planting area. Groundwater samples will be analyzed for chlorinated hydrocarbons utilizing US Environmental Protection Agency (USEPA) Method 8260 in a commercial laboratory. Groundwater samples will be collected in years 2 and 3 of OM&M.

4.3 TREES

4.3.1 Growth Characteristics

The foundation of success of any engineered tree plantings will be the health and growth characteristic of the vegetation planted. These growth characteristic provide an indication of the effectiveness in establishing the trees in the area and there ability to survive over the long term. In addition, parameters such as canopy diameter can be used to refine and calibrate a water balance model with an aboveground biomass component. Tree growth characteristics including tree height, tree diameter, and canopy diameter will be recorded on an annual basis from at least 10 trees at the site.

4.3.2 Transpiration Stream

Direct measurement of transpiration allows for the determination of how much water the tree is actually transpiring. These values can be compared versus potential transpiration rates and can be used to further refine water balance models. In addition, if the water being transpired can be proportioned between surface water sources (precipitation and/or irrigation) and subsurface source (groundwater) direct measures of transpiration can be used to quantify the amount of groundwater being removed by a planting system. This can be used in groundwater and contaminant transport models to predict the effectiveness of engineered phytostabilization systems. Additionally, the direct measurement of transpiration during periods of low rainfall or drought will provide an indication of alternative sources are available to the plant (i.e., if transpiration is still occurring at a relatively high rate during periods of drought, groundwater may be satisfying the plants needs).

Direct measurements of transpiration are usually performed on individual trees. Transpiration can be determined by measuring the rate of water movement through the stem of trees. The most common methods use a heat balance as the estimating tool. Four common methods include:

1. Stem Heat Balance Method;
2. Trunk Sector Heat Balance Method;
3. Heat-Pulse Method; and
4. Thermal Dissipation Method.

These four methods have been reported to be accurate to within 10-percent (Smith and Allen, 1996). Common sampling apparatus produced by Dynamax (Houston, Texas) make use of the Stem Heat Balance Method which is summarized below:

1. The stem is heated electrically via a thin flexible heater that encircles the stem.
2. At steady state, this heat input is balanced by heat fluxes out of the stem which consist of:

- Conduction up the stem;

- Conduction down the stem;

- Conduction radially out of the stem; and

- Convection in the moving transpiration stream.

3. The heat balance is solved for the amount of heat taken up by the water moving up the stem, which is then used to calculate the mass flow of water being transpired (Smith and Allen, 1996; Baker and Nieber, 1989).

Commercial instruments are available in multiple sizes which allow any number of trees to be measured at one time for any period of time. The data is stored electronically and then downloaded to calculate transpiration rates. Once transpiration measurements are made it is often necessary to extrapolate the small sample set to an entire stand (e.g., a rows of trees planted for phytostabilization). To do this, it is often most convenient to convert the transpiration flow measurements (per tree) to transpiration per unit area of land covered by a canopy (e.g., L/d-m^2). In uniform stands of monoculture vegetation and closed canopies, the transpiration is not likely to vary significantly among members. The measurement of a few trees can be used to estimate total stand transpiration by plant density (Smith and Allen, 1996). The trees planted at the site are a single species, therefore measurements made on two trees may be extrapolated to the entire stand.

Sap flow will be measured on two trees at the Site in OM&M years 1 and 2 utilizing the Stem Heat Balance Method or equal procedure. Readings will be taken at a frequency of 1 per hour by a modified SapFlow2® system produced by Dynamax (Houston, Texas) or equivalent equipment. Minimum measurements will include data collection for one week during March, July, and September (years 1 and 2 only).

SECTION 5

DATA ANALYSIS AND REPORT PREPARATION

5.1 DATA ANALYSIS

As stated in Section 1, the two primary objectives for this project are as follows:

1. Demonstrate the ability or inability of engineered tree plantings to hydraulically control groundwater through field measurements; and

2. Utilizing the field measurements, refine and calibrate a water balance model to be used as a screening and evaluation tool for phytostabilization at other Air Force sites (to be completed by others).

The data gathered during this demonstration will be used to qualitatively and quantitatively assess the trees ability to hydraulically control groundwater. The data will be compiled and assessed to determine phytostabilization effectiveness. Section 4 provides detail regarding the usefulness of each of the variables measured for these purposes. When possible, quantitative estimates of phytostabilization effectiveness will be made.

In addition, the data collected will be utilized by the Air Force to refine and calibrate a water balance model. Tree growth data, sap flow data, and meteorological data will be used to calibrate the water balance model. Once calibrated, the water balance model will be used to predict phytostabilization effectiveness at the site in the future. In addition, the ability of the model to predict phytostabilization effectiveness at other sites will be assessed.

5.1.1 Data Validation

All data will be validated for their quality and for their acceptability for their intended use. When applicable, measures of data quality and the criteria for determining their acceptability for the data quality objectives are described in the Base *Quality Program Plan* (REFERENCE, no date). The goal of the data validation/quality assurance (QA) program is to provide data of sufficient quality that they can be used to make a quantitative assessment of the potential effectiveness of phytostabilization. The raw data and QA checks on the raw data will be organized to permit analysis of their precision and probable accuracy, so that they may be used to draw defensible and definitive conclusions.

5.2 FINAL REPORT PREPARATION

Upon completion of field data collection and analysis, a draft, draft final, and final technical report will be prepared summarizing the effectiveness of phytostabilization at the site The report will summarize all field activities completed and provide a summary of all data collected. Plant growth observations, irrigation requirements, transpiration measurements, groundwater impact, and future impact of the engineered tree plantings at the site will be detailed.

The proposed outline for the report is provide in Table 5.1.

TABLE 5.1
PROPOSED TECHNICAL REPORT OUTLINE

PHYTOSTABILIZATION DEMONSTRATION
WORK PLAN
SITE 17
ALTUS AFB, OKLAHOMA

Outline
INTRODUCTION
Phytostabilization Overview
SITE CHARACTERISTICS
General Description and Location
Meteorological Conditions
Topography
Subsurface Conditions
Soil
Groundwater
SAMPLE COLLECTION AND ANALYSIS PROCEDURES
Soil
Groundwater
Trees
RESULTS
Plant Growth Observations
Plant Moisture Requirements
Transpiration Measurements
Impact on Soil Quality
Impact on Groundwater Table Elevation
Impact on Groundwater Quality
Future Impact of Tree Rows (Water Balance Model)
Lessons Learned
CONCLUSIONS AND RECOMMENDATIONS
REFERENCES CITED

SECTION 6

SUPPORT REQUIREMENTS

The following support is required of the Air Force:

- The Air Force (Base coordinators) will arrange for personal identification badges, vehicle passes, and/or entry permits for the initial planting and any subsequent maintenance or monitoring activities.
- Altus AFB personnel will be responsible for identifying the location of all utility lines, fuel lines, or any other underground infrastructure prior to any sampling or planting activities.
- Altus AFB will supply potable water to be used for irrigation purposes.

SECTION 7

SCHEDULE

The following schedule has been established for completion of key tasks. The initial Work Plan submittal is designed to meet the accelerated schedule for tree planting. Thus, only those sections necessary to complete the tree planting are included.

Task	Completion Date
Draft Work Plan to AFCEE	23 December 1998
Initial Tree Planting	February 1998
Final Work Plan to AFCEE	01 March 1999 [a/]
Operations, Maintenance and Monitoring	February 1998 through March 2001
Draft Technical Report to AFCEE	9 April 2001
Draft Final Report to AFCEE	23 May 2001
Final Report to AFCEE	22 June 2001

[a/] Dependent on regulatory agency review.

SECTION 8

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APPENDIX A

PHYTOSTABILIZATION INVESTIGATION RESULTS

For Mr. William P Neal Parsons ES

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

REPLY TO
ATTENTION OF:

CENWK-PE-GG (200-1C) 19 Nov 98

MEMORANDUM FOR Mr. Sam Taffinder, AFCEE/ERT
3207 North Road Brooks AFB, Texas 78235-5363

SUBJECT: Summary of SCAPS Work at Phytostabilization Demonstration Site, Altus AFB, Oklahoma

1. Enclosed is a summary of the Kansas City District's SCAPS work at Altus AFB. The summary includes results of direct sample ion trap mass spectrometer provided by Oak Ridge National Laboratory.

2. Eleven well points were installed. Only two well points contained enough water to sample on the same day they were installed. Seven well points contained enough water to sample after 24 hours. Two well points did not contain water after 24 hours and were not sampled. Depending upon sample requirements, well points which are purged dry during future sampling events, especially 04HSPSD and 06HSPSD, may not recover sufficiently in 24 hours to allow sample collection.

3. One hundred and sixty seven holes were drilled to promote root growth of trees which are to be planted at later date. A five foot length of perforated flexible tubing was placed in each hole and a three inch diameter plastic grate was placed inside the top of each piece of tubing. The grates were difficult to place in the tubing because the top of some of the tubing was out of round. Grates would fit more securely if they fit over the top instead of inside.

4. Thank you for the opportunity to assist you with this effort. Please contact Kathleen Older or James Campbell with any questions (816-983-3985).

for BRUCE C. MURRAY, P.E., P.G.
Chief, Planning and
Engineering Division

Summary of SCAPS Work at Altus AFB, 3 - 10 November, 1998

The Kansas City District SCAPS crew arrived at Altus AFB about 0830 on 3 November and met with Mr. Dan Staton, Chief of Environmental; Mr. Tom Dragoo, Parsons Engineering; Mr Billy Allday, Fire Department; Lt Lange, Biomedical Office ; Capt Wise, Security Office; and Tom Swackhamer, Groundskeeper. The purpose of the meeting was to go over standard Altus AFB requirements for conducting site work and the scope of the field work associated with the AFCEE phytostabilization demonstration. Field work included installing direct push small diameter well points to monitor the water table, sampling the well points with hydrosparge and ion trap mass spectrometer, augering five foot deep holes and installing perforated flexible tubing into the augered holes. Figure 1 is a schematic of the site.

Site utilities had been cleared and marked. Mr. Dragoo was laying out a grid for the auger holes, and also had located the first two well point locations. He waited to locate remaining well points until first two were sampled.

All well points were PowerPunch installations. Figure 2 diagrams a typical PowerPunch installation. A one inch outer diameter 0.010 slotted three foot long schedule 40 PVC screen was placed through the PowerPunch sealing body and into a sacrificial drive point. This screen assembly was inserted into the lead push rod and pushed to terminal depth. Threaded 5 foot long sections of PVC riser were attached together as they were placed into the push rods. The entire length of riser was threaded onto the screen section. The push rods were retracted 3 feet to expose the screen and an electronic water level indicator was used to determine water entry. The string of push rods was turned with pipe wrenches in order to set the sealing body in place. The sealing body isolates the screened interval from overlying material.

Soil classification was obtained at the location of the first well point (figure 3), the sensor probe could not be advanced below 13 feet. The material to about 13 feet consists of red silty clay. Based on push resistance, the top of weathered rock appears to be approximately 18 feet below ground. The first well point (01HSPSD) was installed using the sensor probe hole. Refusal was at 19.8 feet. The well screen was opened three feet but no water entered. A second well point (02HSPSD) was installed next to the first. This well point was screened from 9 to 12 feet below ground surface and water did enter the screen. Since water entered the screen between 9 and 12 feet, subsequent well points were planned to be set at the same interval.

Mr. Rob Smith (ORNL) arrived on site about 1230 and the crew loaded his equipment into the SCAPS vehicle. Mr. Smith set up the direct sample ion trap mass spectrometer (DSITMS) and associated equipment, made standard solutions and calibrated the instrument. After these preparations were made, 02HSPSD (9-12) was sampled and tested using the downhole hydrosparge and the DSITMS. A schematic of the hydrosparge device inside a well point is in figure 4. TCE, DCE, and PCE were identified in 02HSPSD (9-12). Based on this sample result, remaining well points were located as planned.

Well point 03HSPSD was installed to 12 feet below ground surface but no water entered.

On the following morning, 4 November, 01HSPSD (16.8-19.8) contained about 2 feet of water but 03HSPSD only contained about 0.2 feet. The hydrosparge device needs approximately one

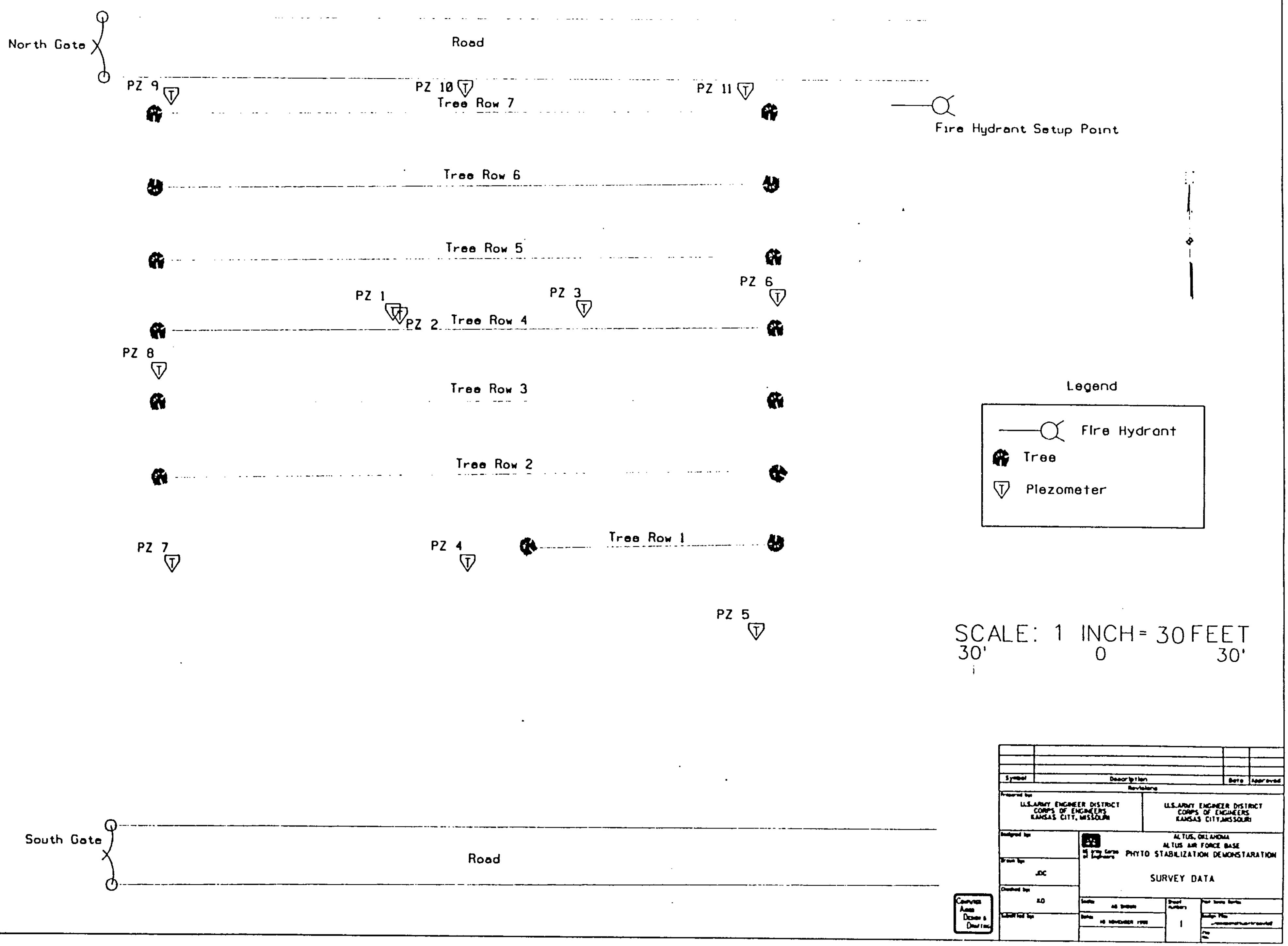

North Gate
Road
PZ 9
PZ 10
PZ 11
Tree Row 7
Fire Hydrant Setup Point
Tree Row 6
Tree Row 5
PZ 1
PZ 2
PZ 3
PZ 6
Tree Row 4
PZ 8
Tree Row 3
Tree Row 2
PZ 7
PZ 4
Tree Row 1
PZ 5
Legend
Fire Hydrant
Tree
Piezometer
SCALE: 1 INCH = 30 FEET
30'
0
30'
South Gate
Road
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS KANSAS CITY, MISSOURI
ALTUS, OKLAHOMA
ALTUS AIR FORCE BASE
PHYTO STABILIZATION DEMONSTARATION
SURVEY DATA

Figure 1

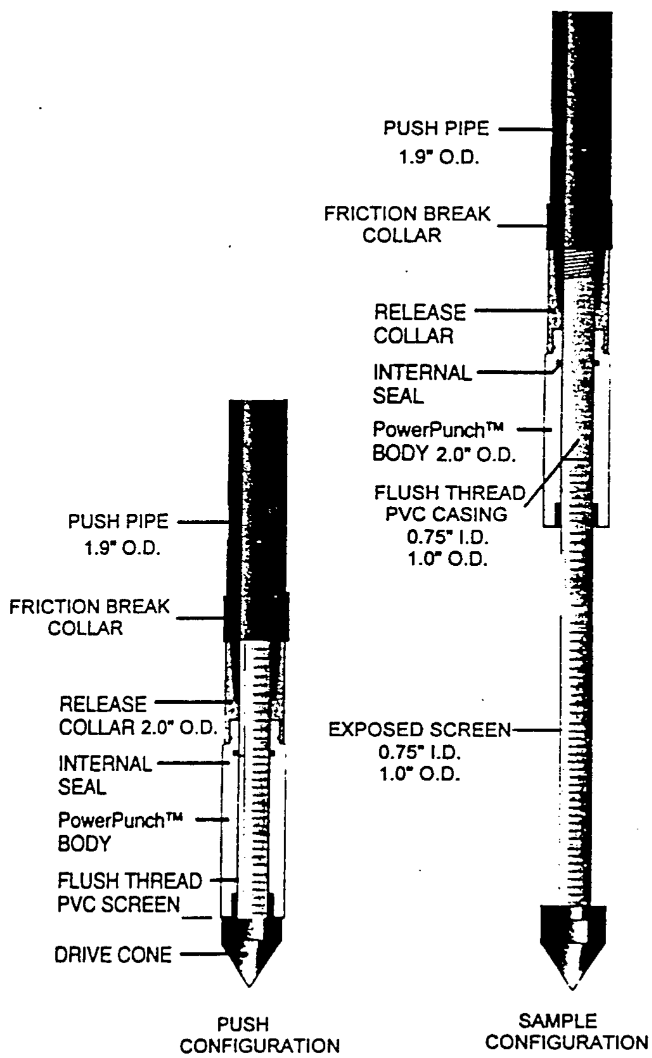

PUSH PIPE
1.9" O.D.
FRICTION BREAK
COLLAR
RELEASE
COLLAR 2.0" O.D.
INTERNAL
SEAL
PowerPunch™
BODY
FLUSH THREAD
PVC SCREEN
DRIVE CONE
PUSH
CONFIGURATION
PUSH PIPE
1.9" O.D.
FRICTION BREAK
COLLAR
RELEASE
COLLAR
INTERNAL
SEAL
PowerPunch™
BODY 2.0" O.D.
FLUSH THREAD
PVC CASING
0.75" I.D.
1.0" O.D.
EXPOSED SCREEN
0.75" I.D.
1.0" O.D.
SAMPLE
CONFIGURATION

Figure 2

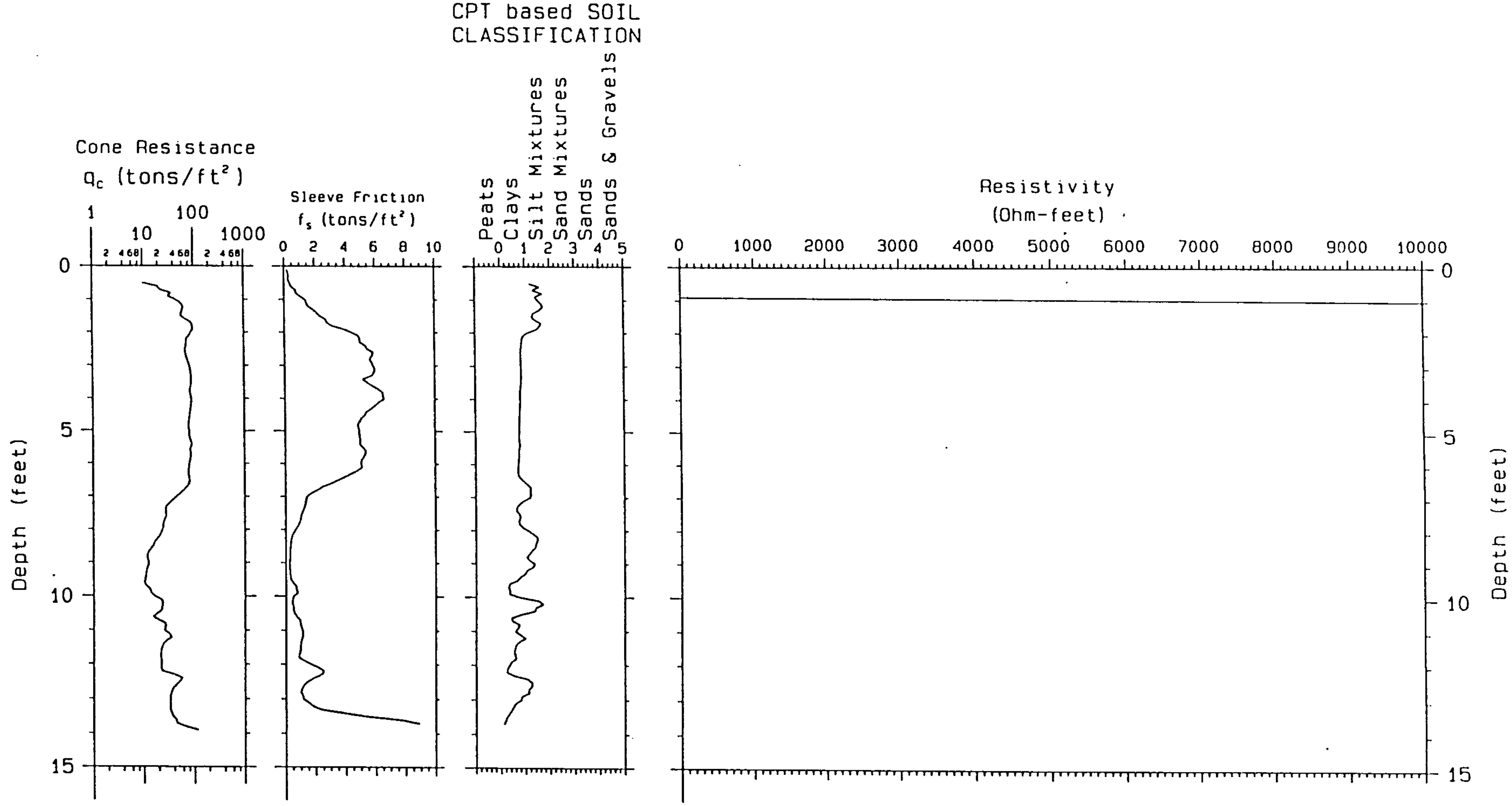


figure 3

Project: altus phytostabilization <NEW>

Probe Depth; 14.02

Pre-Push Depth; 0

Probing date; 11-03-1998

U.S.Army
Engineer
District
Kansas City
Geotechnical Branch

MRK

SCAPS

Site
Characterization
and Analysis
Penetrometer System

CPT; 01PSDAFB

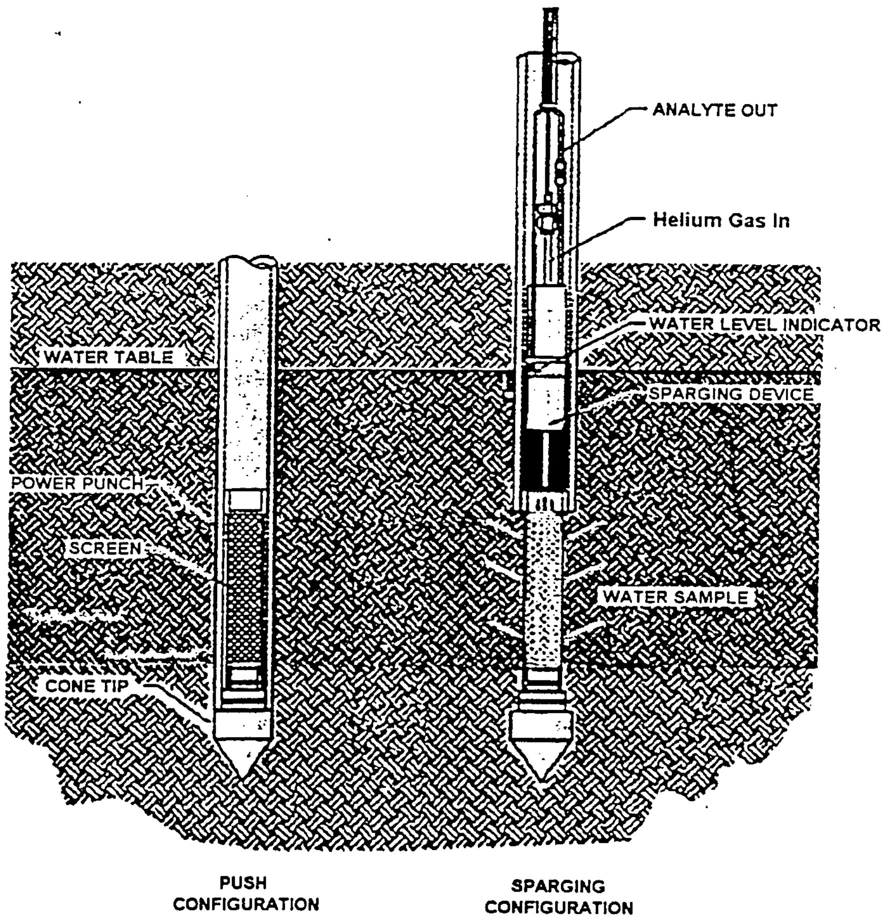

ANALYTE OUT
Helium Gas In
WATER LEVEL INDICATOR
WATER TABLE
SPARGING DEVICE
POWER PUNCH
SCREEN
WATER SAMPLE
CONE TIP
PUSH
CONFIGURATION
SPARGING
CONFIGURATION

Figure 4

foot of water to function so 03HSPSD could not be sampled. Five more well points were installed to approximately 12 feet. Mr. Sam Taffinder from AFCEE arrived on site mid-morning. Mr. Taffinder and Mr. Dragoo checked two existing monitor wells and determined that they were about 26 feet deep instead of 12 or 15 feet deep. Based on this information, the last three well points were installed to refusal which was about 18 feet below ground surface. Nine feet of screen were set approximately 9-18 feet below ground surface in these last three well points. Three attempt were made to set well point 09HSPSD. The point was broken off at refusal and the PVC came up as the push rods were retracted in the first two attempts. The third attempt stopped short of refusal and was successful, however the sealing body did not remain in place and came out with the push rods.

Only one well point, 08HSPSD (8-11 feet), installed on 4 November contained water. 01HSPSD, which was pushed previous day, and 08HSPSD (8-11) were sampled and tested. Both well points contained volatile compounds.

Fifty-four 5 foot deep, 5 ½ inch diameter holes were augered with the Earthprobe at locations marked by Parsons representative. The purpose of these holes is to provide pathways for tree roots to follow to water. The trees will be planted at a later date. Flexible, 3 inch diameter, perforated black plastic tubing was cut and capped and placed into each augered hole so that about 3 to 5 inches extended above ground surface. The annular space was backfilled with cuttings from the hole. Spaces for well box covers were dug around 01HSPSD and 02HSPSD.

On the third morning, 5 November, water levels were obtained from all well points which had not been tested. 04HSPSD only contained 0.2 feet of water and 06HSPSD was dry. The remaining holes were sampled for volatiles. Volatiles were found in 05HSPSD (7-12), 07HSPSD (9-12), and 09HSPSD (7.9-17.5). Small amounts of volatiles were found in 10HSPSD (9-18.6) and 11HSPSD (9-18.3). 10HSPSD and 11HSPSD also contained a small amount of aromatic hydrocarbons. Chemical results are in table 1. Seventy auger holes were completed with perforated tubing. Caps or duct tape were temporarily placed over all the flexible tube openings so debris could not blow in. The extra two holes at 09HSPSD were grouted to the surface with portland cement and water, spaces around 4 well points were dug out for covers. Mr. Smith's equipment was removed from the SCAPS vehicle and loaded into his van.

Work resumed on Monday, 9 November. The SCAPS crew arrived at Altus about 1315. Eighteen of the auger holes were drilled and completed with tubing. Spaces for two well box covers were dug and four spaces were squared off.

Work was completed on Tuesday, 10 November. Twenty remaining auger holes were completed. All temporary caps and duct tape were removed from tubing. Plastic grates which were supposed to sit inside the end of the flexible tubing were installed. Some of these did not fit very well because the tubing was often out of round. Remaining spaces for well covers were dug out and all well covers were set in place with Quicrete. Extra tubing, end caps and grates were taken to Building 502 at the direction of Environmental Office. Water levels were collected from all well points. Table 2 summarizes water levels. Well points and the beginning and end of each tree row were surveyed in for relative position. Mr. Dan Staton inspected the site prior to SCAPS departure.

Table 1 : DSITMS RESULTS (3-5 November 1998) Results are in ppb

Well Point ID	TCE	DCE	PCE	CHCl3	CCl4	Aromatic
01HSPSD (16.8-19.8)	1,700	350	510	ND	ND	ND
02HSPSD (9-12)	250	200	190	ND	ND	ND
03HSPSD (9-12)	125	79	87	ND	ND	ND
04HSPSD (9-12)	NS	NS	NS	NS	NS	NS
05HSPSD (7-12)	4,800	2,200	4,800	880	ND	ND
06HSPSD (9-12)	NS	NS	NS	NS	NS	NS
07HSPSD (9-12)	2,900	1,900	2,000	460	26	ND
08HSPSD (8-11)	2,700	1,700	5,500	1,100	ND	ND
09HSPSD (9.7-17.5)	280	70	110	39	ND	ND
10HSPSD (9-18.6)	4.3	ND	2.4	ND	ND	67
11HSPSD (9-18.3)	8.4	ND	2.0	ND	ND	78

ND non detect at instrument detection levels
NS not sampled due to lack of water
TCE trichlorethene
DCE dichloroethene
PCE tetrachloroethene
CHCl3 chloroform
CCl4 carbon tetrachloride

Table 2: Well Point Water Levels, Altus AFB Phytostabilization Demonstration, Nov 1998

Well Point ID	screened interval below ground surface	water level in feet below ground surface			Final water level
		3 NOV	4 NOV	5 NOV	10 NOV
01HSPSD	16.8-19.8	Dry	16.5	9.5	8.0
02HSPSD	9-12	8.0	Not recorded	not recorded	8.0
03HSPSD	9-12	Dry	11.8	10.3	7.9
04HSPSD	9-12 not sampled		Dry	11.8	8.0
05HSPSD	7-12		Dry	8.3	8.2
06HSPSD	9-12 not sampled		Dry	dry	9.7
07HSPSD	9-12		Dry	8.5	8.3
08HSPSD	8-11		9.6		8.5
09HSPSD	7.9-17.5		Dry	8.5	8.4
10HSPSD	9-18.3		Dry	8.5	8.4
11HSPSD	9-18.3		Dry	16.6	8.0

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

POST OFFICE BOX 2008
OAK RIDGE, TN 37831-6120

PHONE: (423) 574-4861
FAX: (423) 576-7956

INTERNET: SMITHRR1@ORNL.GOV

November 11, 1998

Ms. Kathleen Older
Kansas City Corps of Engineers
USACE EP-GG
Federal Building 601 East 12th St
Kansas City, MO 64106

Kathy,

This is the data packet for the Altus AFB job from November 3 through November 5, 1998. The data is in the usual format including two electronic files on the 3.5" floppy diskette.

I changed a few of the results from what I originally reported in the field. The first being the wells number 8 and 1. The results reported here are substantially less than I reported in the field. The reason for this difference is that my high standard was space charging much worse than I originally thought. Therefore, I felt it would be more accurate to use the next lower standards and extrapolate them out to obtain the well concentrations. I also retracted reporting trichloroethane. Upon reviewing the spectra there just was not enough evidence to factually report its presence.

As always, it's been a pleasure serving the Corps in this regard. Should I be of further assistance then please don't hesitate to ask.

Sincerely,

Rob R. Smith

DSITMS Analysis
Altus AFB
November 3 through November 5, 1998
(results in ppb)

	TCE	DCE	PCE	CHCl3	CCl4	Aromatic
01HSPSD(16.8-19.8)	1,700	350	510	ND	ND	ND
02HSPSD(9-12.0)	250	200	190	ND	ND	ND
03HSPSD(9.0-12.0)	125	79	87	ND	ND	ND
05HSPSD(7.0-12.0)	4,800	2,200	4,800	880	ND	ND
07HSPSD(9.0-12.0)	2,900	1,900	2,000	460	26	ND
08HSPSD(8.0-11.0)	2,700	1,700	5,500	1,100	ND	ND
09HSPSD(9.7-17.5)	280	70	110	39	ND	ND
10HSPSD(9.0-18.6)	4.3	ND	2.4	ND	ND	67
11HSPSD(9.0-18.3)	8.4	ND	2.0	ND	ND	78

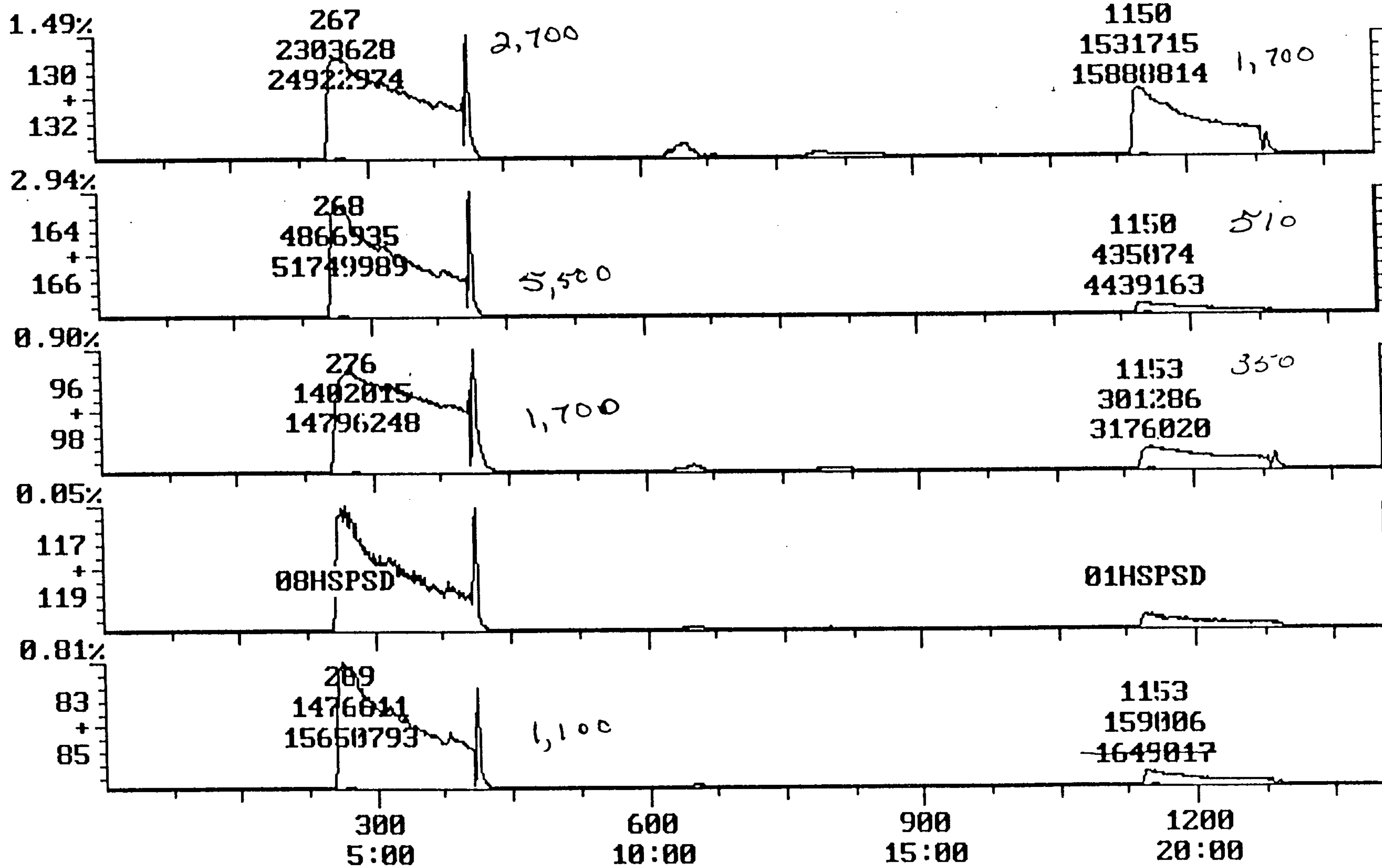
SAMPLE_ID	DATESAMP	TESTNAME	CONC	QUAL	UNITS
01HSPSD(16.8-19.8)	11/04/98	Trichloroethylene	1700	U	ug/L
01HSPSD(16.8-19.8)	11/04/98	1,2-Dichloroethene (Total)	350	U	ug/L
01HSPSD(16.8-19.8)	11/04/98	Tetrachloroethene	510	U	ug/L
01HSPSD(16.8-19.8)	11/04/98	Chloroform	5	J	ug/L
01HSPSD(16.8-19.8)	11/04/98	Carbon Tetrachloride	5	J	ug/L
02HSPSD	11/03/98	Trichloroethylene	250	U	ug/L
02HSPSD	11/03/98	1,2-Dichloroethene (Total)	200	U	ug/L
02HSPSD	11/03/98	Tetrachloroethene	190	U	ug/L
02HSPSD	11/03/98	Chloroform	5	J	ug/L
02HSPSD	11/03/98	Carbon Tetrachloride	5	J	ug/L
03HSPSD(9.0-12.0)	11/05/98	Trichloroethylene	125	U	ug/L
03HSPSD(9.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	79	U	ug/L
03HSPSD(9.0-12.0)	11/05/98	Tetrachloroethene	87	U	ug/L
03HSPSD(9.0-12.0)	11/05/98	Chloroform	5	J	ug/L
03HSPSD(9.0-12.0)	11/05/98	Carbon Tetrachloride	5	J	ug/L
05HSPSD(7.0-12.0)	11/05/98	Trichloroethylene	4800	U	ug/L
05HSPSD(7.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	2200	U	ug/L
05HSPSD(7.0-12.0)	11/05/98	Tetrachloroethene	4800	U	ug/L
05HSPSD(7.0-12.0)	11/05/98	Chloroform	880	U	ug/L
05HSPSD(7.0-12.0)	11/05/98	Carbon Tetrachloride	5	J	ug/L
07HSPSD(9.0-12.0)	11/05/98	Trichloroethylene	2900	U	ug/L
07HSPSD(9.0-12.0)	11/05/98	1,2-Dichloroethene (Total)	1900	U	ug/L
07HSPSD(9.0-12.0)	11/05/98	Tetrachloroethene	2000	U	ug/L
07HSPSD(9.0-12.0)	11/05/98	Chloroform	460	U	ug/L
07HSPSD(9.0-12.0)	11/05/98	Carbon Tetrachloride	26	U	ug/L
08HSPSD(8.0-11.0)	11/04/98	Trichloroethylene	2700	U	ug/L
08HSPSD(8.0-11.0)	11/04/98	1,2-Dichloroethene (Total)	1700	U	ug/L
08HSPSD(8.0-11.0)	11/04/98	Tetrachloroethene	5500	U	ug/L
08HSPSD(8.0-11.0)	11/04/98	Chloroform	1100	U	ug/L
08HSPSD(8.0-11.0)	11/04/98	Carbon Tetrachloride	5	J	ug/L
09HSPSD(9.7-17.5)	11/05/98	Trichloroethylene	280	U	ug/L
09HSPSD(9.7-17.5)	11/05/98	1,2-Dichloroethene (Total)	70	U	ug/L
09HSPSD(9.7-17.5)	11/05/98	Tetrachloroethene	110	U	ug/L
09HSPSD(9.7-17.5)	11/05/98	Chloroform	39	U	ug/L
09HSPSD(9.7-17.5)	11/05/98	Carbon Tetrachloride	5	J	ug/L
10HSPSD(9.0-18.6)	11/05/98	Trichloroethylene	4.3	U	ug/L
10HSPSD(9.0-18.6)	11/05/98	1,2-Dichloroethene (Total)	5	J	ug/L
10HSPSD(9.0-18.6)	11/05/98	Tetrachloroethene	2.4	U	ug/L
10HSPSD(9.0-18.6)	11/05/98	Chloroform	5	J	ug/L
10HSPSD(9.0-18.6)	11/05/98	Aromatic	67	U	ug/L
11HSPSD(9.0-18.3)	11/05/98	Trichloroethylene	8.4	U	ug/L
11HSPSD(9.0-18.3)	11/05/98	1,2-Dichloroethene (Total)	5	J	ug/L
11HSPSD(9.0-18.3)	11/05/98	Tetrachloroethene	2.0	U	ug/L
11HSPSD(9.0-18.3)	11/05/98	Chloroform	5	J	ug/L
11HSPSD(9.0-18.3)	11/05/98	Aromatic	78	U	ug/L

Chromatogram Plot C:\MAGNUM\DATA\~~11039801~~ 11049801 Date: 11/04/98 10:35:20

Comment: 08HSPSD(8.0-11.0) & 01HSPSD(16.8-19.8)

Scan No: 1400 Retention Time: 23:20 RIC: 280 Mass Range: 59 - 197

Plotted: 1 to 1400 Range: 1 to 2203 100% = 186838449



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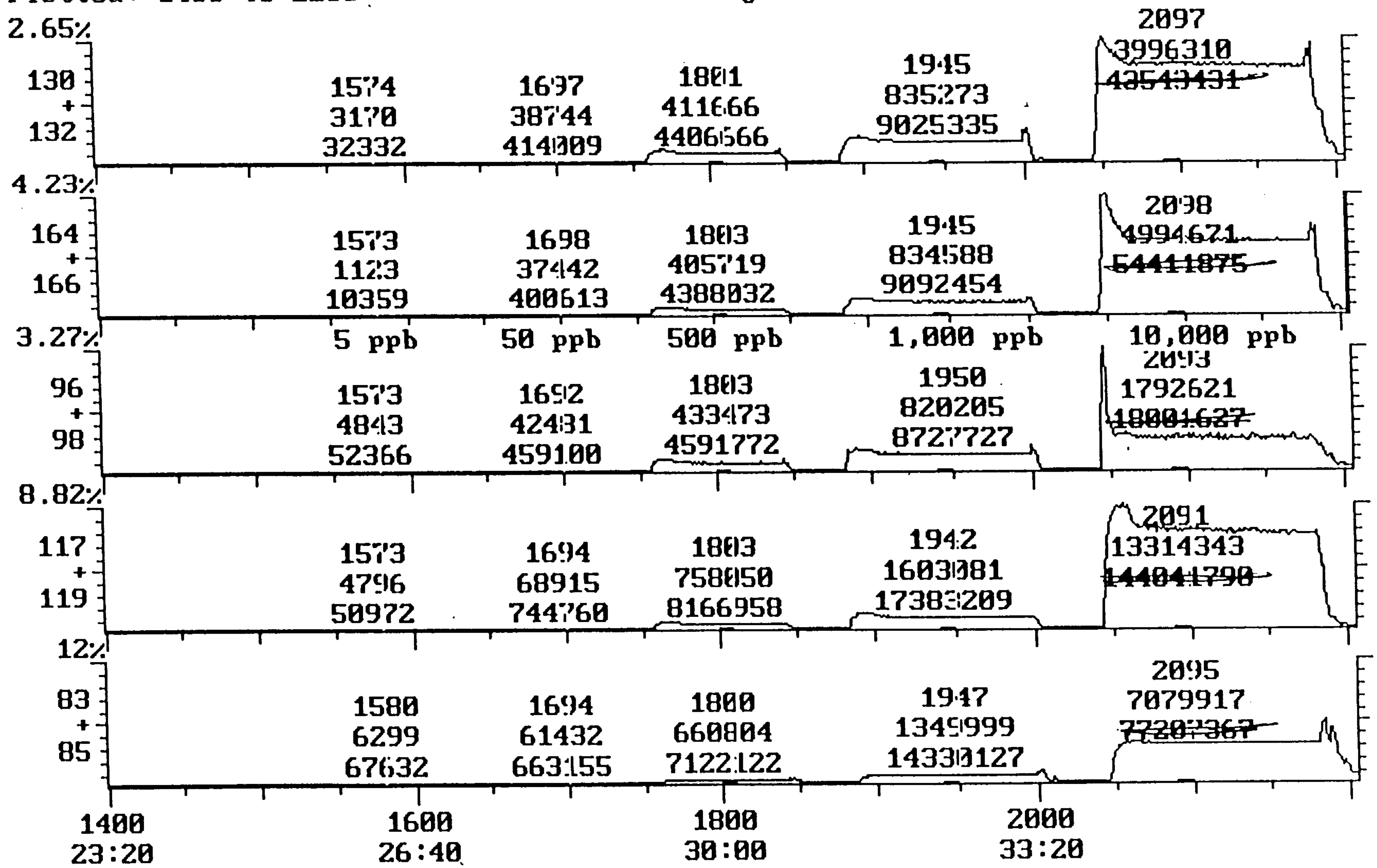
Plotted: 1400 to 2203 Range: 1 to 2203 100% = 186838449



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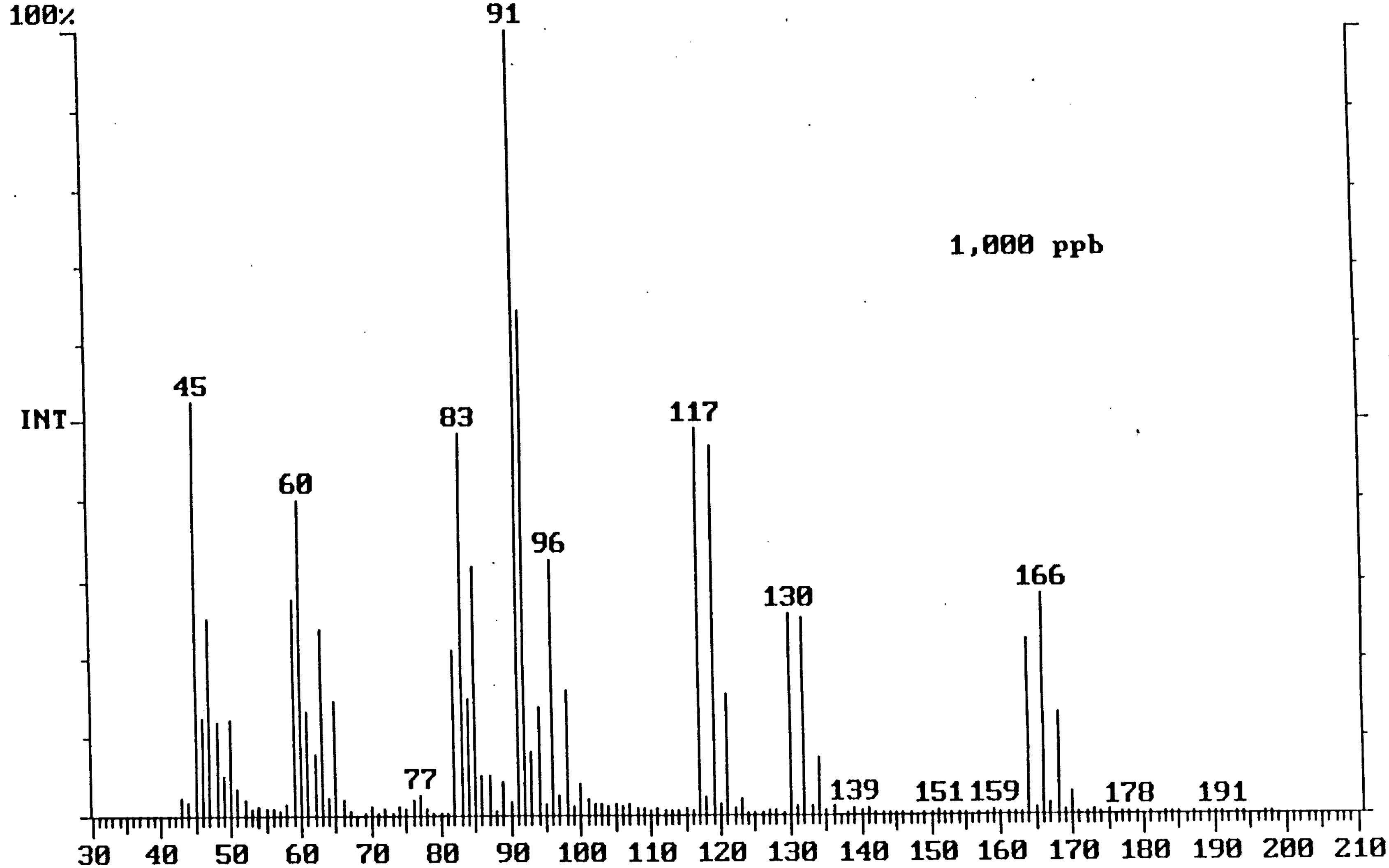
Peaks: 144 Base Pk: 91 Ioniz: 73 us Int: 1643150 100.00% = 1643150



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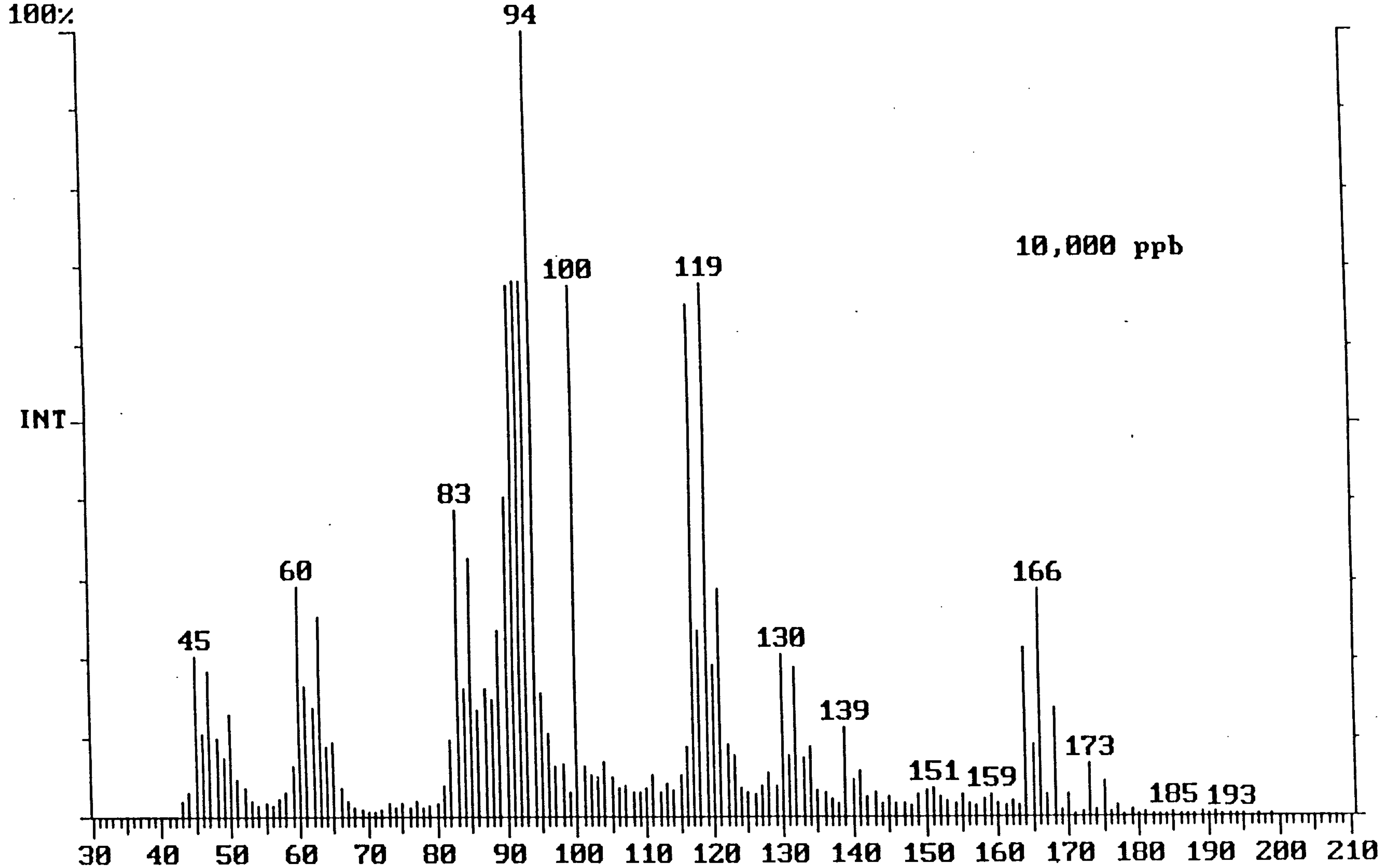

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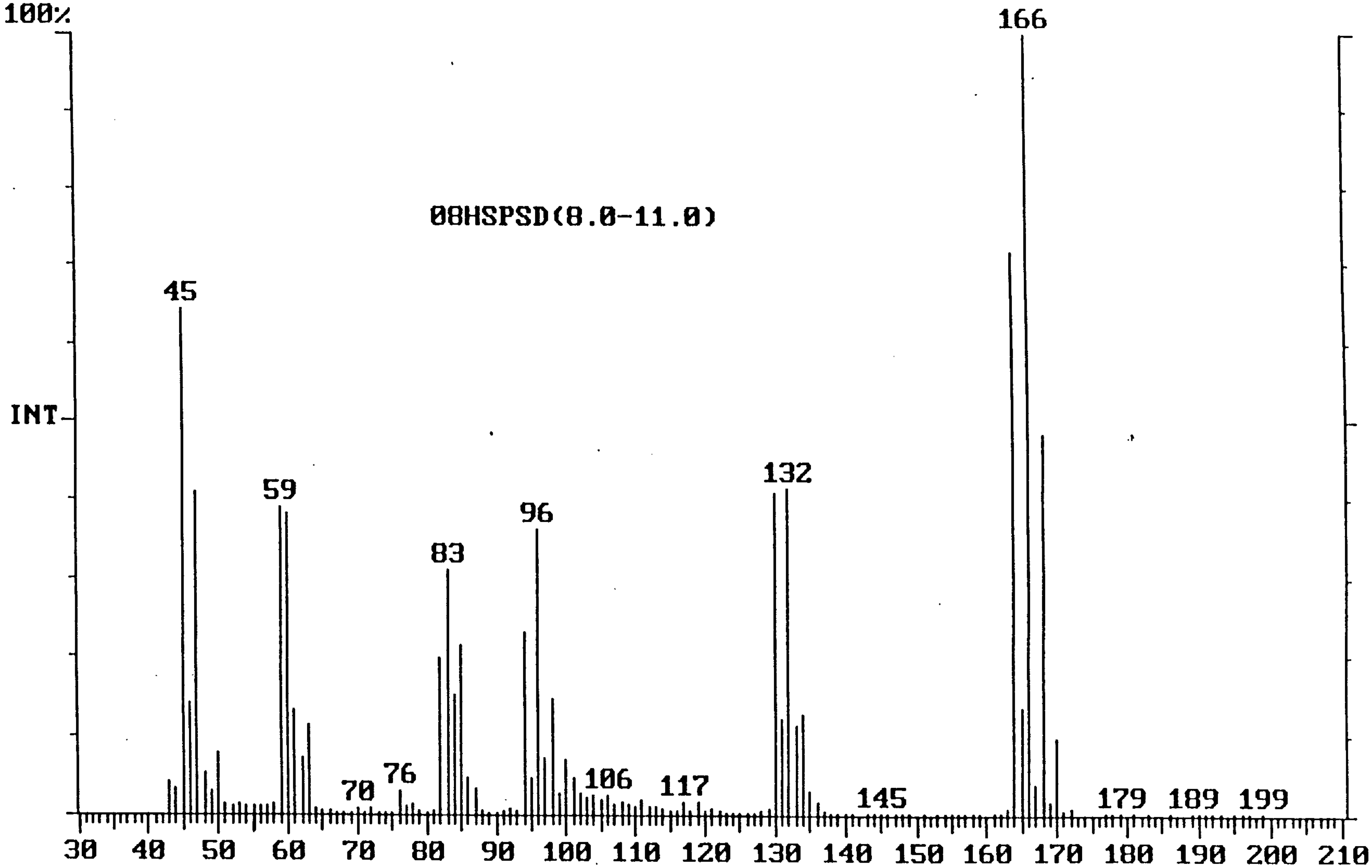
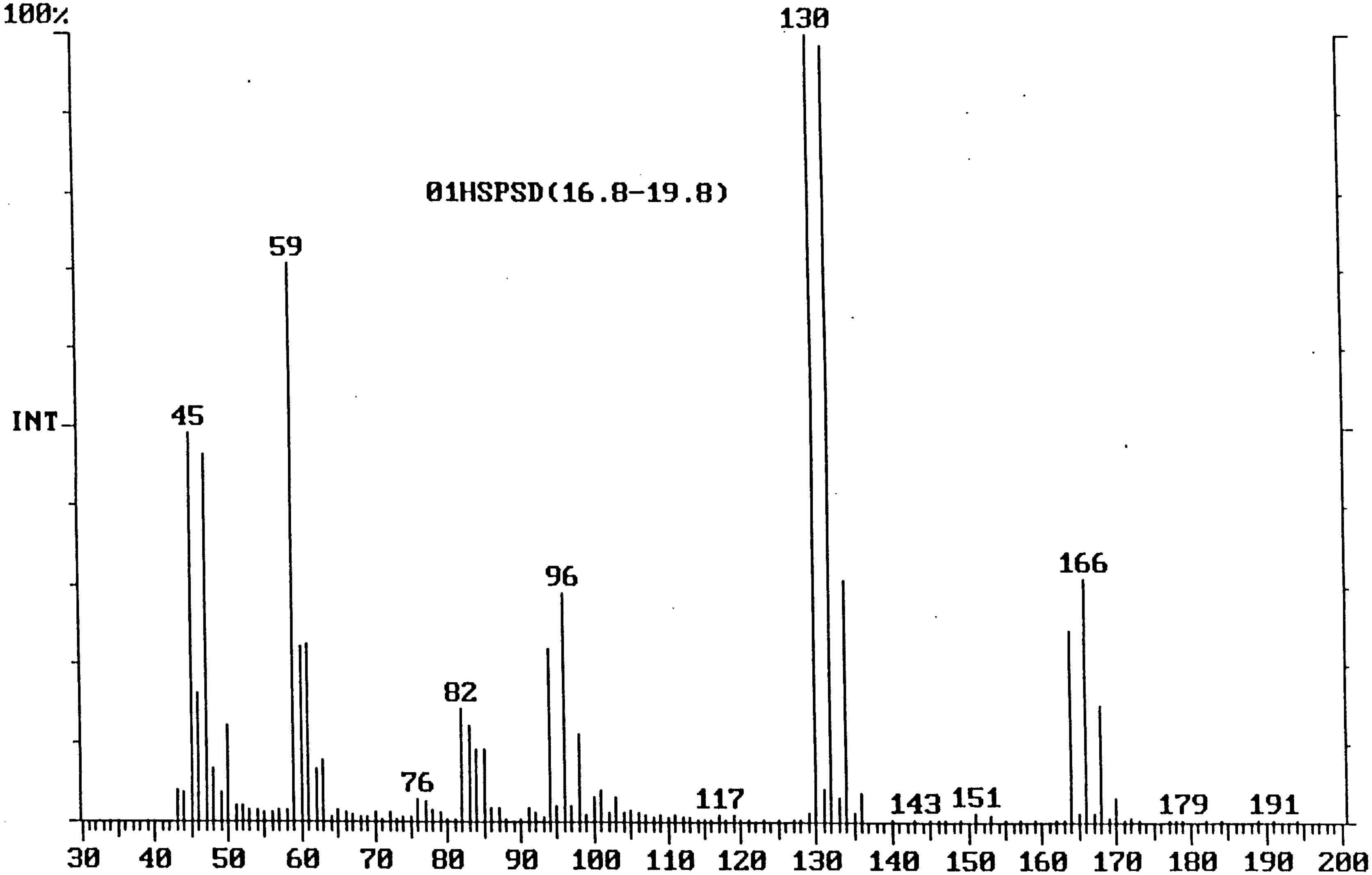
Peaks: 141 Base Pk: 166 Ioniz: 62 us Int: 2746370 100.00% = 2746370



Spectrum Plot C:\MAGNUM\DATA\~~11039001~~ 11042801 Date: 11/04/98 10:35:20
Comment: 08HSPSD(8.0-11.0) & 01HSPSD(16.8-19.8)
Scan No: 1153 Retention Time: 19:13 RIC: 5700493 Mass Range: 43 - 194
Peaks: 121 Base Pk: 130 Ioniz: 136 us Int: 756066 100.00% = 756066



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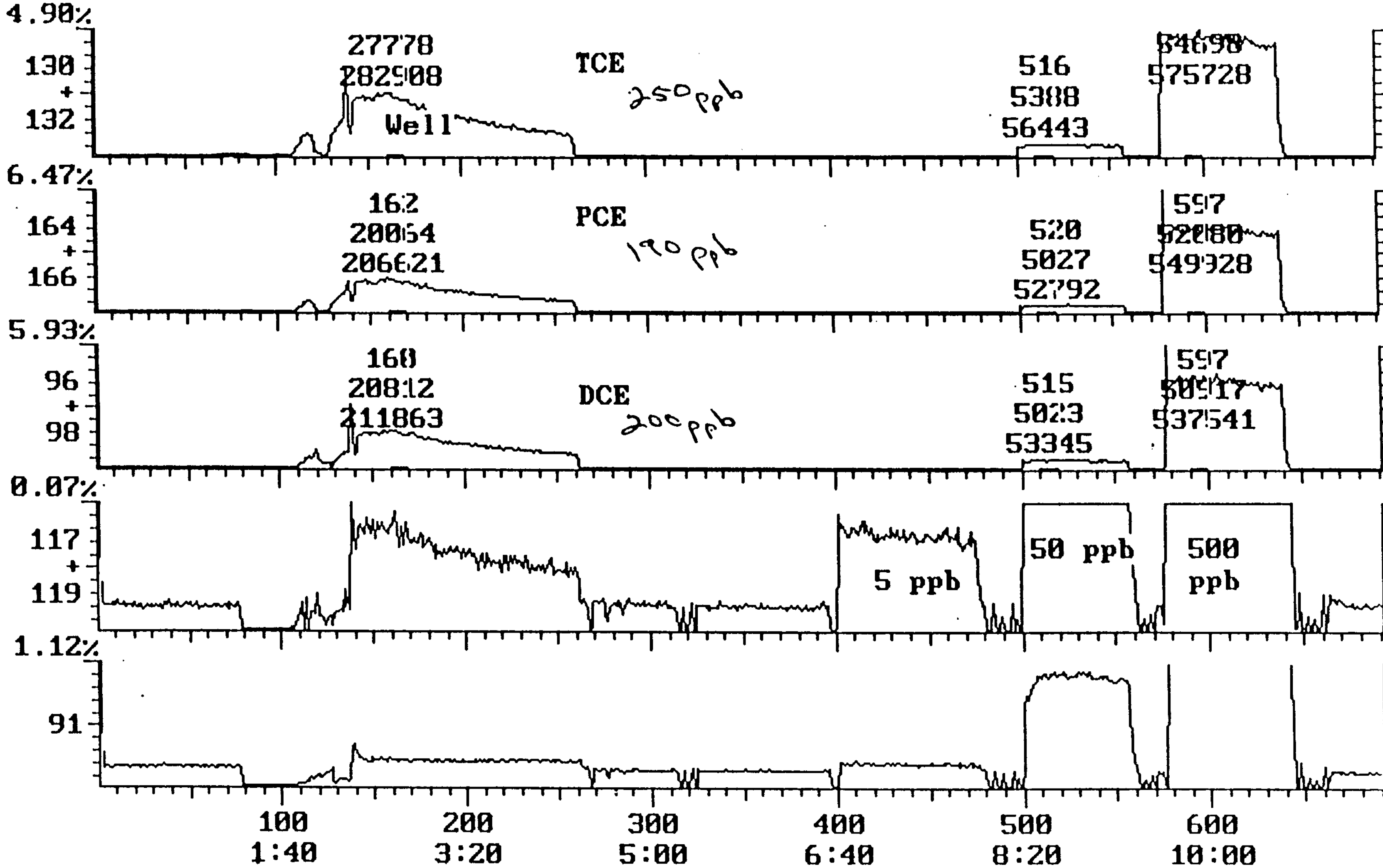
Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0
Plotted: 1 to 690 Range: 1 to 690 100% = 1115334



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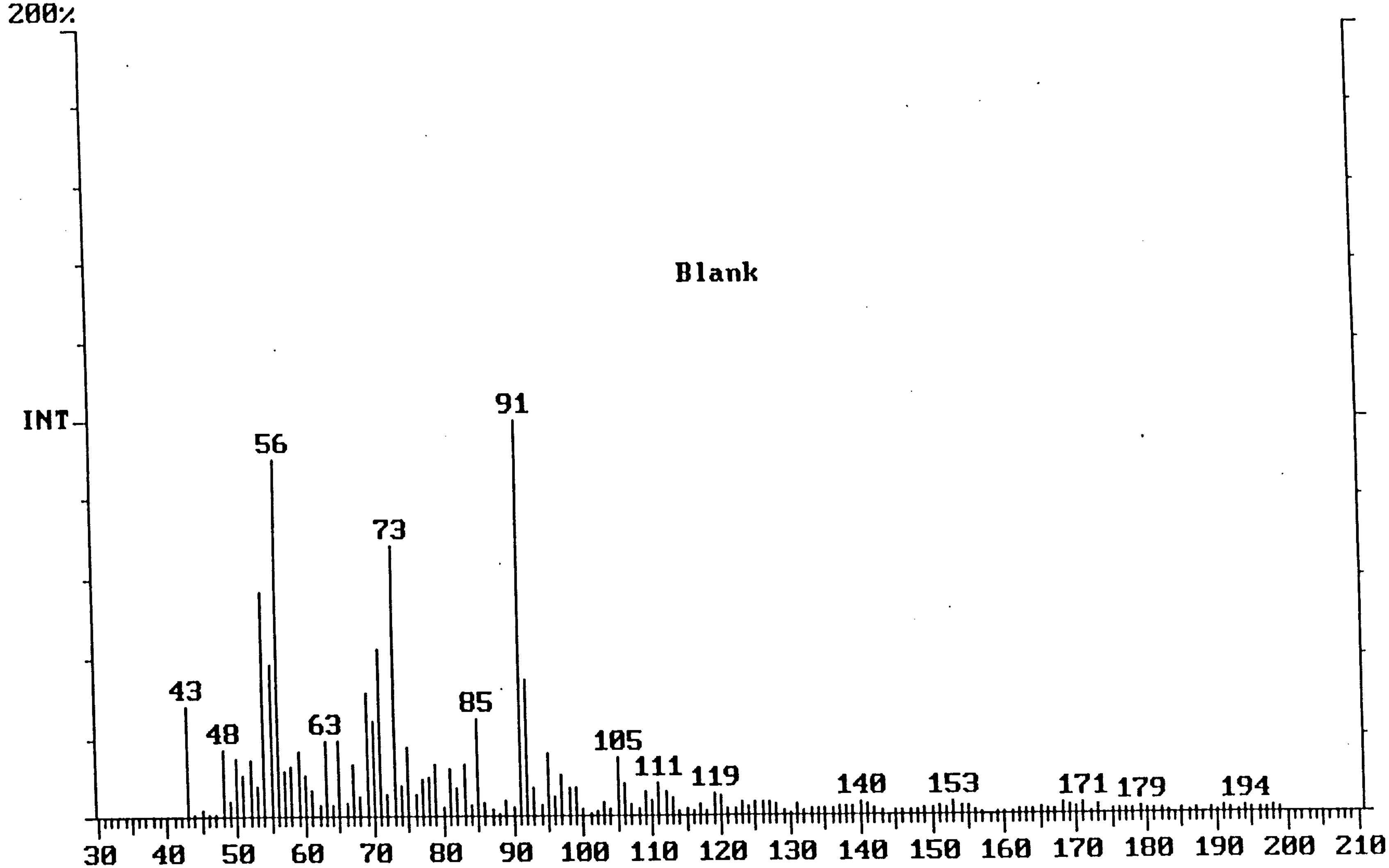

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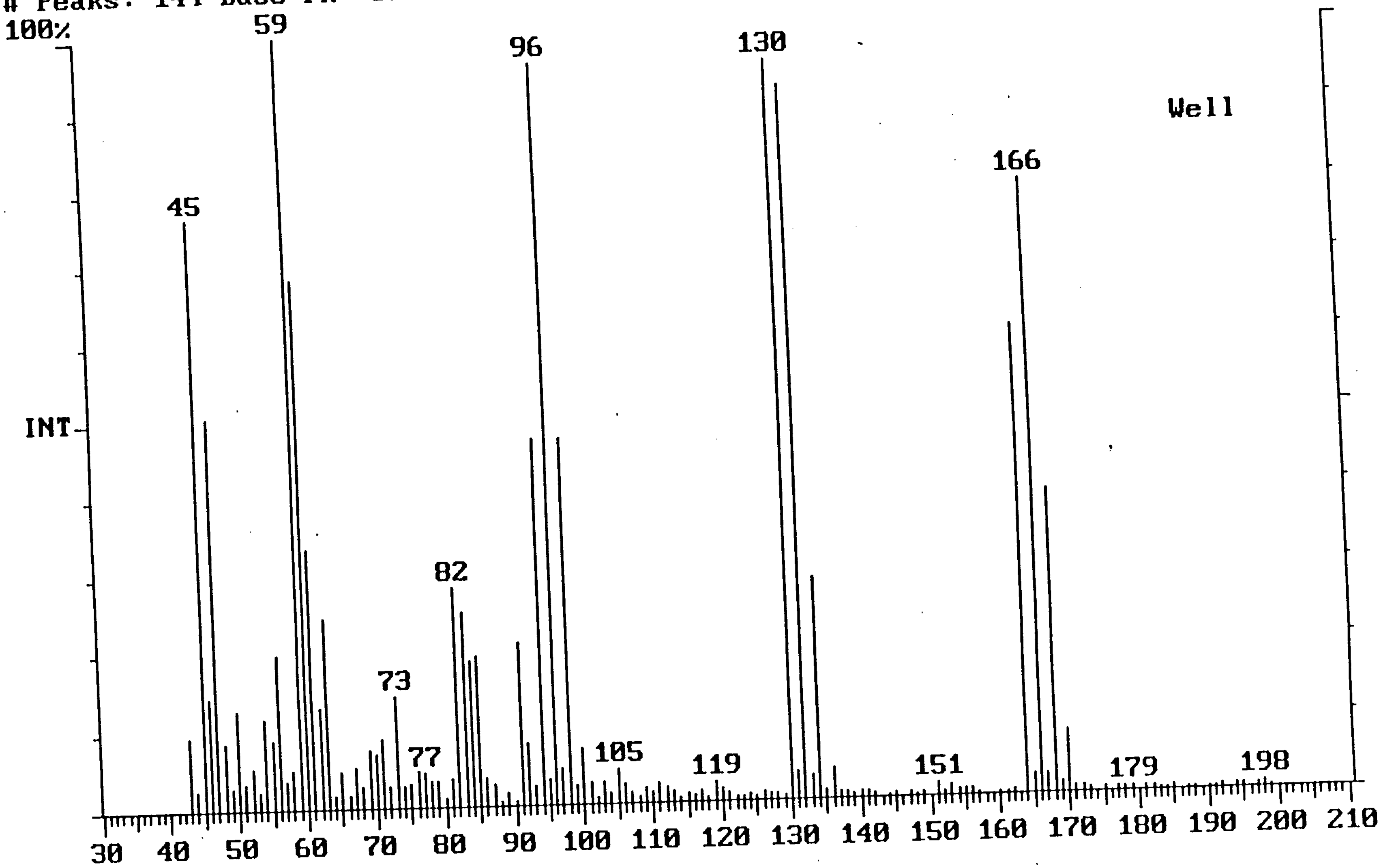

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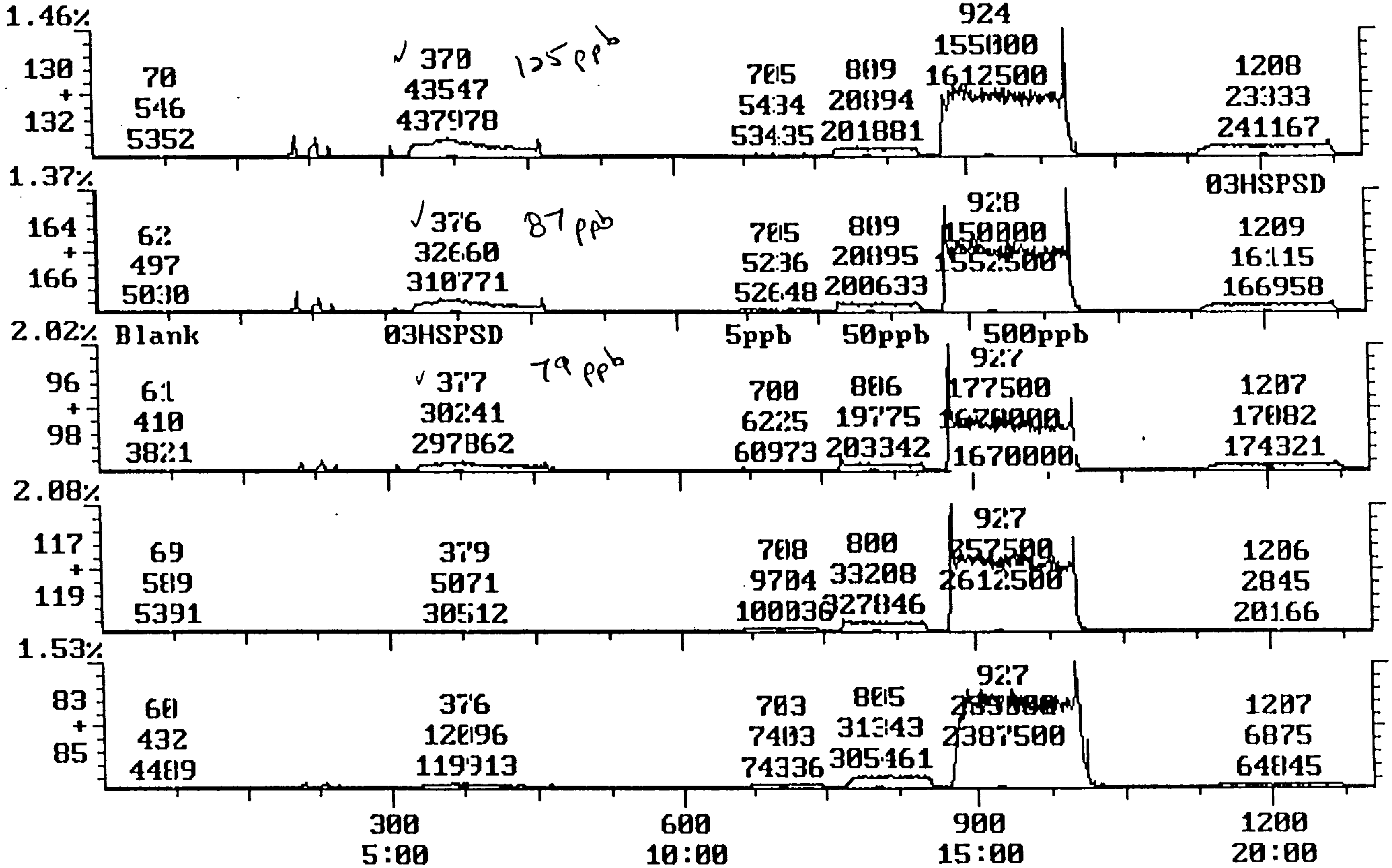
Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0
Plotted: 1 to 1300 Range: 1 to 2589 100% = 21035000



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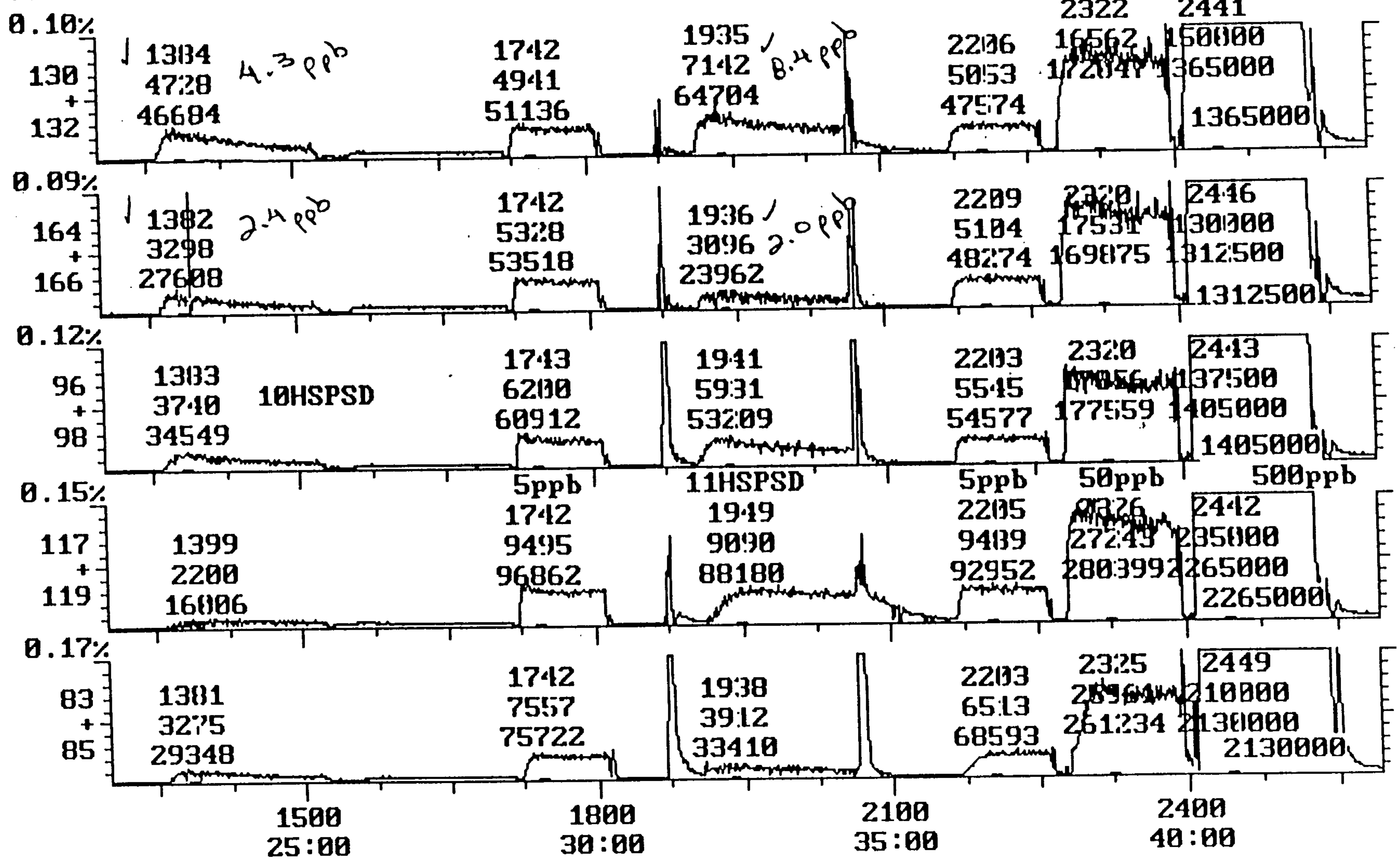
Scan No: 1380 Retention Time: 23:00 RIC: 190645 Mass Range: 44 - 197
Plotted: 1300 to 2589 Range: 1 to 2589 100% = 21035000



Chromatogram Plot C:\...\ALTUS\11_05_98\11059805 11/05/98 11:15:20
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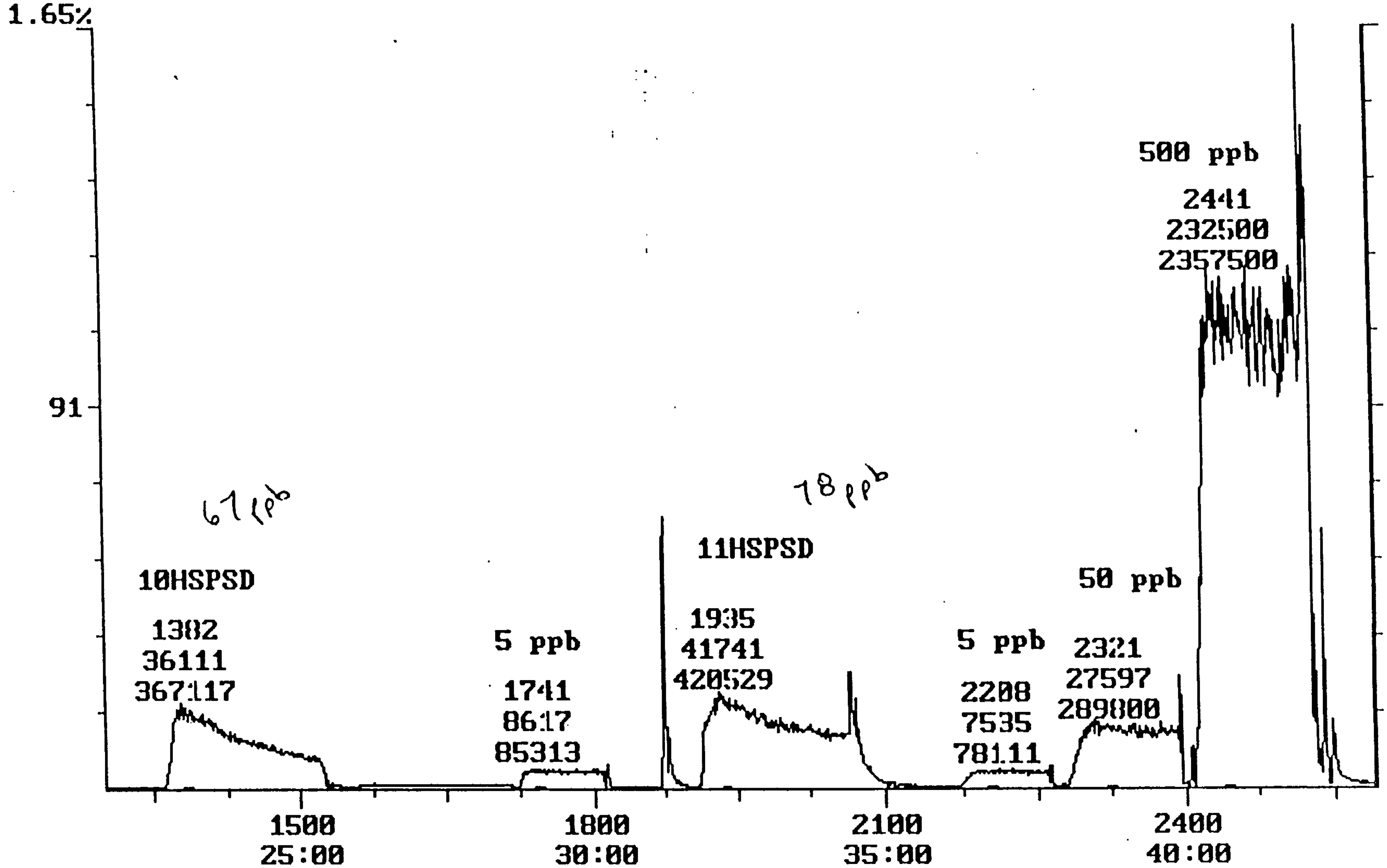
Scan No: 2589 Retention Time: 43:09 RIC: 19726 Mass Range: 43 - 198
Plotted: 1300 to 2589 Range: 1 to 2589 100% = 21035000



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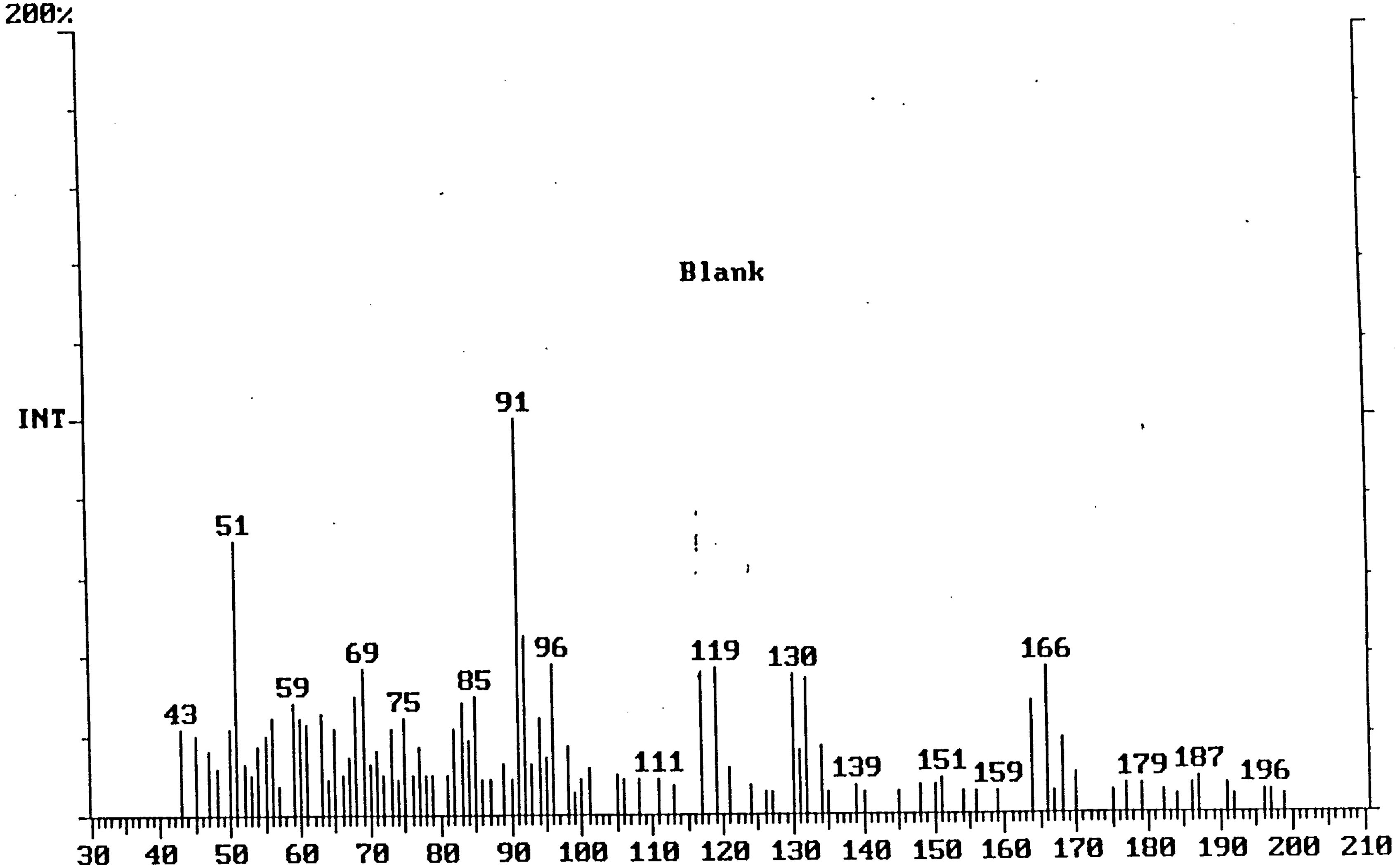
Scan No: 64 Retention Time: 1:04 RIC: 11155 Mass Range: 43 - 199
Peaks: 93 Base Pk: 91 Ioniz: 2382 us Int: 745 200.00% = 1490



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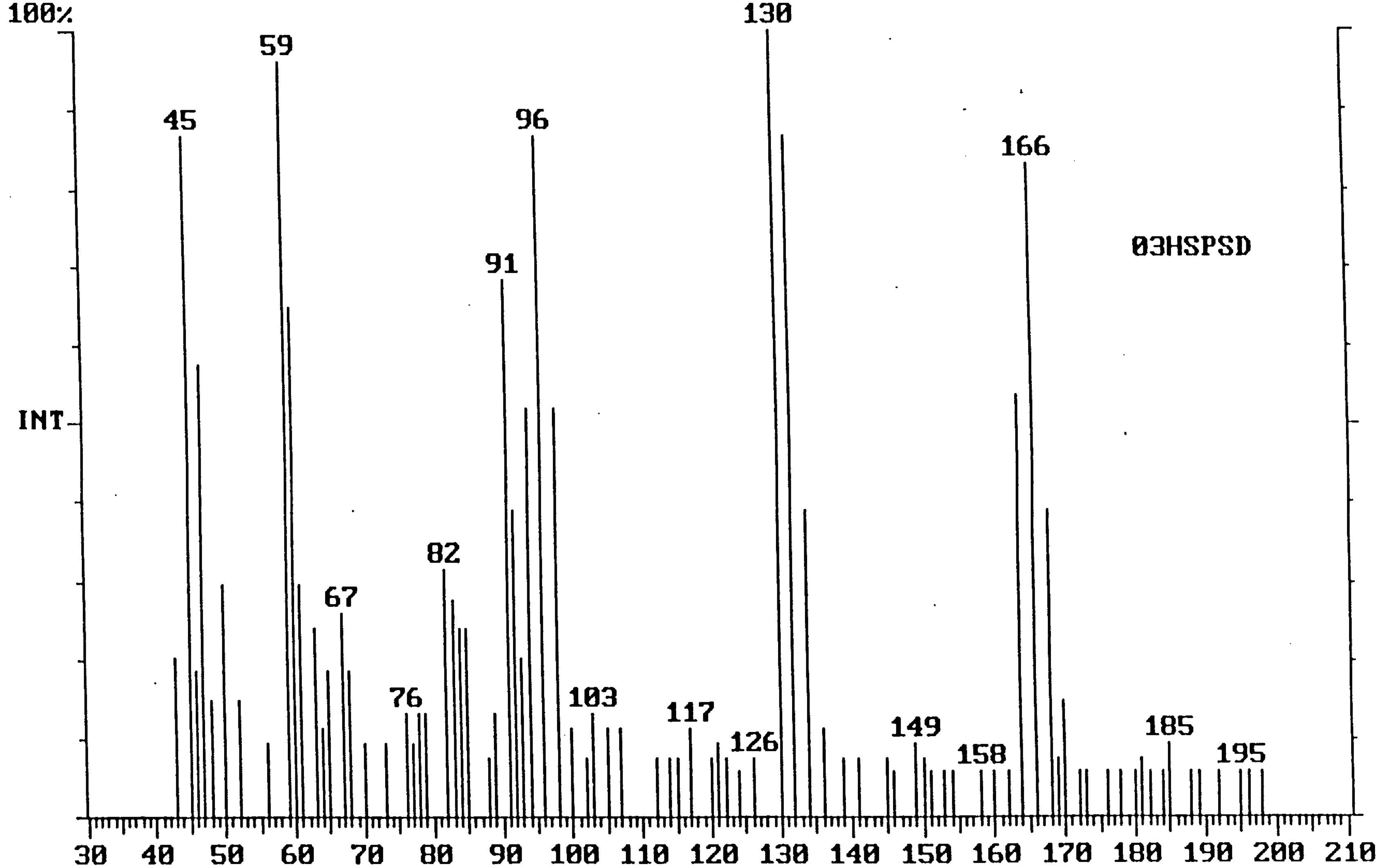
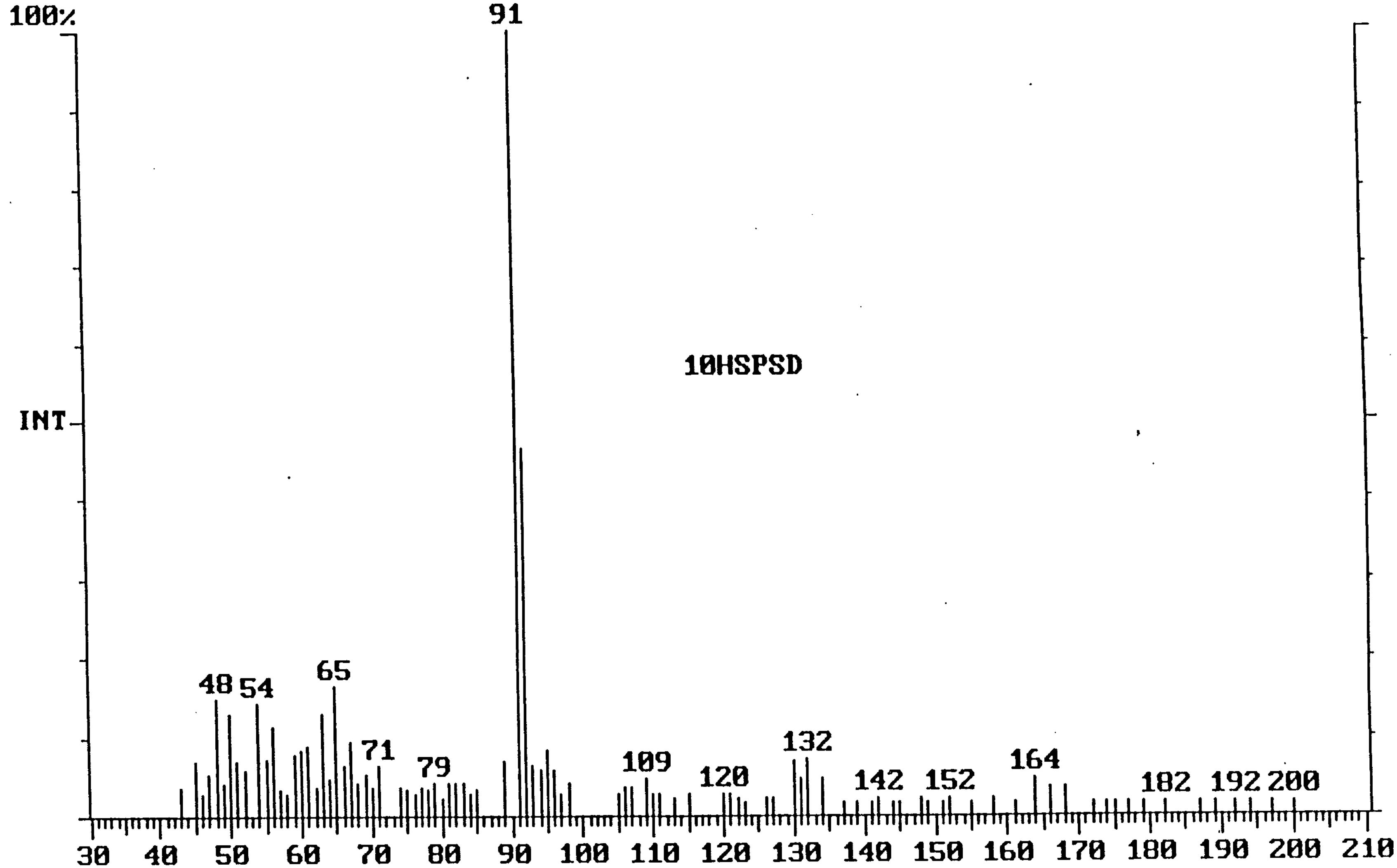
Scan No: 367 Retention Time: 6:07 RIC: 375348 Mass Range: 43 - 198
Peaks: 84 Base Pk: 130 Ioniz: 64 us Int: 21093 100.00% = 21093



Spectrum Plot   C:\...\ALTUS\11_05_98\11059805   11/05/98   11:15:20
Comment: 03HSPSD(9.0-12.0); 10HSPSD(9.0-18.6); 11HSPSD(9.0-18.3)
Scan No: 1385   Retention Time: 23:05   RIC: 179960   Mass Range: 43 - 200
Peaks: 94   Base Pk: 91   Ioniz: 145 us   Int: 33793   100.00% = 33793



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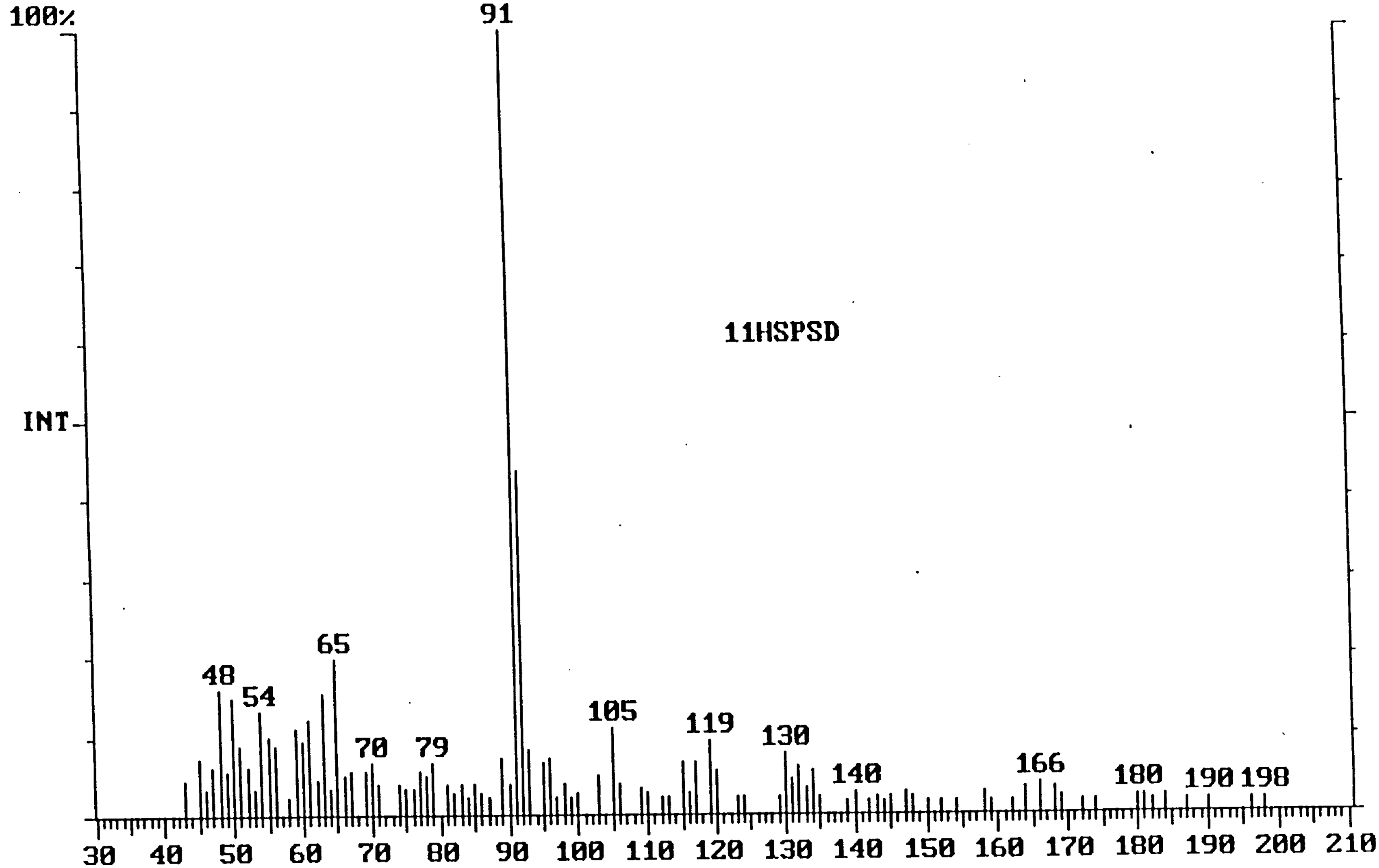
Scan No: 1939 Retention Time: 32:19 RIC: 236816 Mass Range: 43 - 198
Peaks: 99 Base Pk: 91 Ioniz: 116 us Int: 39439 100.00% = 39439



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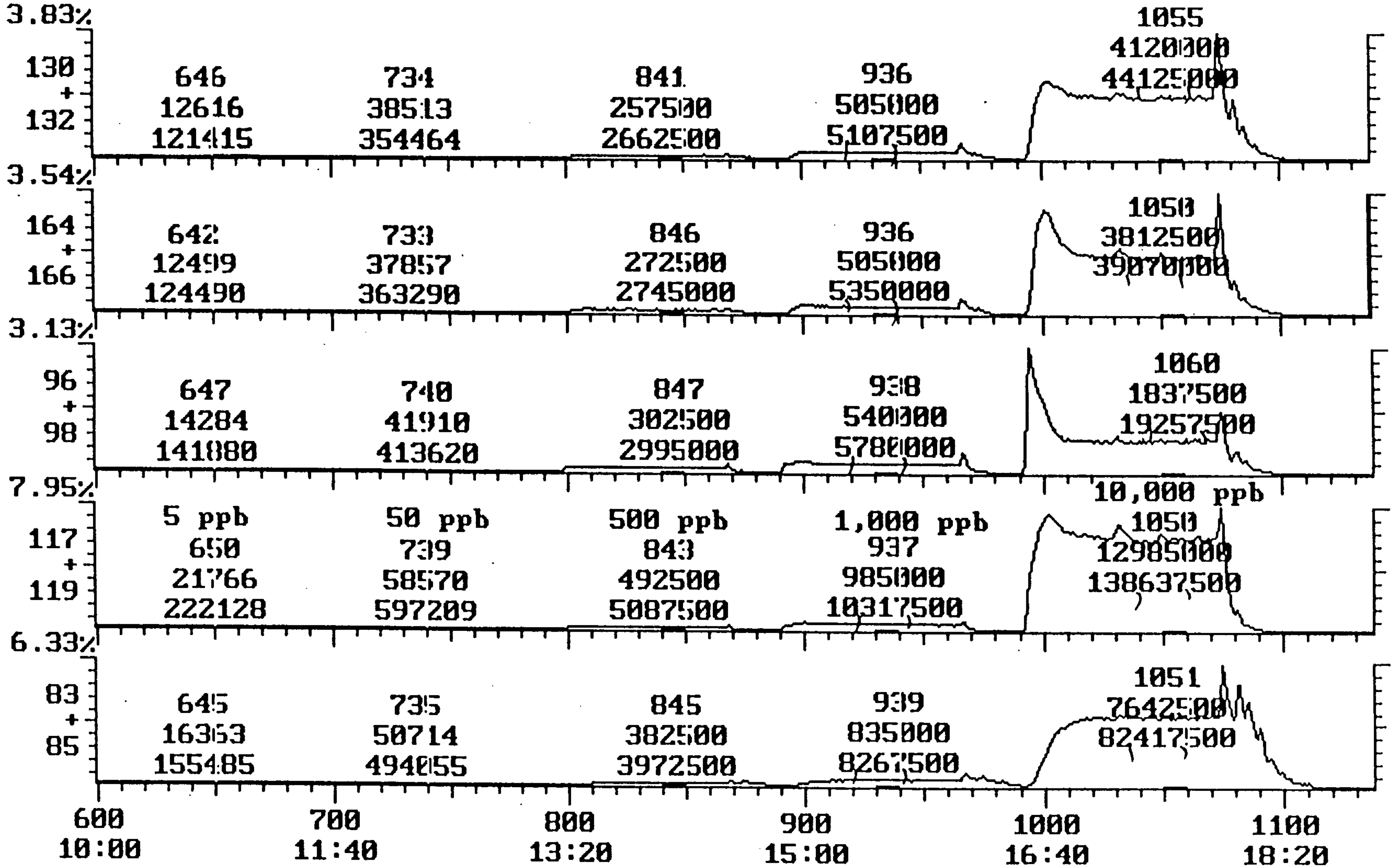
Comment: 05HSPSD(7.0-12.0)
Scan No: 1136 Retention Time: 18:56 RIC: 377301 0 ass Range: 44 - 197
Plotted: 600 to 1136 Range: 1 to 1136 100% = 208935000



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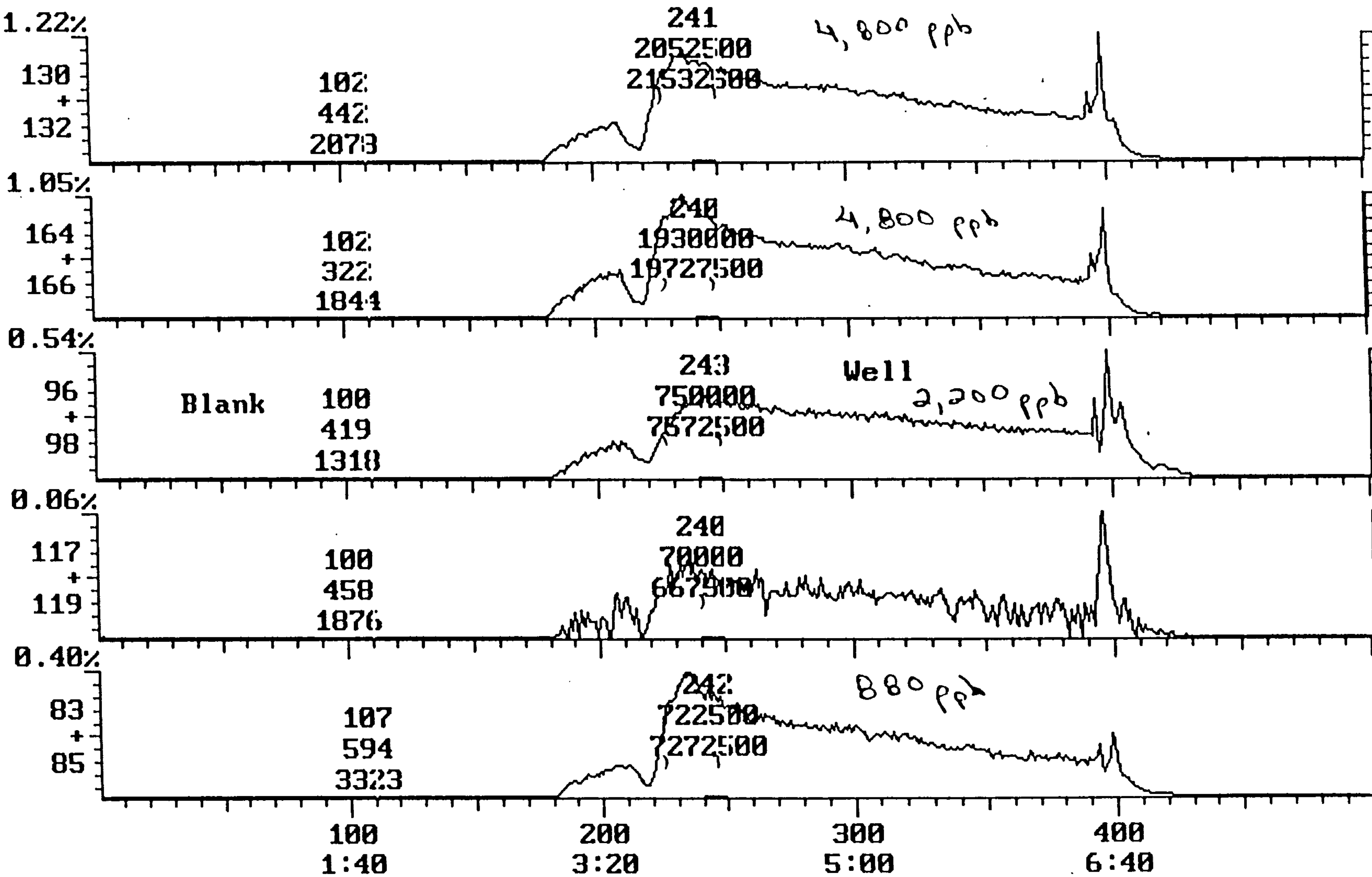
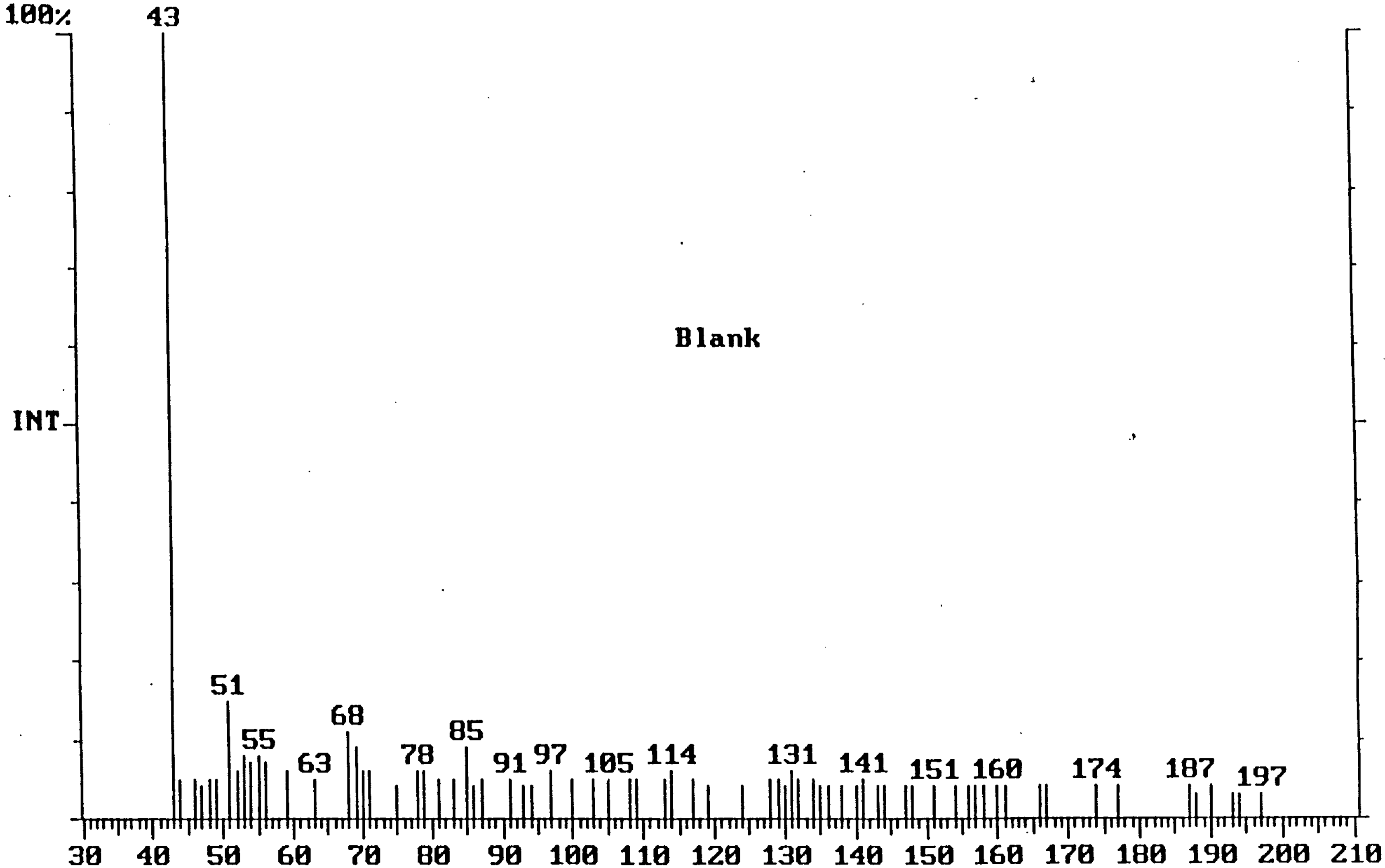
Comment: 05HSPSD(7.0-12.0)
Scan No: 500 Retention Time: 8:20 RIC: 34255 Mass Range: 43 - 199
Plotted: 1 to 500 Range: 1 to 1136 100% = 208935000



Spectrum Plot C:\MAGNUM\DATA\11059801 Date: 11/05/98 07:45:30
Comment: 05HSPSD(7.0-12.0)
Scan No: 111 Retention Time: 1:51 RIC: 15720 Mass Range: 43 - 197
Peaks: 72 Base Pk: 43 Ioniz: 733 us Int: 3444 100.00% = 3444



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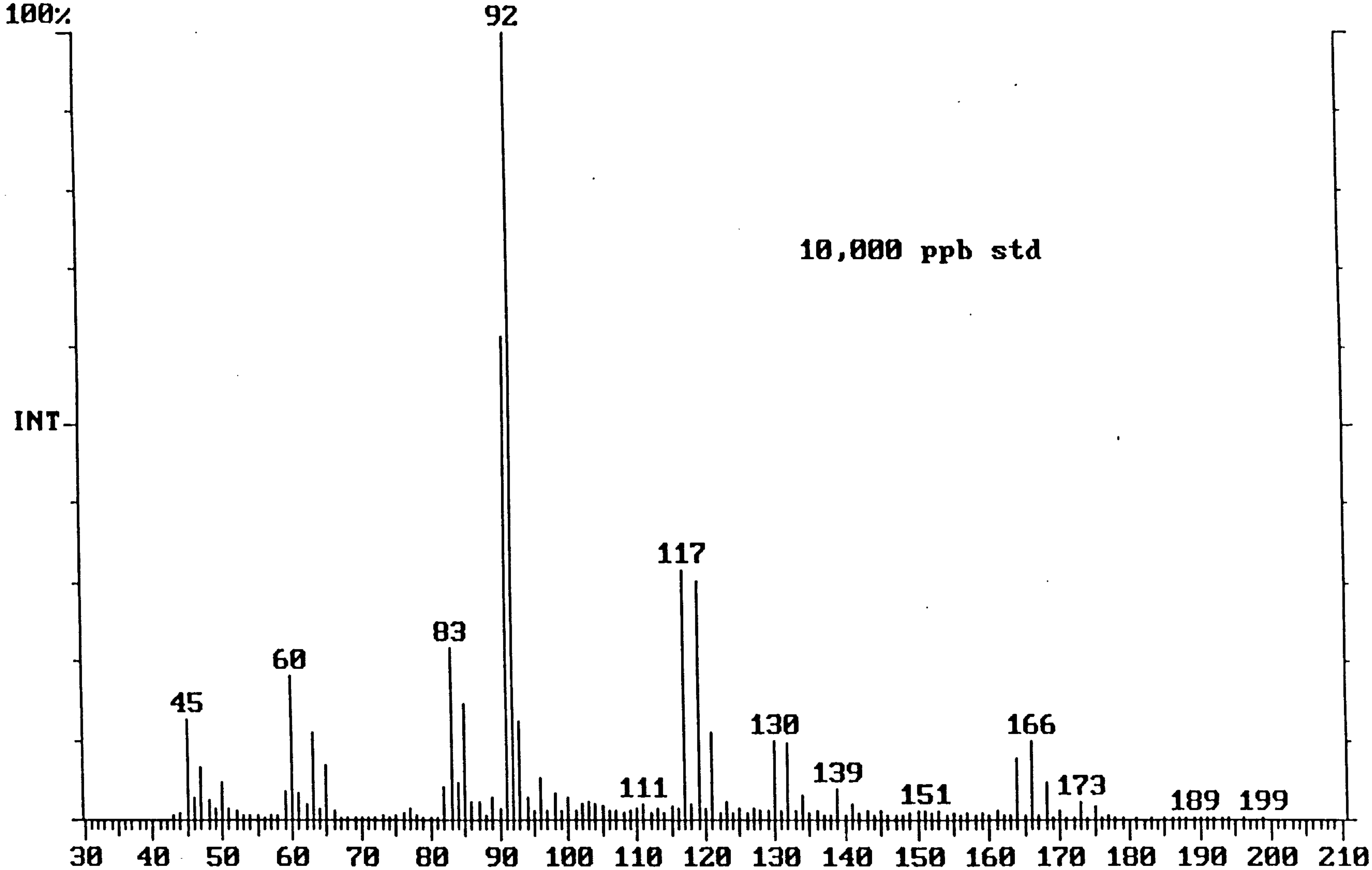
Comment: 05HSPSD(7.0-12.0)
Scan No: 1025 Retention Time: 17:05 RIC: 104532500 ass Range: 43 - 199
Peaks: 151 Base Pk: 92 Ioniz: 10 us Int: 20470000 100.00% = 20470000



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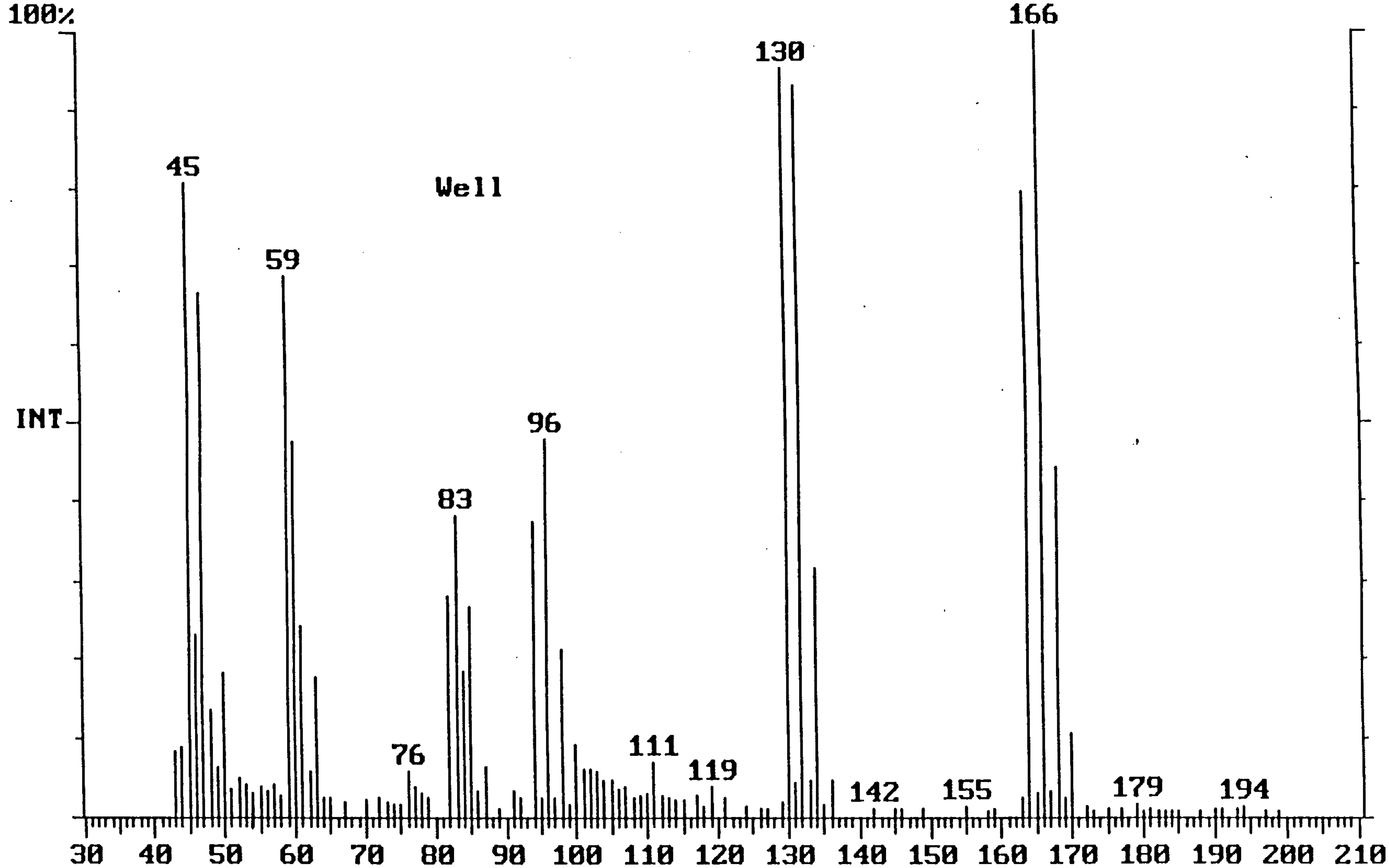
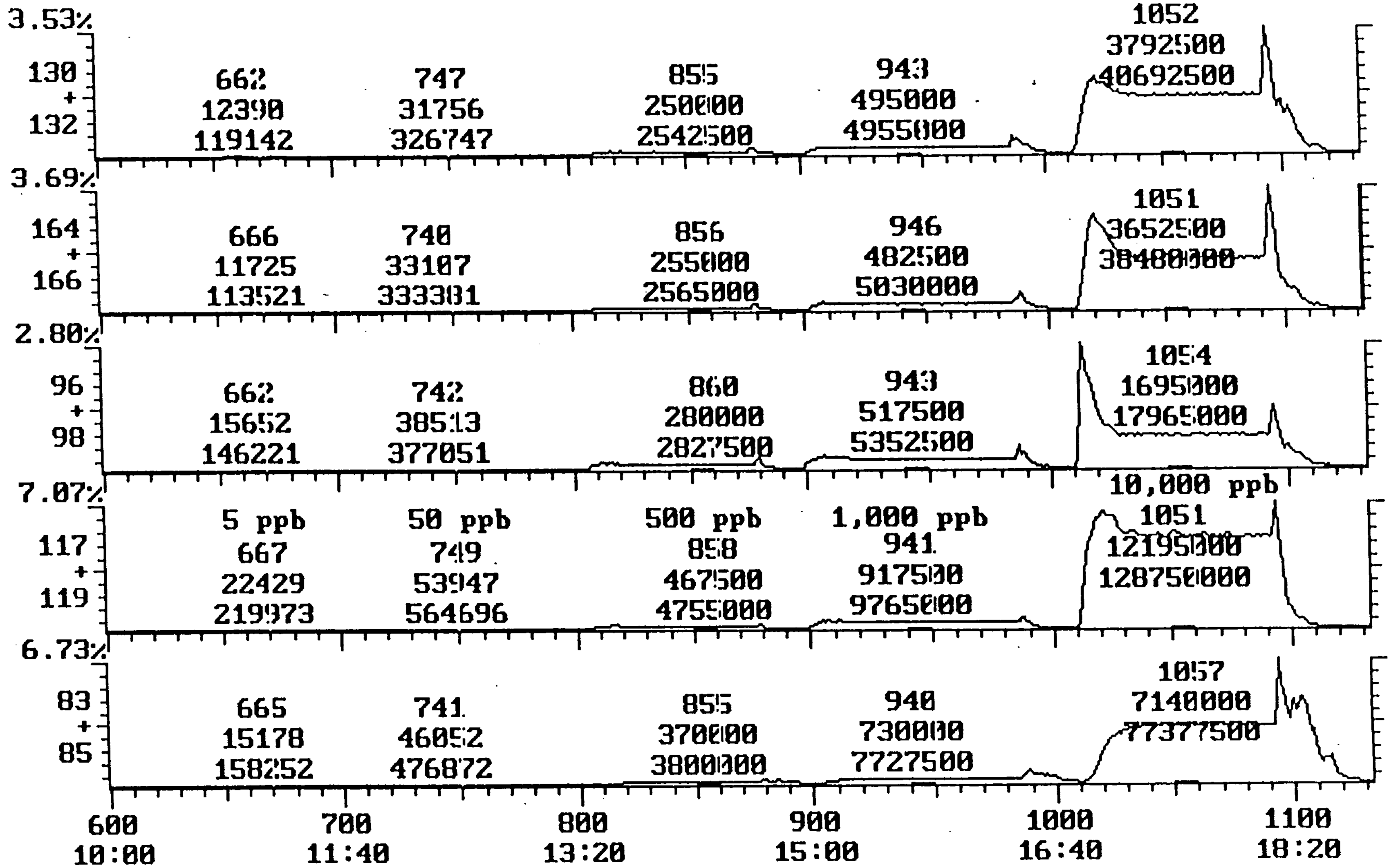
Comment: 05HSPSD(7.0-12.0)
Scan No: 244 Retention Time: 4:04 RIC: 12950000 Mass Range: 43 - 199
Peaks: 112 Base Pk: 166 Ioniz: 10 us Int: 1020000 100.00% = 1020000



Chromatogram Plot C:\MAGNUM\DATA\11059802 Date: 11/05/98 08:09:53
Comment: 07HSPSD(9.0-12.0)
Scan No: 1131 Retention Time: 18:51 RIC: 1247335 Mass Range: 43 - 198
Plotted: 600 to 1131 Range: 1 to 1131 100% = 221987500



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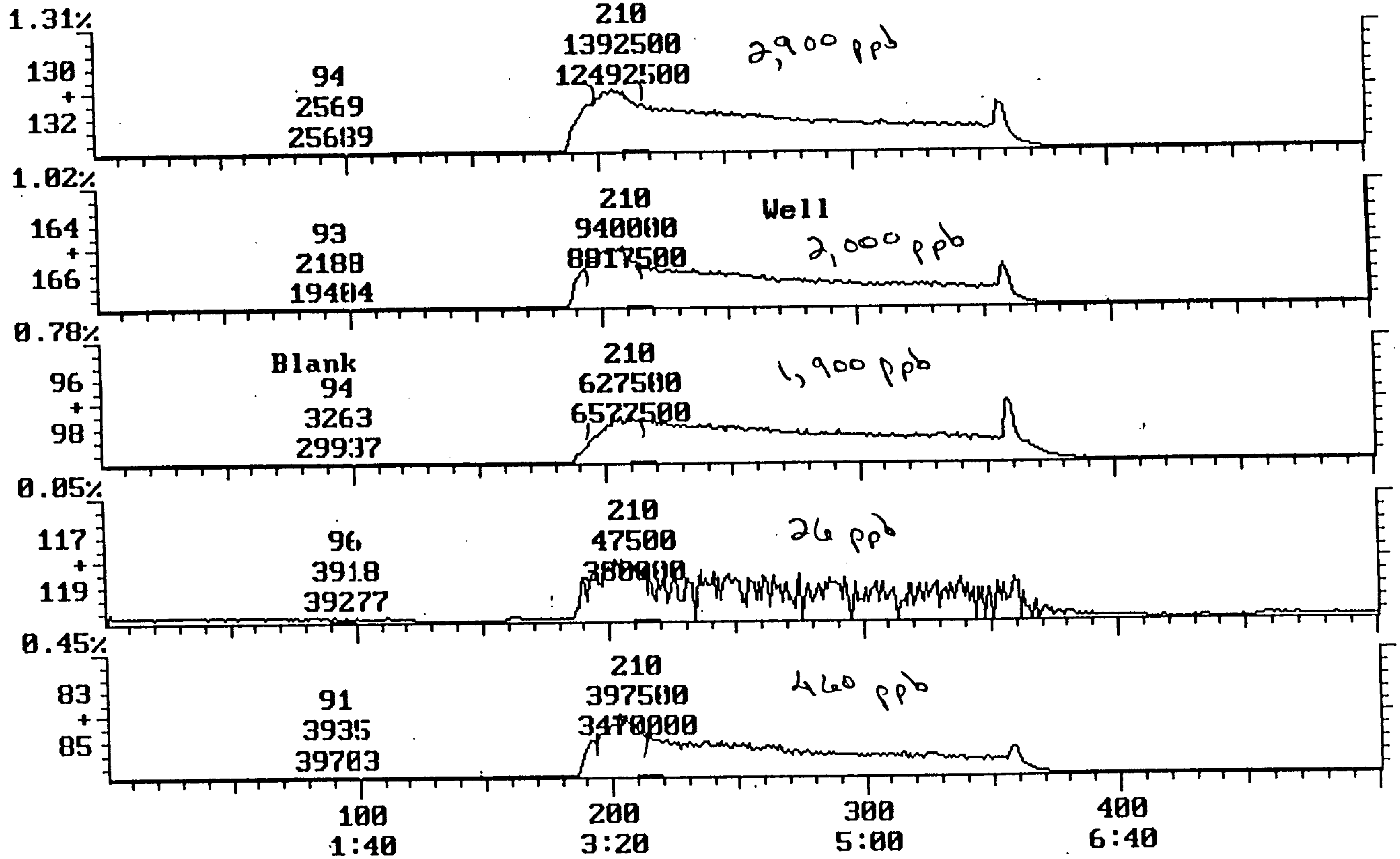
Comment: 07HSPSD(9.0-12.0)
Scan No: 500 Retention Time: 8:20 RIC: 54214 Mass Range: 43 - 197
Plotted: 1 to 500 Range: 1 to 1131 100% = 221987500



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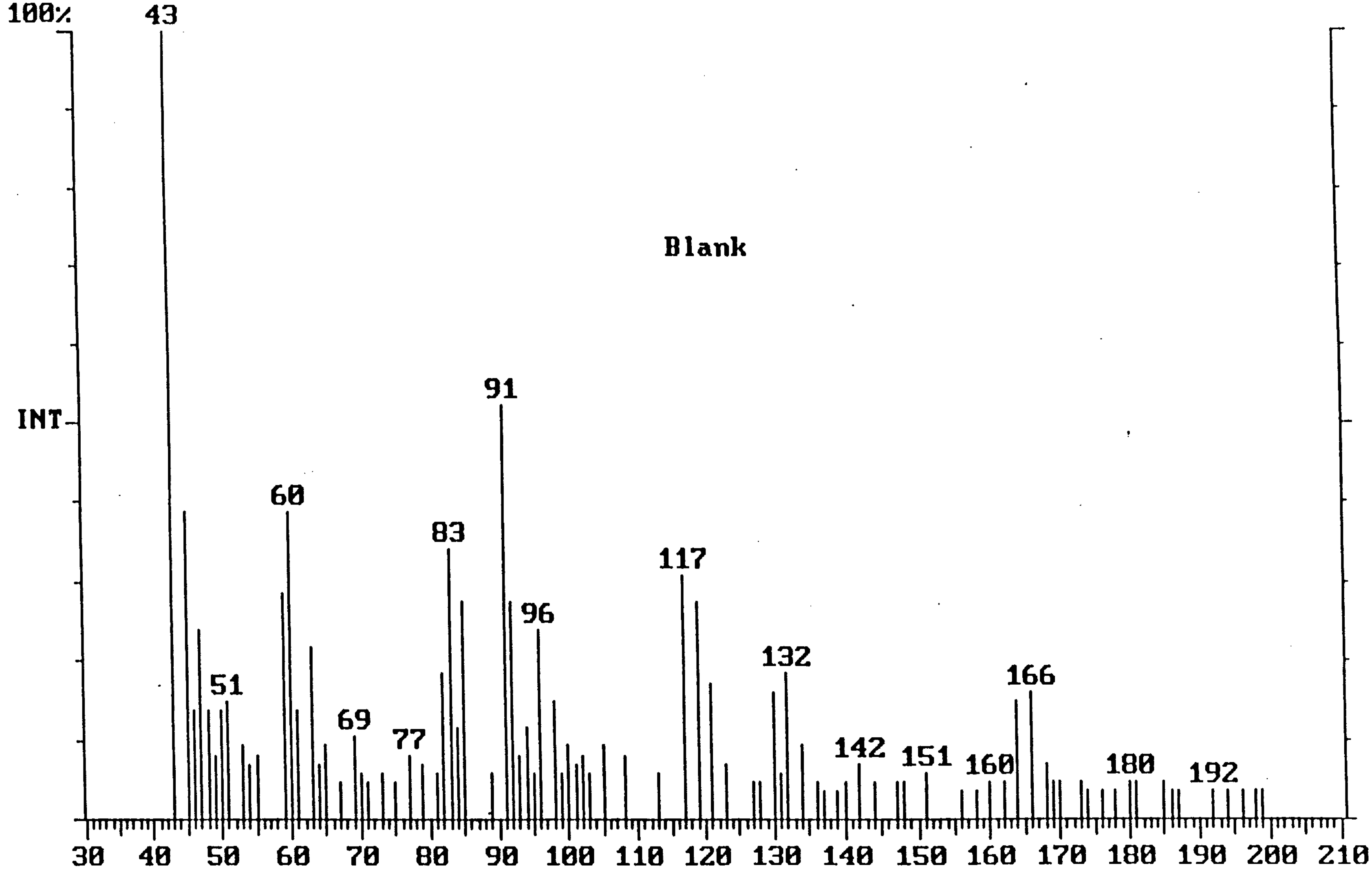
Comment: 07HSPSD(9.0-12.0)
Scan No: 91 Retention Time: 1:31 RIC: 65264 Mass Range: 43 - 199
Peaks: 88 Base Pk: 43 Ioniz: 343 us Int: 6413 100.00% = 6413



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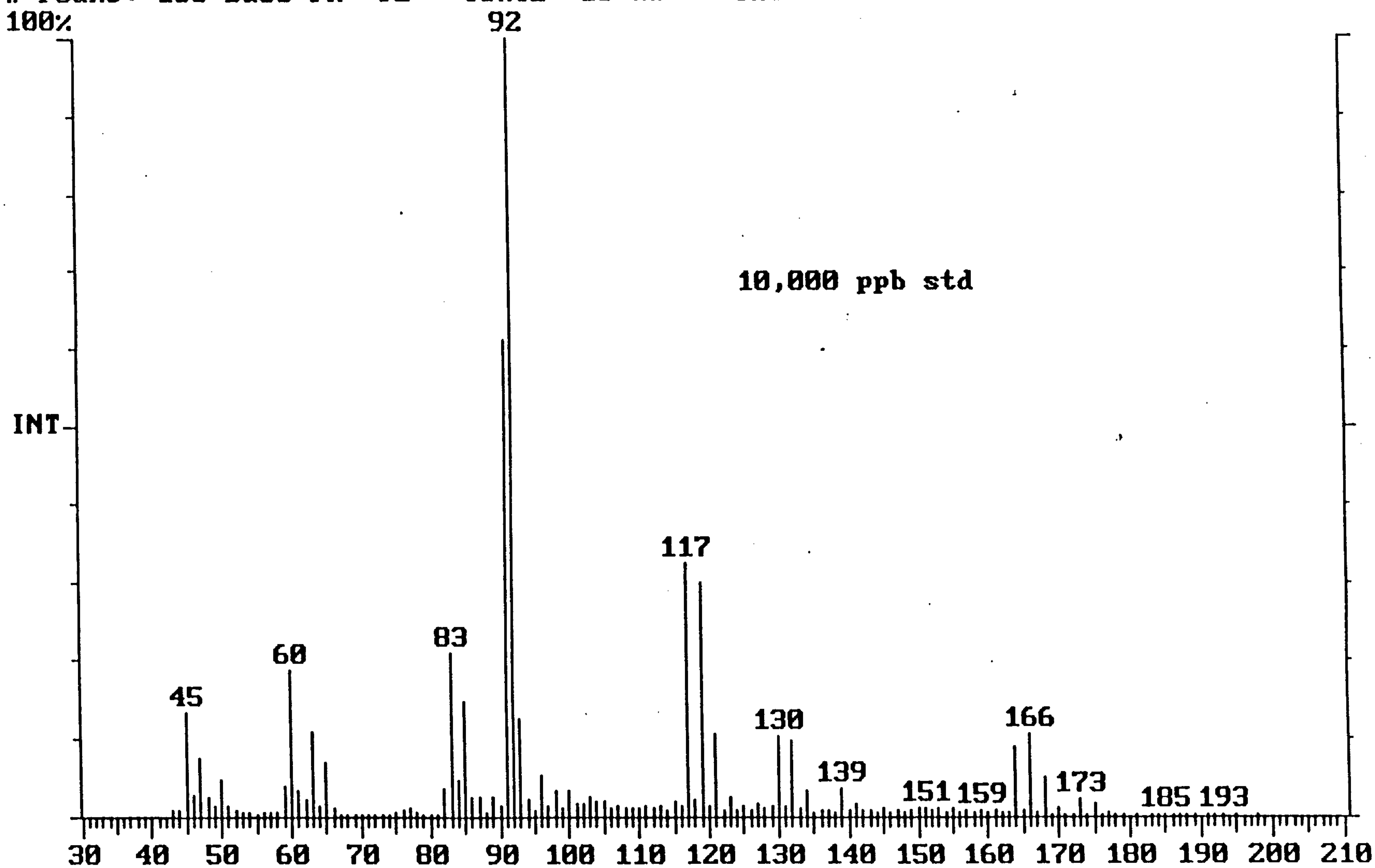
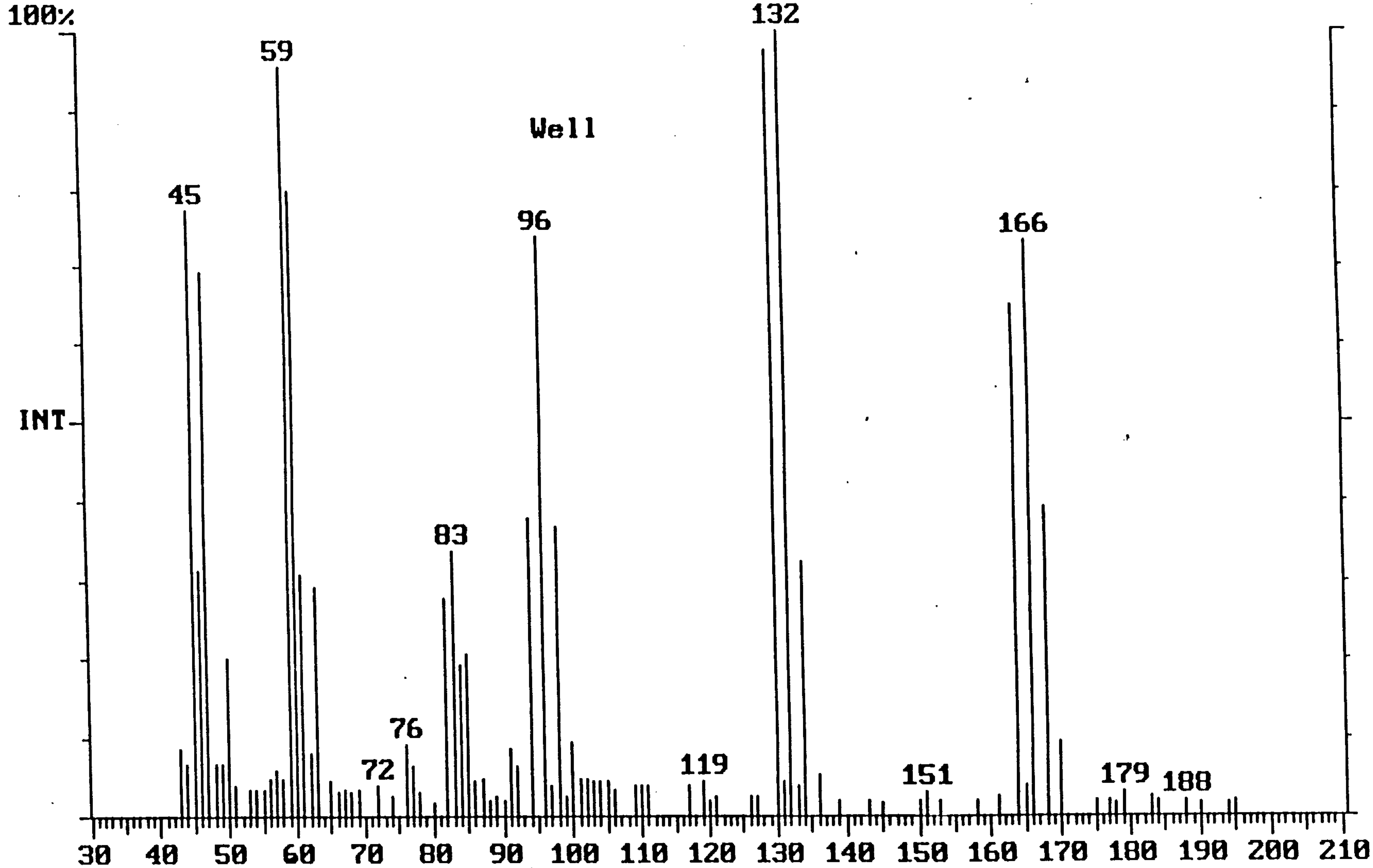
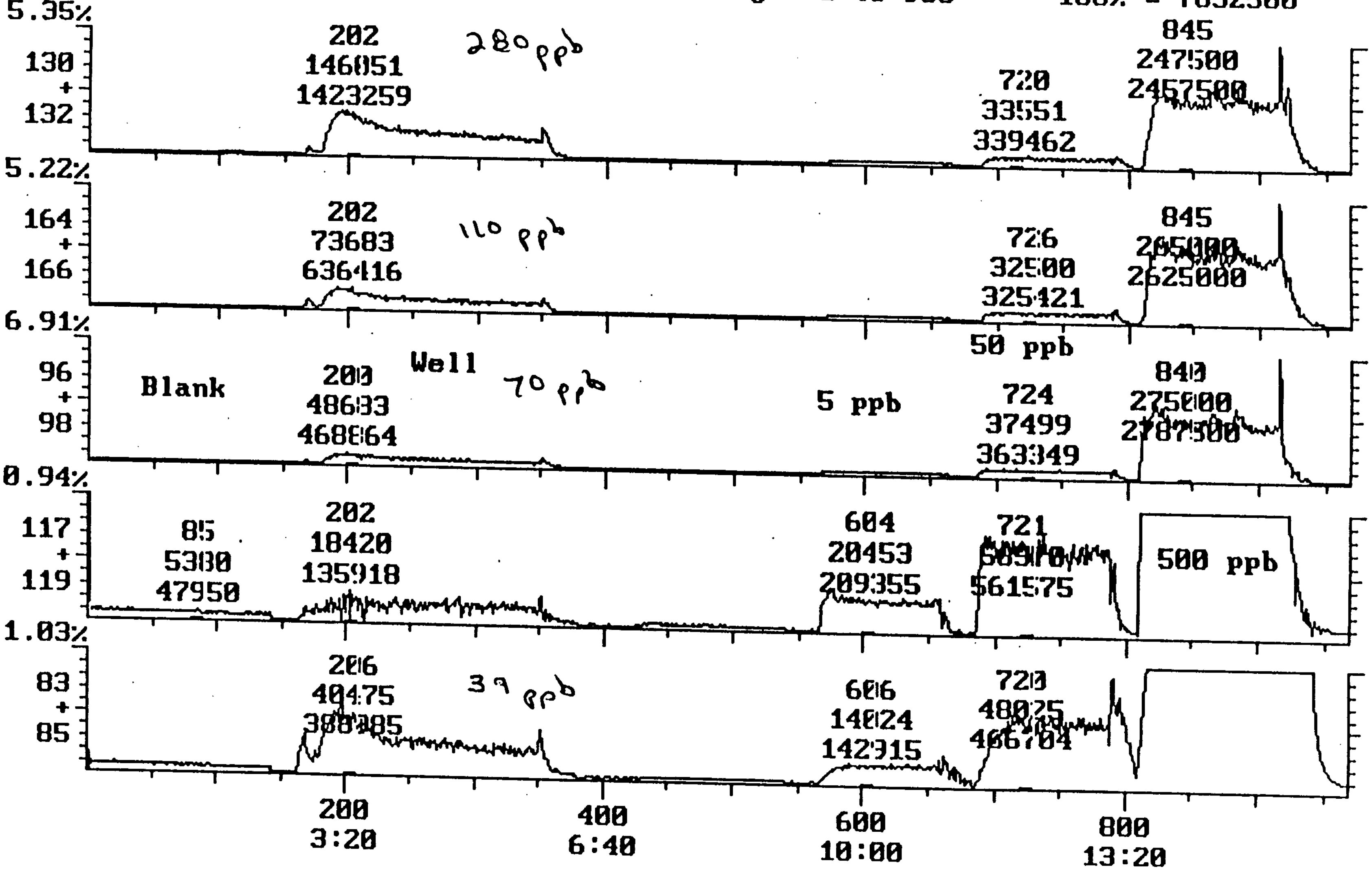
Comment: 07HSPSD(9.0-12.0)
Scan No: 1033 Retention Time: 17:13 RIC: 100630000 ass Range: 43 - 198
Peaks: 150 Base Pk: 92 Ioniz: 10 us Int: 19547500 100.00% = 19547500



Spectrum Plot C:\MAGNUM\DATA\11059802 Date: 11/05/98 08:09:53
Comment: 07HSPSD(9.0-12.0)
Scan No: 216 Retention Time: 3:36 RIC: 7252500 Mass Range: 43 - 195
Peaks: 92 Base Pk: 132 Ioniz: 10 us Int: 535000 100.00% = 535000



Chromatogram Plot C:\MAGNUM\DATA\11059803 Date: 11/05/98 08:34:30
Comment: 09HSPSD(9.7-17.5)
Scan No: 1 Retention Time: 0:01 RIC: 0 Mass Range: 0 - 0
Plotted: 1 to 966 Range: 1 to 966 100% = 7852500



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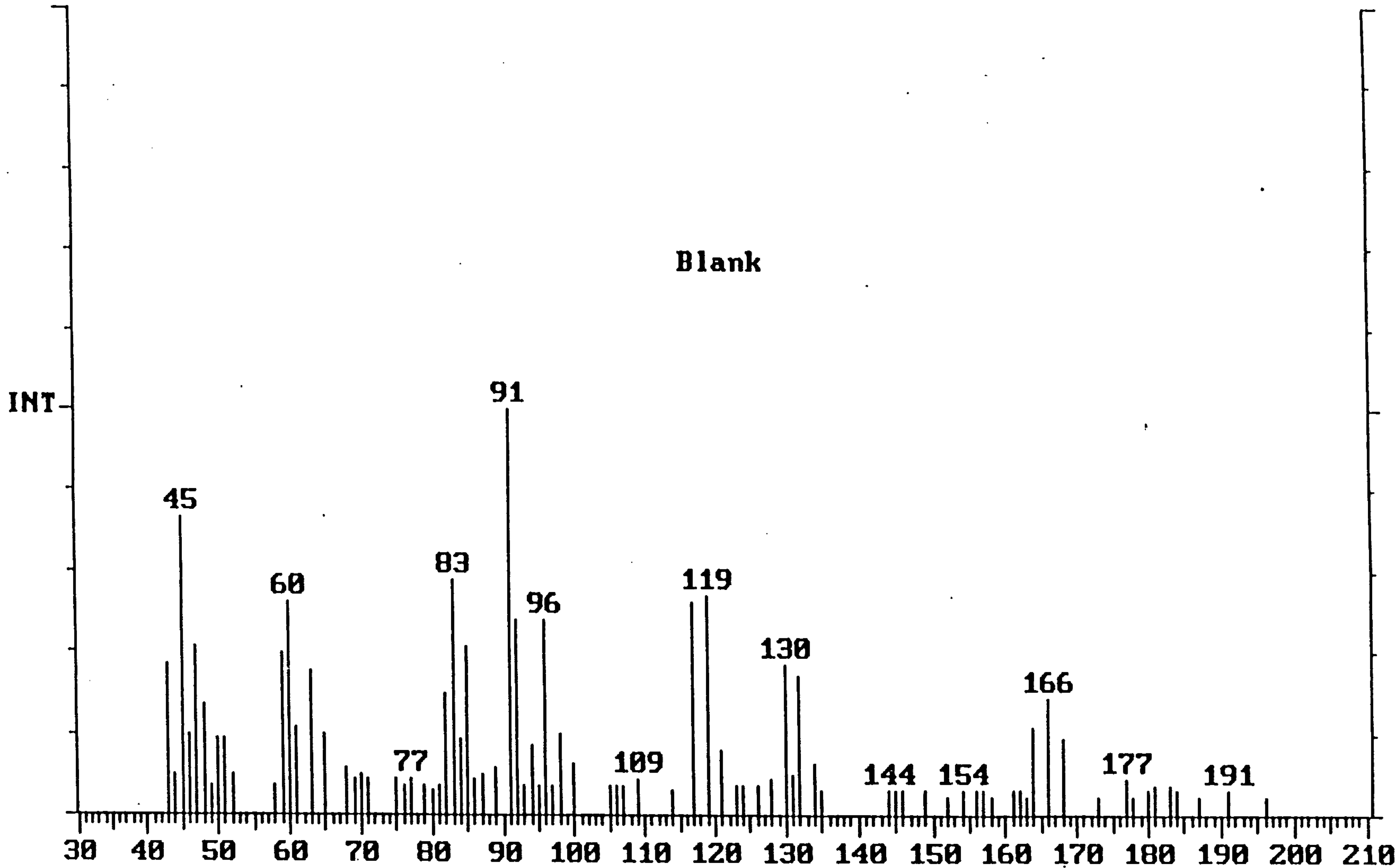
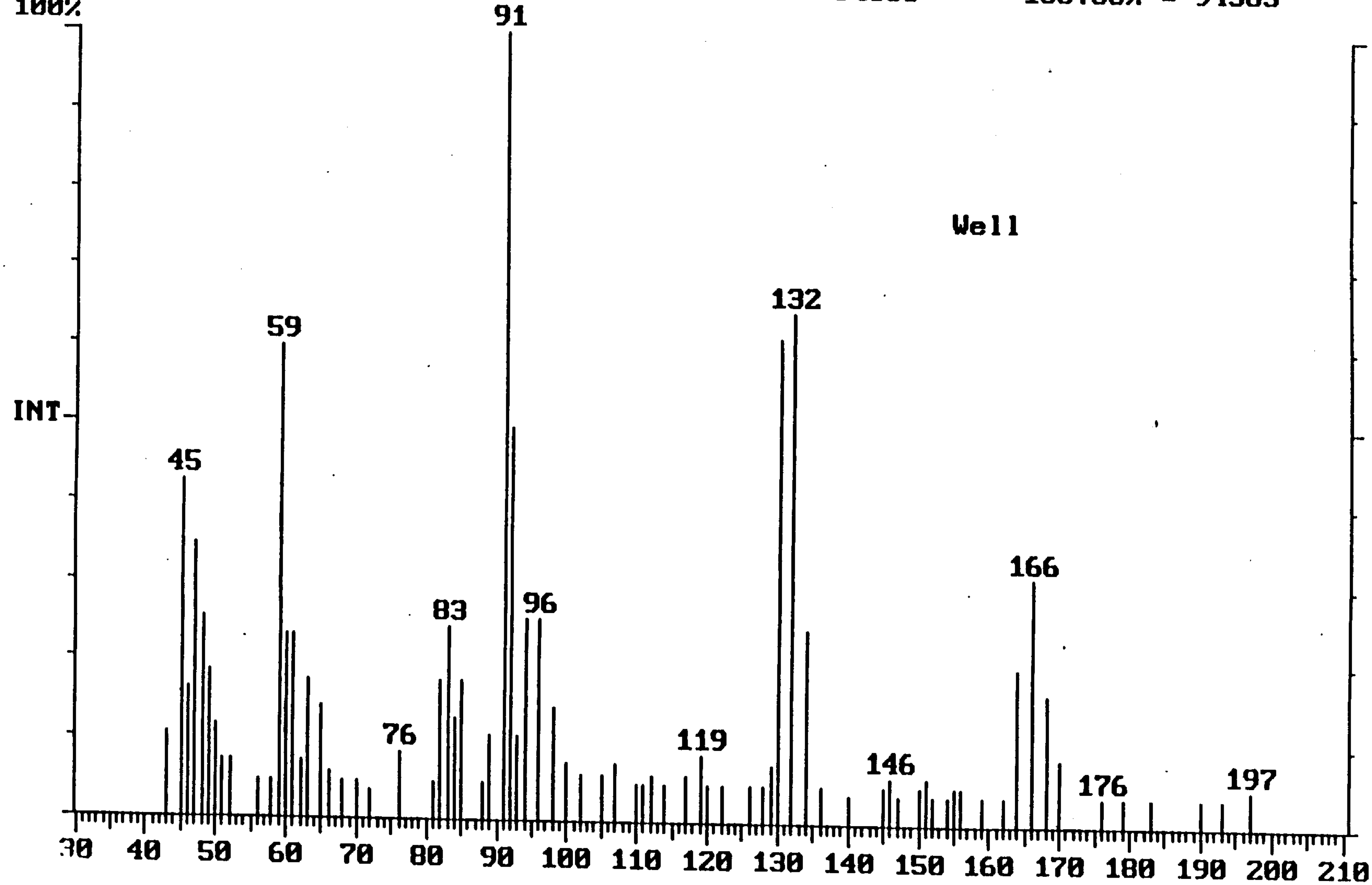
Comment: 09HSPSD(9.7-17.5)
Scan No: 82 Retention Time: 1:22 RIC: 65257 Mass Range: 43 - 196
Peaks: 84 Base Pk: 91 Ioniz: 389 us Int: 4562 200.00% = 9124
200%



Spectrum Plot C:\MAGNUM\DATA\11059803 Date: 11/05/98 08:34:30
Comment: 09HSPSD(9.7-17.5)
Scan No: 208 Retention Time: 3:28 RIC: 994516 Mass Range: 43 - 197
Peaks: 76 Base Pk: 91 Ioniz: 23 us Int: 94565 100.00% = 94565



APPENDIX B

SPECIFICATIONS

SECTION 02950

TREES

SECTION 02950 - TREES

PART I - GENERAL

1.1 SCOPE

A. Furnish all labor, materials, supplies, tools, and transportation; and perform all operations in connection with and reasonably incidental to the complete installation of the trees and warranty as specified herein. The work shall include but is not necessarily limited to the following:

1. Excavate planting pits.
2. Provide and install backfill amendments.
3. Planting trees.
4. Clean-up, inspection and approval.
5. Warranty of all plantings.

1.2 QUALITY ASSURANCE

A. Supplier or grower should have not less than five years experience in growing specified plants.

B. Installation contractor to have not less than five years of experience in successful installation of plant material.

1.3 SUBMITTALS

A. *Certificates*: Submit certificates of inspection as required by governmental authorities.

B. SUBCONTRACTOR shall provide proof within 3 days from notice to proceed, that plant material has been ordered from a nursery with estimated delivery date.

1.4 DELIVERY, STORAGE, AND HANDLING

A. *Packaged Materials*: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during deliver, and while stored at site.

B. *Trees*: Do not prune prior to delivery unless otherwise approved by the CONTRACTOR. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Plants shall be dug and prepared for shipment in a manner that will not cause damage to branches, shape and future development after planting. Trunks shall be wrapped for added protection. Wounds, scars or damage shall be grounds for rejection. Provide protective covering during delivery. Do not drop balled and burlapped stock during delivery. If in full leaf, spray with anti-desiccant such as Wilt-proof or equal.

C. *Transportation*:

1. Plants to be transported to the project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the vehicle to prevent injury to the plants. Closed vehicles shall be adequately ventilated to prevent overheating of the plants.

2. Plants shall be kept moist, fresh and protected at all times. Such protection shall encompass the entire period during which the plants are in transit, being handled, or are in temporary storage.

3. Do not unload ball and burlap trees by rolling. Ball and burlap trees shall be unloaded using hooks on wire baskets. Do not drop plants.

D. *Storage*:

1. Unless specific authorization is obtained by the CONTRACTOR, plants shall not remain on the site of the work longer than 3 days prior to planting. Deliver trees and shrubs after preparations for planting have been completed and plant immediately. If planting is delayed more than 6 hours after delivery, set trees and shrubs in shade, protect from weather and mechanical damage, and keep roots moist by covering with mulch, burlap or other acceptable means of retaining moisture. Keep all roots moist before, during and after planting. Duration and method of storage are subject to CONTRACTOR's approval.

2. Do not move balled and burlapped trees while in storage by rolling. Use hooks in wire baskets. Do not drop plants.

E. *Handling*: SUBCONTRACTOR shall exercise care in the handling of plant materials to avoid damage or stress.

1.5 REJECTION OF MATERIALS

A. Evidence of inadequate protection after digging, in transit, or improper handling or storage, shall be cause for rejection.

B. Upon arrival at the temporary storage location or the site of the work, plants shall be inspected for proper shipping procedures. Should the roots be dried out, large branches be broken, balls or earth broken, or loosened, or areas of bark be torn, the CONTRACTOR will reject the injured plant.

C. When a plant has been so rejected, the SUBCONTRACTOR shall at once remove it from the area of the work and replace it.

1.6 PROJECT CONDITIONS

A. *Work Scheduling*: Proceed with and complete landscape work as required by the *Description of the Work.*

B. *Utilities*: Determine location of underground utilities and perform work in manner which will avoid possible damage. Hand excavate, as required. Maintain grade stakes set by others until removal is mutually agreed upon by parties concerned.

C. *Excavation*: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify the CONTRACTOR before planting.

1.7 INSPECTIONS

Work will be subject to inspection at all times by the CONTRACTOR, who reserves the right to engage an independent testing agency to analyze and test materials used in the construction of the work.

Costs of tests and material analyses made by the testing agency will be borne by the CONTRACTOR when tests indicate compliance and by the SUBCONTRACTOR when tests indicate non-compliance.

A. *Planting Inspection*: CONTRACTOR shall inspect the staked locations of all trees and container plants before digging shall occur. Stake with flags. The SUBCONTRACTOR shall give the CONTRACTOR 48 hours notice to request inspection of staked locations.

1.8 WARRANTY AND REPLACEMENT

A. One year warranty period beginning at completion of planting.

1.9 PLANTING TIME AND COMPLETION

Plants shall be planted only when weather and soil conditions permit and in accordance with locally accepted practice, as accepted by the CONTRACTOR, and within the requirements of the schedule.

PART II - PRODUCTS

2.0 SOIL AMENDMENTS

A. *Bone Meal*: Commercial, raw, finely ground; 4% nitrogen and 20% phosphoric acid.
B. *Organic Matter*:

1. Cow or sheep manure must be composted for 70 to 90 days at 140°F.
2. Minimum acceptable nitrogen/phosphorous/potassium ratio if 1:1:1 (N-P-K).
3. Carbon to nitrogen ratios shall be in the range of 20:1 to 15:1.
4. Trace elements of iron and zinc should be present at a minimum rate of 15 mg/kg.
5. No solid particle greater than 0.5-inch diameter.
6. Acceptable pH range after composting is between 5.5 and 7.7.
7. Moisture content on a dry basis should range between 50 to 60 percent.

C. *Fertilizer*: Simplot Best-Tabs 20-10-5 or approved equal.

2.1 WOOD MULCH

Shredded, not chipped, bark mulch, free from deleterious materials and suitable for top dressing of trees. Mulch shall be of a long fibrous natural capable of matting together and interlocking when moistened and settled. Shredded cedar bark or equivalent.

2.2 WATER

SUBCONTRACTOR is responsible for coordination of his water needs for irrigation water with the CONTRACTOR.

2.3 TREES

A. *General*: Plant materials furnished shall be healthy and vigorous, well-branched, and well-proportioned in respect to height and width relationships, free from disease, injury, insects and their eggs, larvae and weed roots. Plants shall have a well developed fibrous root system. Plant material furnished shall be well branched and proportioned in respect to height and width relationships, and characteristic of the exact type specified.

1. All plants shall meet the requirements the reference standards for size, branching, condition, ball size, number of canes and all other conditions particular to each species.

2. Plants shall meet the type and sizes specified in the *Description of Work.*

B. Plants shall be free of physical damage such as scrapes, broken or split branches, scars, bark abrasions, sun scalds, fresh limb cuts, disfiguring knots, or other defects.

C. *Balled and Burlapped Plants*: Shall be nursery grown stock adequately balled with firm, natural balls of soil in sizes and ratios specified in this reference standards. Balls shall be firmly wrapped with non-treated burlap, secured with wire or jute. Broken balls will not be accepted.

2.4 MISCELLANEOUS LANDSCAPE MATERIALS

The SUBCONTRACTOR shall supply the following in accordance with local practices: Tree Stakes, Staking Wire, Tree Collar, Wrapping Material, Turnbuckles, and Tree Guys.

2.5 VENT PIPE

The SUBCONTRACTOR shall supply a 3-inch diameter perforated pipe to be installed within each planting pit from 2 to 7-feet bgs. The end of the pipe should be finished with a flexdrain snap end cap. The pipe should extend to a least 3-inches above surface grade and be capped with a 3-inch diameter drain grate.

PART III - EXECUTION

3.0 SITE PREPARATION

A. All areas within the limits of planting shall be planted with trees as specified.

B. To the extent practical, the existing surface vegetation should be maintained during installation .

C. Planting may not begin until completion of an operational irrigation system .

3.1 LAYOUT

Layout individual tree locations and areas for multiple plantings. Stake locations and outline areas and secure CONTRACTOR's approval before start of planting work. The configuration for the tree plantings is as described in the *Description of Work.*

3.2 SEQUENCING

Begin planting after the installation of an operable irrigation system.

3.3 PREPARING SOIL MIX AND BACKFILLING FOR TREE PLANTINGS

A. Before mixing, clean soil from pit of roots, plants, sods, stones, clay lumps, asphaltic material, concrete, metal and wire fragments and other extraneous materials harmful or toxic to plant growth.

B. Thoroughly mix equal portions (by volume) of excavated soil and organic matter.

C. Properly compact soil to avoid air pockets in planting holes. Use remaining excavated soil for plant basin.

D. Place bone meal in each planting pit in accordance with local practices.

E. Place fertilizer (at least 3 tabs) in each planting pit.

3.4 PLANTING PITS

A. Auger or hand dig planting pits vertically for plant material. Angled planting is not acceptable.

B. SUBCONTRACTOR shall auger a 12" diameter x 7'-0" deep hole, and fill with equal portions of excavated soil and organic matter below each planted tree.

C. SUBCONTRACTOR shall install a 3" diameter vent pipe of PVC or HDPE construction in each planting pit to provide oxygen to the subsurface. The vent pipe shall be installed so that the screened portion of the pipe is placed at 2 to 7' bgs.

D. Control any adverse compaction in the soil conditions. Scarify the sides of the planting pit with shovel.

E. *Planting Pit Widths*: The planting pit shall be minimum of two times the root ball width, and shall be the height of the rootball.

F. It is not anticipated that the planting shall be done where the depth of soil over underground construction obstructions, or rock, is insufficient to accommodate the roots or where pockets in rock or impervious soil will require drainage. If such conditions are encountered in excavation of planting areas, remove rocks or other underground obstruction.

3.5 STAKING

A. Secure all trees with two stakes, guying cords and connectors.

3.6 MULCHING

A. Immediately after planting and compaction, spread a layer of wood mulch material on finished grade within basin of plants to the depth of three inches.

3.7 WRAPPING

A. For fall plantings in accordance with local practices, immediately after planting, wrap the trunk and main branches of all deciduous trees.

B. Wrap spirally, starting at the highest point moving down the trunk.

C. Overlap wrap two inches on each spiral.

3.8 MAINTENANCE

A. Begin maintenance immediately after planting.

B. See Section 02999 for maintenance requirements.

3.9 CLEAN-UP

Keep pavements clean and work area in an orderly conditions. Protect landscape work and materials from damage due to landscape operations, operations by other contractors and trades and trespassers. Maintain protection during installation until final acceptance. Treat, repair or replace damaged landscape work as directed.

END OF SECTION 02950

SECTION 02810

IRRIGATION

SECTION 02810 - IRRIGATION

PART I - GENERAL

1.1 SCOPE

A. Furnish all labor materials, supplies, equipment, tools, and transportation, and perform all operations in connection with and reasonably incidental to the complete installation of the irrigation system as specified herein. Items of work specifically included are:

1. Procurement of all applicable licenses, permits, and fees, including any permits associated with the installation of the taps.
2. Excavation, installation, and backfill of tap into potable water line.
3. Excavation, installation, and backfill of water meter and vault.
4. Excavation, installation, and backfill for piping and controls for irrigation system including all incidental items (e.g., valve boxes).

1.2 SUBMITTALS

A. Deliver four (3) copies of all submittals to the CONTRACTOR within 10 days from the date of *Notice to Proceed.*

B. *Materials List*: Include pipe, fittings, mainline components, water emission components, control system components. Quantities of materials need not be included.

C. *Manufacturer's Data*: Submit manufacturers; catalog cuts, specifications, and operating instructions for equipment shown on the materials list.

1.3 QUALITY ASSURANCE

A. *Installer Qualifications*: Installer shall have had considerable experience and demonstrate ability in the installation of irrigation systems of specific types in a neat, orderly, and responsible manner in accordance with recognized standards of workmanship.

B. *Special Requirements*:

1. Working involving substantial plumbing for installation of copper piping, backflow prevention devices, and related work must be executed by licensed and bonded Plumber(s).

2. Replacement of Paving and Curbs - Where trenches and lines cross existing roadways, paths, curbing, etc., damage to these must be kept to a minimum and must be restored to original condition.

3. Damage to Other Improvements - SUBCONTRACTOR must replace or repair damage to grading, soil preparation, seeding, sodding, or planting done under other Sections during Work associated with installation of irrigation system at no additional cost to CONTRACTOR.

1.4 RULES AND REGULATIONS

A. Work and materials shall be in accordance with the latest edition of the National Electric Code, and Uniform Plumbing Code as published by the Western Plumbing Officials Association, and applicable laws and regulations of the governing authorities. Backflow assembly installation will be performed by a licensed and bonded plumber.

3.7 INSTALLATION OF MAINLINE COMPONENTS

A. *Main System Shut Off Valve*: Install conforming to local practices and codes and shall be installed in a valve box to allow for access.

B. *Backflow Prevention Assembly*: Install conforming to local practices and codes. Install assembly so that its elevation, orientation, access, and drainage conform to the manufacturer's recommendations and applicable health codes.

C. *Isolation Gate Valve Assembly*:

1. Install conforming to local practices and codes.

2. Locate at least 12-inches from and align with adjacent walls or edges of paved areas.

D. *Water Meter*: In the main header near the controller system prior to any lateral connections, a water meter (totalizing type) shall be installed in a valve box to allow for periodic readings. An additional isolation valve shall be installed just downstream of the water meter in the same valve box.

E. *Quick Coupling Valve*: A quick coupling valve for water access shall be installed downstream of the controller system within a valve box.

3.8 INSTALLATION OF SPRINKLER COMPONENTS

A. *Remote Control Valve (RCV) Assembly for Sprinkler Laterals*:

1. A total of four zones (25 trees each) should be used to irrigate the plantings.

2. Flush mainline before installation of RCV assembly.

3. Install conforming to local practices and as required by the design and layout of the irrigation system. Wire connectors and waterproof sealant shall be used to connect control wires to remote control valve wires. Install connectors and sealant per the manufacturer's recommendations.

4. Install only one RCV to a valve box. Locate valve box at least 12-inches from and align with nearby walls or edges of paved areas. Group RCV assemblies together where practical. Arrange grouped valve boxes in rectangular patterns. Allow at least 12-inches between valve boxes.

5. Adjust RCV to regulate the downstream operating pressure.

6. Attach ID tag with controller station number to control wiring.

B. *Sprinkler Assembly*:

1. Flush lateral pipe before installing sprinkler assembly.

2. Install per the manufacturer's instructions.

3. Install two (2) rings of drip system around each tree. An outer ring with dimensions of 4-feet by 4-feet and an inner ring of 2-feet by 2 feet.

1. Within 5 calendar (5) days of completion of testing, the SUBCONTRACTOR shall provide a letter report to the CONTRACTOR certifying the tests (with the exception of the operational test) were completed and all deficiencies were corrected.

1.6 GUARANTEE/WARRANTY AND REPLACEMENT:

The purpose of this guarantee/warranty is to insure that the CONTRACTOR receives irrigation materials of prime quality, installed and maintained in a thorough and careful manner.

A. For a period of one year from commencement of the formal maintenance period, guarantee/warranty irrigation materials, equipment, and workmanship against defects. Fill and repair depressions. Restore landscape or structural features damaged by the settlement of irrigation trenches or excavations. Repair damage to the premises caused by a defective item. Make repairs within seven calendar days of notification from the CONTRACTOR.

B. Contract documents govern replacements identically as with new work. Make replacements at no additional cost to the contract price.

C. Guarantee/warranty applies to originally installed materials and equipment and replacements made during the guarantee/warranty period.

PART II - PRODUCTS

2.1 QUALITY

Use materials which are new and without flaws or defects of any type, and which are the best of their class and kind.

2.2 SUBSTITUTIONS

Substitutions shall be approved by the CONTRACTOR.

2.3 WATER TAP

A. *Water Tap*:

1. Provide materials required by local codes for installation of the municipal water tap, vault and associated piping.

2.4 SLEEVING

A. Install separate sleeve beneath paved areas to route each run of irrigation pipe or wiring bundle.

B. Sleeving material beneath pedestrian pavements shall be PVC Class 200 pipe with solvent welded joints.

C. Sleeving beneath drives and streets shall be PVC Class 200 pipe with solvent welded joints.

D. Sleeving diameter equal to twice that of the pipe or wiring bundle.

2.5 PIPE AND FITTINGS

A. *Mainline Pipe and Fittings*:

1. Use rigid, unplasticized polyvinyl chloride (PVC) 1120, 1220 National Sanitation Foundation (NSF) approved pipe, extruded from material meeting the requirements of Cell Classification 12454-A or 12454-B, ASTM Standard D1784, with an integral belled end.

2. Use solvent weld pipe for mainline pipe with a nominal diameter less than 3-inches or where a pipe connection occurs in a sleeve. Use Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784. Use primer approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564. I

B. *Lateral Pipe and Fittings*:

1. Use rigid, unplasticized polyvinyl chloride (PVC) 1120, 1220 National Sanitation Foundation (NSF) approved pipe, extruded from material meeting the requirements of Cell Classification 12454-A or 12454-B, ASTM Standard D1784, with an integral belled end suitable for solvent welding.

2. Use Class 160, SDR-26, rated at 160 PSI, conforming to the dimensions and tolerances established by ASTM Standard D2241. Use solvent weld pipe for lateral pipe. Use Schedule 40, Type 1, PVC solvent weld fittings conforming to ASTM Standards D2466 and D1784 for PVC pipe. Use primer approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564, of a type approved by the pipe manufacturer.

C. *Specialized Pipe and Fittings*:

1. *Copper pipe*: Use Type "K" rigid conforming to ASTM Standard B88. Use wrought copper or cast bronze fittings, soldered or threaded. Use a 95% tin and 5% antimony solder.

2. *Ductile iron pipe*: Use Class 50 conforming to ANSI A21.51 (AWWA C151). Use a minimum of Class 53 thickness pipe for flanged piping. Use mechanical joints conforming to ANSI A 21.10 (AWWA C110) and ANSI A21. 11 (AWWA C111) or flanged fittings conforming to ANSI/AWWA C1 10 and ANSI B16.1 (125#).

3. Use a dielectric union wherever a copper-based metal (copper, brass, bronze) is joined to an iron-based metal (iron, galvanized steel, stainless steel).

4. *Low Density Polyethylene Hose*:

   a. Use pipe specifically intended for use as a flexible swing joint.

   b. Use spiral barb fittings supplied by the same manufacturer as the hose.

5. Assemblies calling for threaded pipe connections shall utilize PVC Schedule 80 nipples and PVC Schedule 80 threaded fittings.

6. *Joint sealant*: Use only teflon-type tape or teflon based paste pipe joint sealant on plastic threads. Use nor hardening, nontoxic pipe joint sealant formulated for use on water-carrying pipes on metal threaded connections.

2.6 MAINLINE COMPONENTS

A. *Main System Shutoff Valve*: as per local practice and in compliance with local code.

B. *Backflow Prevention Assembly*: reduced pressure type as per local practice and in compliance with local code.

C. *Isolation Gate Valve Assembly*: as per local practice and in compliance with local code.

D. *Quick Coupling Valve Assembly (water access valve)*: as per local practice and in compliance with local code.

D. *Water Meter*: totalizing type installed in valve box in main line near irrigation control system.

2.7 IRRIGATION COMPONENTS

A. *Remote Control Valve (RCV) Assembly for Sprinkler System*:

1. DV Control Valve XCZ-075 (Rain Bird) or approved equal. CONTRACTOR to install as required by the control system manufacturer. Use wire connectors and waterproofing sealant to join control wires to solenoid valves. Use standard Christy I.D. tags with hot-stamped black letters on a yellow background. Install a separate valve box over a 6-inch depth of 3/4-inch gravel for each assembly.

B. *Sprinkler Components*:

1. Drip system. Netafim Techline dripper line with an application rate of 1 GPH or approved equal.

2.8 CONTROL SYSTEM COMPONENTS

A. *Irrigation Controller Unit*: LEIT 40000 Irrigat5ion Control Unit (Altec Irrigation, Sand Diego, California) or approved equal.

B. *Soil Moisture Sensors*: Sensors and control wire material provided by others. CONTRACTOR to install sensors with assistance by CONTRACTOR.

1. *Conduit*: PVC Schedule 40.

C. *Control Wire*:

1. *Wire*: Use American Wire Gauge (AWG) No. 14 solid copper, Type UF or PE cable, UL approved for direct underground burial from the satellite control unit to each remote control valve.

2. *Conduit*: PVC Schedule 40.

3. *Splices*: Use wire connector with waterproof sealant. Wire connector to be of plastic construction consisting of two (2) pieces, one piece which snap locks into the other. A copper crimp sleeve to be provided with connector.

4. *Warning tape*: Inert plastic film highly resistant to alkalis, acids, or other destructive chemical components likely to be encountered in soils. Three inches wide, colored yellow, and imprinted with "CAUTION: BURIED ELECTRIC LINE BELOW."

2.10 OTHER COMPONENTS

A. *Other Materials*: Provide other materials which are part of the irrigation system, even though such items may not have been referenced in these specifications.

B. *Bollards*: 3-inch diameter concrete filled galvanized steel pipe painted yellow. To be installed around irrigation control system.

PART III: EXECUTION

3.1 INSPECTIONS AND REVIEWS

A. *Site Inspections*:

1. Verify construction site conditions and note irregularities affecting work of this section. Report irregularities to the CONTRACTOR prior to beginning work.

2. Beginning work of this section implies acceptance of existing conditions.

B. Utility Locates ("Call Before You Dig"):

1. Arrange for and coordinate with CONTRACTOR to ensure all utilizes are cleared prior to beginning the work.

C. *Irrigation System Layout Review*: Irrigation system layout review will occur after the staking has been completed. Notify the CONTRACTOR three (3) days in advance of review. Modifications will be identified by the CONTRACTOR at this review.

3.2 LAYOUT OF WORK

A. Stake out the irrigation system. Items staked include: pipe, isolation valves, quick coupling valves, remote control valves, sprinklers, and controller.

B. Install all mainline pipe and mainline components inside of project right of way lines.

3.3 EXCAVATION. TRENCHING. AND BACKFILLING

A. Excavate to permit the pipes to be laid at the intended elevations and to permit work space for installing connections and fittings.

B. *Minimum cover* (distance from top of pipe or control wire to finish grade):

1. 18-inch over mainline pipe and sleeving.

2. 18-inch over lateral pipe to sprinklers

4. 20-inch over control wire.

C. PVC lateral pipes may be pulled into the soil utilizing a vibratory plow device specifically manufactured for pipe pulling. Minimum burial depths equals minimum cover listed above.

D. Backfill only after lines have been reviewed and tested.

E. Excavated material is generally satisfactory for backfill. Backfill shall be free from rubbish, vegetable matter, frozen materials, and stones larger than 2-inches in maximum dimension. Remove material not suitable for backfill. Backfill placed next to pipe shall be free of sharp objects which may damage the pipe.

F. Backfill unsleeved pipe in either of the following manners:

1. Backfill and puddle the lower half of the trench. Allow to dry 24 hours. Backfill the remainder of the trench in 6-inch layers. Compact to density of surrounding soil.

2. Backfill the trench by depositing the backfill material equally on both sides of the pipe in 6-inch layers and compacting to the density of surrounding soil.

G. Enclose pipe and wiring beneath roadways, walks, curbs, etc., in sleeves. Minimum compaction of backfill for sleeves shall be 95% Standard Proctor Density, ASTM D69878. Conduct one compaction test for each sleeved crossing less than 50 feet long. Conduct two compaction tests for each sleeved crossing greater than 50 feet long. Costs for such testing and any necessary retesting shall be borne by the SUBCONTRACTOR. Use of water for compaction around sleeves, "puddling", will not be permitted.

H. Dress backfilled areas to original grade. Incorporate excess backfill into existing site grades.

I. Where utilities conflict with irrigation trenching and pipe work, contact the CONTRACTOR for trench depth adjustments.

3.4 WATER TAP

A. Install the hot-tap and associated piping materials in conformance with local regulations. Coordinate with CONTRACTOR to ensure installation is in conformance with Base specifications.

B. Install all components of the water tap in conformance with local regulations.

3.5 SLEEVING AND BORING

A. Install sleeving at a depth which permits the encased pipe or wiring to remain at the specified burial depth.

B. Extend sleeve ends six inches beyond the edge of the paved surface. Cover pipe ends and mark with stakes.

C. Bore for sleeves under obstructions which cannot be removed. Employ equipment and methods designed for horizontal boring.

A. *General*:

1. Keep pipe free from dirt and pipe scale. Cut pipe ends square and debur. Clean pipe ends.

2. Keep ends of assembled pipe capped. Remove caps only when necessary to continue assembly. .

3. Trenches may be curved to change direction or avoid obstructions within the limits of the curvature of the pipe. Minimum radii of curvature is 25 feet for 2-inch diameter pipe, 100 feet for 3-inch diameter pipe. All curvature results from the bending of the pipe lengths. No deflection will be allowed at a pipe joint.

B. *Mainline Pipe and Fittings*:

1. Use only strap-type friction wrenches for threaded plastic pipe.

2. *PVC Solvent Weld Pipe*:

a. Use primer and solvent cement. Join pipe in a manner recommended by the manufacturer and in accordance with accepted industry practices.

b. Cure for 30 minutes before handling and 24 hours before allowing water in pipe.

c. Snake pipe from side to side within the trench.

C. *Lateral Pipe and Fittings*:

1. Use only strap-type friction wrenches for threaded plastic pipe.

2. *PVC Solvent Weld Pipe*:

a. Use primer and solvent cement. Join pipe in the manner recommended by the manufacturer and in accordance with accepted industry practices.
b. Cure for 30 minutes before handling and 24 hours before allowing water in the pipe.
c. Snake pipe from side to side within the trench.

D. *Specialized Pipe and Fittings*:

1. *Copper Pipe*:

a. Buff surfaces to be joined to a bright finish. Coat with solder flux.

b. Solder so that a continuous bead shows around the joint circumference.

2. *Ductile Iron Pipe*:

a. Join pipe in the manner recommended by manufacturer and in accordance with accepted industry practices.

3. Insert a dielectric union wherever a copper-based metal (copper, brass, bronze) and an iron-based metal (iron, galvanized steel, stainless steel) are joined.

4. *Low Density Polyethylene Hose*: Install per manufacturer's recommendations.

5. *PVC Threaded Connections*:

a. Use only factory-formed threads. Field-cut threads are not permitted.

b. Use only Teflon-type tape or teflon based paste.

c. When connection is plastic-to-metal, the plastic component shall have male threads and the metal component shall have female threads.

6. Make metal-to-metal, threaded connections with Teflon-type tape or pipe joint compound applied to the male threads only.

3.7 INSTALLATION OF MAINLINE COMPONENTS

A. *Main System Shut Off Valve*: Install conforming to local practices and codes and shall be installed in a valve box to allow for access.

B. *Backflow Prevention Assembly*: Install conforming to local practices and codes. Install assembly so that its elevation, orientation, access, and drainage conform to the manufacturer's recommendations and applicable health codes.

C. *Isolation Gate Valve Assembly*:

1. Install conforming to local practices and codes.

2. Locate at least 12-inches from and align with adjacent walls or edges of paved areas.

D. *Water Meter*: In the main header near the controller system prior to any lateral connections, a water meter (totalizing type) shall be installed in a valve box to allow for periodic readings. An additional isolation valve shall be installed just downstream of the water meter in the same valve box.

E. *Quick Coupling Valve*: A quick coupling valve for water access shall be installed downstream of the controller system within a valve box.

3.8 INSTALLATION OF SPRINKLER COMPONENTS

A. *Remote Control Valve (RCV) Assembly for Sprinkler Laterals*:

1. A total of four zones (25 trees each) should be used to irrigate the plantings.

2. Flush mainline before installation of RCV assembly.

3. Install conforming to local practices and as required by the design and layout of the irrigation system. Wire connectors and waterproof sealant shall be used to connect control wires to remote control valve wires. Install connectors and sealant per the manufacturer's recommendations.

4. Install only one RCV to a valve box. Locate valve box at least 12-inches from and align with nearby walls or edges of paved areas. Group RCV assemblies together where practical. Arrange grouped valve boxes in rectangular patterns. Allow at least 12-inches between valve boxes.

5. Adjust RCV to regulate the downstream operating pressure.

6. Attach ID tag with controller station number to control wiring.

B. *Sprinkler Assembly*:

1. Flush lateral pipe before installing sprinkler assembly.

2. Install per the manufacturer's instructions.

3. Install two (2) rings of drip system around each tree. An outer ring with dimensions of 4-feet by 4-feet and an inner ring of 2-feet by 2 feet.

3.9 INSTALLATION OF CONTROL SYSTEM COMPONENTS

A. *Irrigation Controller Unit*:

1. The location of the controller unit will be dependent on the layout of the sprinkler system. This location will be mutually agreed upon between the SUBCONTRACTOR and CONTRACTOR.

2. Install one valve output surge protection arrestor on each control wire and one for the common wire.

3. Attach wire markers top the ends of control wires inside the controller unit housing. Label wires with the identification number of the RCV to which the control wire is connected.

4. Connect control wires to the corresponding controller terminal.

B. *Soil Moisture Sensors*:

1. Install two soil moisture sensors in individual planting pits for each control zone (estimated to be 8 total). Soil moisture sensor and control wire material to be provided by CONTRACTOR.

2. Install the two sensors in one planting pit for each zone. Install the first sensor near the mid-point of the root ball. Install the second sensor at approximately 6' bgs.

3. Run control wire through conduit back to a central location near the control system. Terminate all control wires in a valve box.

4. Attach wire markers to the ends of control wires inside the valve box. Label wires with the identification number of the soil moisture sensor to which the control wire is connected.

C. *Control Wire*:

1. Bundle control wires where two or more are in the same trench. Bundle with pipe wrapping tape spaced at 10-foot intervals.

2. Control wiring may be chiseled into the soil utilizing a vibratory plow device specifically manufactured for pipe pulling and wire installation. Appropriate chisel must be used so that wire is fed into a chute on the chisel, and wire is not subject to pulling tension. Minimum burial depth must equal minimum cover previously listed.

3. Provide a 24-inch excess length of wire in an 8-inch diameter loop at each 90 degree change of direction, at both ends of sleeves, and at 100-foot intervals along continuous nuns of wiring. Do not tie wiring loop. Coil 24-inch length of wire within each remote control valve box.

4. Install common ground wire and one control wire for each remote control valve. Multiple valves on a single control wire are not permitted.

5. If a control wire must be spliced, make splice with wire connectors and waterproof sealant, installed per the manufacturer's instructions. Locate splice in a valve box which contains an irrigation valve assembly, or in a separate 6-inch round valve

box. Use same procedure for connection to valves as for in-line splices.

6. Unless noted on plans, install wire parallel with and below mainline pipe.

7. Protect wire not installed with PVC mainline pipe with a continuous run of warning tape placed in the backfill six inches above the wiring.

3.10 INSTALLATION OF OTHER COMPONENTS:

A. *Tools and Spare Parts*: Prior to the Review at completion of construction, supply to the CONTRACTOR operating keys, servicing tools, spare parts, and any other items as necessary.

B. *Other Materials*: Install other materials or equipment details which are part of the irrigation system, even though such items may not have been referenced in these specifications.

C. *Bollards*: Install a minimum of four (4) bollards in a rectangular pattern around control system and valve box assemblies . Install bollards with a minimum above ground height of 4-feet and below ground depth of 2-feet. Secure bollards with concrete in a hole at least 18-inches in diameter and 3-feet in depth.

3.11 PROJECT RECORD (AS-BUILT) DRAWINGS

A. At completion of project, submit as-built drawings (can be hand drawn) showing dimensions from two permanent points of reference (building comers, sidewalk, road intersections or permanent structures), location of following items:

1. Connection to existing water lines.
2. Routing of sprinkler pressure lines.
3. Remote Control Valve Assembly.
4. Quick Coupling Valve Assembly
5. Drain Valves.
6. Control wiring routing if not with mainline pipe.
7. Gate Valve Assembly.

3.12 OPERATION INSTRUCTIONS

A. Submit three written operating instructions including winterization procedures and start-up, with cut sheets of products, and coordinate controller/watering operation instruction with CONTRACTOR.

3.13 MAINTENANCE

A. Upon completion of construction and Review by the CONTRACTOR, maintain irrigation system according to Specification 02999.

3.14 CLEANUP

A. Upon completion of work, remove from the site all machinery, tools, excess materials, and rubbish.

END OF SECTION 02810

SECTION 02999

PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

SECTION 02999 - PLANTING AND IRRIGATION MAINTENANCE - YEAR 1

PART I - GENERAL

1.0 SUMMARY

Furnish all supervision, labor, material, equipment and transportation required to maintain all landscape areas called for under this Contract, in an attractive, healthy, operable condition for a period of one year from the date of final acceptance and coordination with the CONTRACTOR. SUBCONTRACTOR shall be responsible for all maintenance and shall provide winter watering as needed to insure healthy, vigorous plant growth.

1.1 QUALITY ASSURANCE

A. *Work Force*: SUBCONTRACTOR's representative shall have at least 5 years experience in the maintenance and repair of all types of plantings and irrigation systems which are part of this Contract.

B. *Materials*: All materials used in maintenance and repair shall conform to these Specifications or shall be otherwise accepted by the CONTRACTOR.

1.2 SUBMITTALS

A. Submit 10 business days prior to commencement of warranty period, an irrigation and plant maintenance schedule outlining tasks and responsibilities by month for a one year period.

B. Maintain a record of maintenance activities, including all records of all materials, color provided and the area, rate and amount of herbicide or pesticide used, irrigation schedules, and total water used for irrigation.

   1. Submit to CONTRACTOR on a monthly basis.

PART II - MATERIALS

None

PART III - EXECUTION

3.0 GENERAL

A. Walk project a minimum of once per week during the growing season and once every month during off season and record in writing using a standard format:

   1. General condition or status of plant materials.
   2. Stressed, dead or dying plant materials.
   3. Broken tree stakes, guy wires, missing tree ties.

4. Water retention basins needing repair.
5. Weed control needed.
6. Status of irrigation systems noting:
    a. Any line breaks or leaks.
    b. Broken or missing heads.
    c. Any leaks at valves.
    d. Receive status report from controller.

Inspection may be accomplished during regular maintenance visits.

3.1 TREES

A. *General*:

1. The SUBCONTRACTOR shall warranty all such plant materials against defects due to any cause except vandalism and acts of God for a period of one year from the date of acceptance.

2. The SUBCONTRACTOR shall make replacements within seven days of notification by the CONTRACTOR's Representative. Replacement planting for trees shall be done in the spring planting season only, except as otherwise approved. Remove dead plants within 7 days of notification.

3. Replacement plants shall be of the same kind, condition, size, and quality and shall closely match adjacent specimens of the same species. Replacements shall also be subject to all requirements stated in this specification. All expenses incurred in the replacements shall be borne by the SUBCONTRACTOR.

4. Plants shall be healthy, and in flourishing condition at the end of the warranty period. Plants shall be free of dying branches and branch tips, and shall bear foliage of normal density, size and color.

5. Two weeks prior to completion of warranty period, SUBCONTRACTOR shall remove all tree stakes, tree guys, straps, wire and tree wrap, unless otherwise directed by the CONTRACTOR's Representative.

B. *Watering*: Automate the irrigation system to supply the necessary water for the health of the tree plantings over the course of the year including the winter, early spring and fall, and the growing season.

C. *Pruning*: None required except at time of planting and as needed to correct damage.

D. *Stakes and Guys*: Inspect regularly to prevent girdling of trunks or branches and to prevent rubbing which might cause bark wounds. Remove and replace damaged stakes and guys as directed by the CONTRACTOR's Representative.

E. *Weed Control*: Tree basins shall be kept free of weeds and grasses on a monthly basis. Frequent soil cultivation which might destroy shallow roots will not be allowed. Use of mulches to prevent seed germination will be allowed.

F. *Insects and Disease Control*: Control insects and disease as necessary to prevent damage to the health or appearance of plants, using only approved materials and methods.

G. *Tree Protection*: Remove and/or apply tree wrap to all trees at the following times when they occur during the maintenance period: remove at the beginning of the growing season, and wrap trees again in late fall, starting wrap from the bottom up to the first branch.

H. *Emergency Repairs*: SUBCONTRACTOR shall be available to the CONTRACTOR at any time during the maintenance period to perform emergency repairs that may be necessary. Costs will be negotiated by the CONTRACTOR and the SUBCONTRACTOR at the time based on SUBCONTRACTOR's submitted hourly rates.

3.2 IRRIGATION SYSTEM

A. *General*:

1. SUBCONTRACTOR shall check all systems for proper operation after each mowing, and all repairs shall be made before the next watering cycle. Any damage caused to the system by SUBCONTRACTOR's operations shall be repaired at no cost to the CONTRACTOR.

2. SUBCONTRACTOR shall be responsible for programming the irrigation controller including schedule, cycles, amount of water, etc. SUBCONTRACTOR shall review watering schedule with the CONTRACTOR.

3. SUBCONTRACTOR shall repair all damages to the irrigation system at his own cost. Repairs shall be made within one watering period.

B. Correct all problems which develop in the system due to faulty materials or workmanship during the warranty period.

C. Repair or replace such work as directed by the CONTRACTOR's Representative.

D. Make repairs and replacement promptly when notified.

E. Provide a written warranty for each segment of the project stating date of completion and guarantee period.

F. The CONTRACTOR reserves the right to make temporary repairs during the warranty period as necessary to keep systems in operating condition without voiding the contractor's warranty, nor relieving the contractor of his responsibility.

G. *Winterization*: Under the warranty period, the SUBCONTRACTOR shall be responsible for draining the system in preparation for the first and second winters after construction. SUBCONTRACTOR shall remove all water from the system using compressed air.

H. *Spring Start-Up*: Under the warranty period, SUBCONTRACTOR shall be responsible for starting up the irrigation system in the first spring following construction only. SUBCONTRACTOR shall fully activate the system and demonstrate that it is in full working order. Any repairs needed as a result of improper winterization or negligence due to the SUBCONTRACTOR shall be corrected by the SUBCONTRACTOR at no additional cost to the CONTRACTOR.

3.3 LICENSES AND TAXES

A. *Licenses*: SUBCONTRACTOR agrees to obtain and pay for all licenses required by city, county, state and federal governments that are necessary for the legal conduct of his business.

END OF SECTION -02999

APPENDIX C

OPERATION AND MAINTENANCE MANUAL
(TO BE PROVIDED BY LOCAL SERVICE PROVIDER)

APPENDIX D

HEALTH AND SAFETY PLAN

HEALTH AND SAFETY PLAN
FOR AFCEE PHYTOSTABILIZATION
AT
TRAVIS AIR FORCE BASE, CALIFORNIA
AND
ALTUS AIR FORCE BASE, OKLAHOMA

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

AND

AIR MOBILITY COMMAND (AMC)

AMC CONTRACT F11623-94-0024

August 1998

Prepared by:

PARSONS ENGINEERING SCIENCE, INC.
1700 Broadway, Suite 900
Denver, Colorado 80290

Reviewed and Approved By:

	By	Date
Project Manager	[signature]	9.16.98
Office H & S Representative	[signature]	9/16/98

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

SECTION 1

PURPOSE AND POLICY

The purpose of this health and safety plan is to establish personnel protection standards and mandatory safety practices for all Parsons Engineering Science, Inc. (Parsons ES) and subcontractor personnel involved in the phytostabilization demonstrations at Travis Air Force Base (AFB) California, and Altus AFB, Oklahoma. This plan provides guidance for general operations on phytostabilization demonstration sites and provides for contingencies that may arise during field operations. All Parsons ES field team members and subcontractors are responsible for reading and conforming to this plan and the associated addenda. No employee will perform a project activity that he or she believes may endanger his or her health and safety or the health and safety of others. All personnel will strive for a record of zero accidents on this project. To the greatest extent possible, work tasks will be designed and conducted to minimize or eliminate hazards to personnel.

A project description and scope of work summary for the project are provided in Section 2. Section 3 presents the project team organization, personnel responsibilities, and lines of authority. Training and medical monitoring requirements are contained in Section 4. Section 5 presents a safety and health risk analysis. Section 6 contains the program emergency response plan. Program requirements for levels of protection are included in Section 7, and air monitoring procedures are provided in Section 8. Site control measures, including designation of site work zones, are contained in Section 9, and Section 10 provides decontamination procedures. Section 11 contains information on the use and calibration of air monitoring equipment. Appendix A contains a Plan Acceptance Form, Site-Specific Training Record Form, Field Experience Documentation Form, Air Monitoring Data Forms, Accident Report Form, Near-Miss Incident Form, Shipping Paper, Daily Vehicle Inspection Report, and Respirator Use Forms.

SECTION 2

PROJECT DESCRIPTION AND SCOPE OF WORK

2.1 PROJECT DESCRIPTION

Under this contract, Parsons ES will provide services to the Air Force Center for Environmental Excellence (AFCEE) and Air Mobility Command (AMC) that will demonstrate the application of engineered tree plantings to hydraulically control shallow groundwater contaminated with chlorinated solvents at two sites located on Travis AFB and Altus AFB.

Engineered tree plantings will be designed, installed, and monitored for a three year duration. Data collected by Parsons will be used to assist AFCEE with the refinement and calibration of a water balance model for each site.

2.1 SITE HISTORY AND DESCRIPTION

Phytostabilization demonstrations will be conducted at Travis AFB in Solano County, California and at Altus AFB in Altus, Oklahoma.

At Travis AFB, field activities will be performed in the area at Building 755, currently the Battery and Electric Shop and formerly a site where rocket engines were tested. Additional site information and maps are located in the work plan entitled *Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Building 755, Travis Air Force Base, California* (Parsons Engineering Science, Inc., 1998).

At Altus AFB, field activities will be conducted at Site 17, an area used as a holding pond for solvents in the southern portion of the base. Additional site information and maps are located in the work plan entitled *Work Plan for the Demonstration of Phytostabilization of Chlorinated Solvents from Groundwater at Site 17, Altus Air Force Base, Oklahoma* (Parsons Engineering Science, Inc., 1998)

2.3 SCOPE OF WORK

Field activities in support of the phytostabilization demonstrations may include excavating; auger and Geoprobe® drilling; monitoring well installation; and soil, soil column moisture, transpiration gas, and groundwater sampling.

SECTION 3

PROGRAM TEAM ORGANIZATION

The Parsons ES team assigned to the phytostabilization demonstrations, their responsibilities, and lines of authority are outlined below.

Name	Task Assigned
Mr. John Stewart	Program Manager
Mr. Doug Downey	Technical Director
Mr. Bill Plaehn	Project Manager
Mr. Timothy Mustard	Program Health and Safety Manager
Mr. Bill Plaehn	Site Manager - Travis AFB
Mr. Bill Plaehn	Site Health and Safety Officer - Travis AFB
Mr. Tom Dragoo	Site Manager - Altus AFB
Mr. Tom Dragoo	Site Health and Safety Officer - Altus AFB
Mr. Sam Taffinder	AFCEE/ERT Point of Contact (POC)

The program manager, Mr. John Stewart, will be the Parsons ES POC for program matters, and will interface with the contracting officer, Base representatives, and the AMC and AFCEE project technical representatives

The technical director, Mr. Doug Downey, is responsible for conduct and review of all technical work on this project to ensure technical accuracy and adequacy. He will provide advice to the project manager and project personnel on technical issues. He will also be responsible for peer review of all deliverables prior to submission.

The project manager, Mr. Bill Plaehn, is directly responsible for the execution of all phases of this project. He is responsible for planning, staffing, assuring adequate planning for health and safety and quality assurance/quality control (QA/QC), execution of each phase, coordination with AFCEE, and interpretation of data and reporting. The project manager will also coordinate with the site manager to obtain permission for site access, coordination of activities with appropriate officials, and serve as the liaison with public officials. The project manager will also ensure that quality work is accomplished on schedule.

The program health and safety manager, Mr. Timothy Mustard, will ensure that all field activities are performed with strict adherence to OSHA requirements and the program health and safety plan. He will be responsible for updating and revising the program health and safety plan, as needed, and for ensuring that all field team members meet health and safety training and medical monitoring requirements.

The site health and safety officer (SHSO) along with the project manager is responsible for ensuring that day-to-day project activities are performed in strict conformance with the program health and safety plan. The SHSO, project manager, and program health and safety manager have the authority to stop work if actions or conditions are judged to be unsafe or not in conformance with the program health and safety plan. The SHSO will also be responsible for ensuring that field personnel are in compliance with Occupational Safety and Health Administration (OSHA) requirements for training and medical monitoring prior to and for the duration of the field activities.

The site manager will support the project manager for the specific work the team will accomplish at each site and will be responsible for scheduling and coordinating the testing activities at the respective sites. The site manager will assist the project manager in the day-to-day organization and execution of the various project tasks.

SECTION 4

SITE-SPECIFIC EMPLOYEE TRAINING AND MEDICAL MONITORING REQUIREMENTS

The Parsons ES corporate health and safety manual, incorporated by reference, presents general requirements for Parsons ES employee training and medical monitoring. All field team members will have completed the 40-hour basic health and safety training as specified by OSHA in Title 29, Code of Federal Regulations, Part 1910.120, paragraph (e) (29 CFR 1910.120[e]) and the 8-hour annual refresher training thereafter. All supervisory personnel onsite will be required to have completed an 8-hour supervisor course as required in 29 CFR 1910.120(e).

In addition to the 40-hour course, all field employees will be required to have completed a minimum of 3 days onsite training under the supervision of a trained and experienced supervisor, not necessarily at one of the phytostabilization demonstration sites. If this training is received during a phytostabilization demonstration, the training will be documented on the Field Experience Documentation Form provided in Appendix A. Employees will not participate in field activities until they have been trained to the level required by their job function and responsibility. In addition, at least one person on every Parsons ES field crew will have completed Red Cross or equivalent first-aid and cardiopulmonary resuscitation (CPR) courses. All training documentation for Parsons ES personnel will be verified by the SHSO and maintained by the health and safety manager.

All Parsons ES field team members will be on current medical monitoring programs in accordance with federal OSHA requirements (29 CFR 1910.120) and Parsons ES corporate policies. Listed below are additional health and safety training and medical monitoring requirements for this project.

4.1 ADDITIONAL SAFETY TRAINING REQUIREMENTS

If Level B (self-contained breathing apparatus [SCBA]) respiratory protection is used, additional training may be required for those personnel involved. This training will be conducted onsite as necessary by a qualified, Level B-experienced supervisor. Employees will also be trained in use, care, maintenance, limitations, and disposal of personal protective equipment (PPE) in accordance with 29 CFR 1910.132. All field team members must have site-specific training as discussed in the following subsection.

4.1.1 Site-Specific Safety Briefings

Site-specific safety and health briefings will be conducted by the Parsons ES site manager or SHSO for all personnel who will engage in any phytostabilization demonstration activities. Site-specific safety briefings will address the activities, procedures, monitoring, and equipment applicable to the site operations, as well as site or facility layout, potential hazards, and emergency response services at the site. Additional topics that will be addressed at the safety briefings will include:

- Names of responsible health and safety personnel;
- Identification of site hazards;
- Site contingencies and emergency procedures;
- Exposure risk;
- Symptoms of exposure and exposure treatment for chemical contaminants;
- Use, care, maintenance, and limitations of PPE;
- Decontamination procedures to be followed;
- Location of safety equipment;
- Review of planned activities;
- Defined safety procedures to be followed during field activities; and
- Emergency and evacuation procedures.

Safety briefings will be conducted daily prior to commencement of field activities. Documentation of training and briefings, including agenda and signatures of attending personnel, will be maintained onsite. Site-specific training forms are provided in Appendix A.

4.2 MEDICAL MONITORING REQUIREMENTS

Prior to being assigned to the field activities, each Parsons ES employee will receive a preassignment or baseline physical examination. Preassignment screening has two major functions: 1) determination of an individual's fitness for duty, including the ability to perform work while wearing PPE; and 2) provision of baseline data for comparison with future medical data. Medical qualification/certification documentation will be maintained by the program health and safety manager. All medical examinations and procedures will be performed by or under the supervision of a licensed physician, preferably an occupational physician. The examination content will be determined by the examining physician in accordance with 29 CFR 1910.120(f).

SECTION 5

SAFETY AND HEALTH RISK ANALYSIS

5.1 CHEMICAL HAZARDS

The chemicals of primary concern occurring at the Travis and Altus AFB sites include chlorinated solvents; semi-volatiles; and the petroleum hydrocarbon constituents benzene, toluene, ethylbenzene, and xylenes (BTEX).

Tables 5.1.1 and 5.1.2 summarize the health hazards and properties of the aforementioned and additional compounds. If other compounds are discovered at these sites, the pertinent information about these compounds will be provided in Table 5.1.1 (Travis AFB) and Table 5.1.2 (Altus AFB). The health hazards or other physical/chemical hazards (e.g., corrosiveness, flammability) of the compounds will then be communicated to the onsite employees.

Hazardous substances of primary concern identified are those potentially occurring in contaminated groundwater, soils, sediment, surface water, air, buildings, or abandoned structures.

5.2 PHYSICAL HAZARDS

In addition to the hazardous substances potentially present at the Travis and Altus AFB sites, other physical hazards or hazardous conditions may be expected at the sites during the course of performing phytostabilization demonstration activities. These hazards include possible risks from injury while working around motor vehicles including the auger drilling rig and the Geoprobe® unit; stationary or moving equipment; fire or explosion hazards; slip, trip, and fall hazards; electrical hazards; and excessive noise conditions. Additional physical hazards include heat stress and cold-related exposures.

The guidelines presented in this section are applicable to all types of equipment that may be used during phytostabilization demonstration activities at Travis and Altus AFB. Individual equipment types or certain specialized equipment may require additional safety considerations or specialized training prior to its use. Should any specialized equipment be required during the performance of a task, the program health and safety manager will ensure that operators receive appropriate training. The program health and safety manager is also responsible for ensuring that all equipment is routinely inspected and that any piece of equipment considered unsafe is not used until the unsafe conditions are corrected or repaired.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
Acetone	750	500	2,500 (10% LEL) [f]	100	9.69	Colorless liquid with mint-like odor. Irritates nose, eyes, and throat. Causes headaches, dizziness, central nervous system (CNS) depression, and dermatitis.
Anthracene	0.2 mg/m^3 [g,h]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA [i]	7.23	Colorless to yellow crystals with blue fluorescence. Irritates eyes, skin, and respiratory tract. Causes dermatitis, bronchitis, and lung, skin, and kidney cancer. Mutagen and carcinogen.
Antimony	0.5 mg/m^3	0.5 mg/m^3	50 mg/m^3	NA	NA	Silver-white, lustrous, hard, brittle metal, scale-like crystals or dark-gray, lustrous powder. Irritates skin, eyes, nose, throat, and mouth. Causes coughing, dizziness, headaches, nausea, vomiting, diarrhea, stomach cramps, insomnia, anorexia, and inability to properly smell.
Benzene	1 (29 CFR 1910.1028) [j]	0.5 (skin) [k]	500	4.7	9.24	Colorless to light-yellow liquid (solid<42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
Benzo(a)anthracene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	7.53	Colorless, crystalline solid with greenish-yellow fluorescence. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzo(b)fluoranthene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	NA	Colorless, needle-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzoic Acid	NA	NA	NA	NA	NA	White crystalline or flaky powder or light tan chips with a faint pleasant odor to odorless and a bitter taste. Irritates skin. Inhaled vapors are highly toxic.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
Benzo(k)fluoranthene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	NA	Pale-yellow, needle-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen.
Benzo(g,h,i)perylene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	NA	Large, pale yellow-green, plate-like crystals. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Carcinogen and possible mutagen.
Benzyl Butyl Phthalate	NA	NA	NA	NA	NA	Clear, oily liquid with a slight characteristic odor. Irritates eyes, nose, throat, and skin. Cause CNS depression, nervous system degeneration, dizziness, light-headedness, leukemia, and damage to the testes.
Beryllium	0.002 mg/m^3	0.002 mg/m^3	4 mg/m^3	NA	NA	Hard, brittle, gray-white, metallic solid. Irritates lungs, skin, eyes, and mucous membranes. Causes berylliosis, anorexia, low-weight, weakness, chest pain, coughing, blue skin, clubbed fingers, pulmonary insufficiency, dermatitis, and lung cancer. Mutagen and carcinogen.
Bromodichloromethane	NA	NA	NA	1,680 mg/m^3	10.88	Nonflammable liquid. Carcinogen.
Cadmium (dust)	0.005 mg/m^3 [l] (29 CFR 1910.1027) [l]	0.01 mg/m^3 [m] 0.002 mg/m^3 [n]	9 mg/m^3	NA	NA	Silver-white, blue-tinged, lustrous, odorless, metallic solid. Causes pulmonary edema, shortness of breath, coughing, chest tightness/pain, loss of sense of smell, chills, muscle aches, headaches, nausea, vomiting, diarrhea, mild anemia, and prostatic and lung cancer. Also attacks kidneys. Mutagen, experimental teratogen, and carcinogen.
Carbon Disulfide	4 (skin)	10 (skin)	500	0.0011-7.7	10.08	Colorless to faint-yellow liquid with sweet ether or foul (reagent grade) odor. Irritating to eyes, skin, and mucous membranes on contact. Causes dizziness, headaches, poor sleep, fatigue, nervousness, low-weight, psychosis, nervous system degeneration, Parkinson-like syndrome, ocular changes, heart disease, gastritis, dermatitis, eye and skin burns, liver and kidney damage, and reproductive effects. Mutagen and experimental teratogen.
Carbon Tetrachloride	2	5 (skin)	200	21.4-200	11.47	Colorless liquid with characteristic, ether-like odor. Irritates eyes and skin. Causes CNS depression, nausea, vomiting, liver/kidney damage, drowsiness, dizziness, and incoordination. In animals, causes liver cancer. Mutagen, experimental teratogen, and carcinogen.
Chloroform (Trichloromethane)	2	10	500	205 [o]	11.42	Colorless, heavy liquid with pleasant odor. Irritates eyes and skin. Anaesthetic. Causes dizziness, mental dullness, nausea, confusion,

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a/] (ppm)	TLV [b/] (ppm)	IDLH [c/] (ppm)	Odor Threshold [d/] (ppm)	Ionization Potential [e/] (eV)	Physical Description/Health Effects/Symptoms
						headache, fatigue, anesthesia, and enlarged liver. Also attacks kidneys and heart. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
4-Chloro-3-methylphenol	NA	NA	NA	0.1 mg/kg	NA	White or slightly pink crystals, odorless when pure, but usually with a phenolic odor. Irritates skin.
Chrysene	0.2 mg/m^3 [g/]	0.2 mg/m^3 [g/]	80 mg/m^3 [g/]	NA	7.75	Colorless, crystalline solid with blue to red fluorescence. Irritates eyes, skin, and respiratory tract. Causes burns to skin and eyes, dermatitis, bronchitis and lung, skin, and kidney cancer. Mutagen and carcinogen.
Cobalt metal (dust and fumes)	0.05 mg/m^3	0.02 mg/m^3	20 mg/m^3	>1 mg/m^3 [p/]	NA	Odorless, silver-gray to black, magnetic, somewhat malleable, hard, solid metal. Causes coughing, shortness of breath, wheezing, decreased pulmonary function, dermatitis, low-weight, fibrosis, asthma, and respiratory hypersensitivity. Fumes cause metal fume fever. Suspected carcinogen.
1,1-Dichloroethane (DCA)	100	100	3,000	120	11.06	Colorless, oily liquid with chloroform-like odor and hot saccharine taste. Irritates skin. Causes CNS depression and kidney, lung, and liver damage. Experimental teratogen and questionable carcinogen.
1,2-Dichloroethane (DCA) (Ethylene Dichloride, EDC)	1	10	50	100	11.05	Colorless liquid with a pleasant, chloroform-like odor. Strong narcotic. Irritates eyes. Causes corneal opaqueness, nausea, CNS depression, vomiting, dermatitis, and damage to liver, kidneys, and cardiovascular system. In animals, causes cancer of the forestomach, mammary gland, and circulatory system. Mutagen, experimental teratogen, and carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acrid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Di-n-butylphthalate (Dibutylphthalate)	5 mg/m^3	5 mg/m^3	4,000 mg/m^3	0.26	NA	Colorless to faint-yellow, oily liquid with a slight, aromatic odor and strong, bitter taste. Irritates eyes, upper respiratory system, and stomach. Causes hallucinations, distorted perceptions, nausea or vomiting, and kidney, urethra or bladder changes. Mutagen and experimental teratogen.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
Dinitrotoluene (DNT)	1.5 mg/m^3 (skin)	0.15 mg/m^3 (skin)	50 mg/m^3	NA	NA	Orange-yellow, crystalline solid with a characteristic odor. Causes permanent tissue damage due to oxygen deficiency, blue skin, anemia, jaundice, and reproductive effects. In animals, causes liver, skin, and kidney tumors. Mutagen, experimental teratogen, and carcinogen.
Di-n-octylphthalate	NA	NA	NA	NA	NA	Colorless to light-colored, oily liquid with slight odor. Causes eye, skin, mucous membrane or respiratory irritation.
Ethylbenzene	100	100	800 (10% LEL)	0.25-200	8.76	Colorless liquid with an aromatic odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. Mutagen and experimental teratogen.
Bis(2-Ethylhexyl)Phthalate (Di-sec Octyl Phthalate)	5 mg/m^3	5 mg/m^3	5,000 mg/m^3	NA	NA	Colorless to light-colored, oily liquid with slight odor. Irritates eyes and mucous membranes. Also affects respiratory system, CNS, and gastrointestinal tract. In animals, causes liver damage, liver tumors, and teratogenic effects. Carcinogen.
Fluoranthene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	NA	Pale-yellow, crystalline solid. Causes burns to skin and eyes. Causes nausea, tachycardia, arrhythmia, liver injury, pulmonary edema, and respiratory arrest.[q] Mutagen and carcinogen.
Fluoride	2.5 mg/m^3	2.5 mg/m^3	500 mg/m^3	5.0 mg/m^3	NA	Odorless, white powder or crystals or colorless to dark solid. [Pesticide grade is often dyed blue.] Irritates eyes and respiratory system. Affects CNS, skeleton, kidneys, skin. Causes nausea, abdominal pain, diarrhea, excessive salivation, thirst sweating, stiff spine, dermatitis, convulsions, and calcification of the ligaments of the ribs and pelvis. Mutagen.
2-Hexanone (Methyl n-butyl ketone)	5	5 (skin)	1,600	3.0	9.34	Colorless liquid with an acetone-like odor. Irritates eyes, nose, and skin. Causes nervous system degeneration, weakness, tingling skin, dermatitis, headaches, and drowsiness. Experimental teratogen.
Indeno(1,2,3-cd)pyrene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	NA	Yellow, crystalline solid. Solutions show greenish-yellow fluorescence. Irritates eyes, respiratory tract, and skin. Causes dermatitis, bronchitis, and lung, kidney, and skin cancer. Mutagen and carcinogen.
Lead	0.05 mg/m^3 (29 CFR 1910.1025) [i]	0.05 mg/m^3	100 mg/m^3	NA	NA	Heavy, ductile, bluish-gray, soft metal. Irritates eyes. Causes weakness, exhaustion, insomnia, facial pallor, anorexia, low-weight, malnutrition,

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TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [c] (eV)	Physical Description/Health Effects/Symptoms
						constipation, abdominal pain, gastritis, colic, constipation, gingival lead line, anemia, wrist and ankle paralysis, joint pains, tremors, low blood pressure, and kidney disease. Mutagen, experimental teratogen, and suspected carcinogen.
Manganese (compounds and fume, as Mn)	5 mg/m^3 (ceiling) [f] 1 mg/m^3 [g]	0.2 mg/m^3 [i] 1 mg/m^3 [f]	500 mg/m^3	NA	NA	Lustrous, brittle, silvery, solid metal. Irritates eyes and skin. Causes Parkinson's disease, loss of strength, insomnia, confusion, dry throat, coughing, rales, shortness of breath, tight chest, flu-like fever, lower back paint, vomiting, vague discomfort, fatigue, and kidney damage. Fumes cause metal fume fever. Mutagen, experimental teratogen, and questionable carcinogen.
Methylene Chloride (Dichloromethane, Methylene Dichloride)	25	50	2,300	25-320	11.32	Colorless liquid (gas > 104°F) with a sweet, chloroform-like odor (not noticeable at dangerous concentrations). Irritates eyes and skin. Causes nausea, vomiting, fatigue, weakness, unnatural drowsiness, light-headedness, numbness, tingling limbs, and nausea. In animals, causes lung, liver, salivary and mammary gland tumors. Mutagen, experimental teratogen, and carcinogen.
Methyl Ethyl Ketone (2-Butanone)	200	200	3,000	4.8-25	9.54	Colorless liquid with a moderately sharp, fragrant mint- or acetone-like odor. Irritates eyes, nose, and skin. Causes headaches, dizziness, vomiting, and dermatitis. Experimental teratogen.
Methyl Isobutyl Ketone (MIBK, Hexone)	50	50	500	0.28-8	9.30	Colorless liquid with a fruity, ethereal odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. In animals, causes liver and kidney damage. Experimental teratogen.
Nickel (soluble) (insoluble or metal)	0.1 mg/m^3 1 mg/m^3	0.1 mg/m^3 1 mg/m^3	10 mg/m^3 10 mg/m^3	NA NA	NA NA	Lustrous, silvery, odorless, hard, malleable, ductile, metallic solid. Causes nausea, vomiting, diarrhea, conjunctivitis, sensitization dermatitis, allergic asthma, pneumonitis, and lung and nasal cancer. Mutagen, experimental teratogen, and carcinogen.

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold[d] (ppm)	Ionization Potential[e] (eV)	Physical Description/Health Effects/Symptoms
Perchlorethylene (Tetrachloroethene or PCE)	25 [l]	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Pyrene	0.2 mg/m^3 [g]	0.2 mg/m^3 [g]	80 mg/m^3 [g]	NA	7.72	Colorless to pale-yellow crystalline solid. Solutions slightly bluish with blue fluorescence. Irritates eyes, skin, and respiratory tract. Causes dermatitis, bronchitis, and lung, skin, and kidney cancer. Mutagen and carcinogen.
Silver (soluble compounds and metal)	0.01 mg/m^3	0.01 mg/m^3 (soluble) 0.1mg/m^3 (metal)	10 mg/m^3	NA	NA	White, lustrous, soft, ductile, malleable, solid metal. Causes irritability, skin ulceration, gastrointestinal disturbances, pulmonary edema, hemorrhaging, and localized death of bone marrow, liver, and kidney tissue. Also causes permanent grayish pigmentation of the eyes, skin, throat, and mucous membranes. Questionable carcinogen.
Tetrachloroethene (PCE) (Perchlorethylene)	25 [l]	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 [o]	8.82	Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
1,1,1-Trichloroethane (TCA) (Methyl Chloroform)	350	350	700	20-500	11.00	Colorless liquid with a mild chloroform-like odor. Irritates eyes and skin. Causes headaches, exhaustion, CNS depression, poor equilibrium, dermatitis, liver damage, cardiac arrhythmia, hallucinations or distorted

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TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
						perceptions, motor activity changes, aggression, diarrhea, and nausea or vomiting. Mutagen, experimental teratogen, and questionable carcinogen.
1,1,2-Trichloroethane (TCA)	10 (skin)	10 (skin)	100	NA	11.00	Colorless liquid with a sweet, chloroform-like odor. Irritates eyes, skin, lungs, and nose. Causes dermatitis, liver and kidney damage, and CNS depression. In animals, causes liver cancer. Mutagen and carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vanadium (as vanadium pentoxide dust)	0.05 mg/m^3 [n] (ceiling)	0.05 mg/m^3 [n]	35 mg/m^3	0.5-2.2 mg/m^3	NA	Yellow-orange powder or dark-gray, odorless flakes dispersed in air. Irritates eyes, skin, and throat. Causes green tongue, metallic taste, coughing, runny nose, wheezing, bronchitis, rales, shortness of breath, conjunctivitis, eczema, anemia, loss of appetite, pallor, emaciation, albumin and blood in the urine, and disorders of the gastrointestinal tract, kidneys, blood or CNS.
Vinyl Chloride	1 (29 CFR 1910.1017) [j]	5	NA	260	9.99	Colorless gas (liquid<7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or blue skin on the extremities, liver cancer, and frostbite (liquid). Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.
Vinylidene Chloride [1,1-Dichloroethene (DCE)]	1	5	NA	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
Xylene (o-, m-, and p-isomers)	100	100	900	0.05-200 [o]	8.56 8.44 (p)	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain, and olfactory and pulmonary changes. Also targets blood, liver, and

TABLE 5.1.1 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - TRAVIS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
						kidneys. Mutagen and experimental teratogen.

a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.

b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), *1997 TVLs® and BEIs®*.

c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.

d/ When a range is given, use the highest concentration.

e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.

f/ Indicates that the IDLH value was based on 10% of the lower explosive limit for safety considerations, even though relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations *(NIOSH Pocket Guide to Chemical Hazards, 1997)*.

g/ Based on coal tar pitch volatiles.

h/ mg/m^3 = milligrams per cubic meter.

i/ NA = Not available.

j/ Refer to expanded rules for this compound.

k/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.

l/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.

m/ Total dust.

n/ Respirable fraction.

o/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.

p/ Irritation threshold.

q/ (ceiling) = Ceiling concentration which should not be exceeded at any time.

r/ Based on analogy to phenol.

s/ Based on fume.

t/ Based on dust.

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [a] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
Benzene	1 (29 CFR 1910.1028) [f]	0.5 (skin) [g]	500	4.7	9.24	Colorless to light-yellow liquid (solid<42°F) with an aromatic odor. Eye, nose, skin, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, anorexia, exhaustion, dermatitis, bone marrow depression, and leukemia. Mutagen, experimental teratogen, and carcinogen.
2-Butanone (Methyl Ethyl Ketone, MEK)	200	200	3,000	4.8-25	9.54	Colorless liquid with a moderately sharp, fragrant, mint- or acetone-like odor. Irritates eyes, nose, and skin. Causes headaches, dizziness, vomiting, and dermatitis. Experimental teratogen.
Carbon Disulfide	4 (skin)	10 (skin)	500	0.0011-7.7	10.08	Colorless to faint-yellow liquid with sweet ether or foul (reagent grade) odor. Irritating to eyes, skin, and mucous membranes on contact. Causes dizziness, headaches, poor sleep, fatigue, nervousness, low-weight, psychosis, nervous system degeneration, Parkinson-like syndrome, ocular changes, heart disease, gastritis, dermatitis, eye and skin burns, liver and kidney damage, and reproductive effects. Mutagen and experimental teratogen.
Carbon Tetrachloride	2	5 (skin)	200	21.4-200	11.47	Colorless liquid with characteristic, ether-like odor. Irritates eyes and skin. Causes CNS depression, nausea, vomiting, liver/kidney damage, drowsiness, dizziness, and incoordination. In animals, causes liver cancer. Mutagen, experimental teratogen, and carcinogen.
Chlorobenzene	75	10	1,000	0.21-60	9.07	Colorless, liquid narcotic with an almond-like odor. Irritates eyes, nose, and skin. Causes drowsiness, incoordination, and CNS depression. In animals, causes lung and kidney injury. Mutagen and experimental teratogen.
Chloroform (Trichloromethane)	2	10	500	205 [h]	11.42	Colorless, heavy liquid with pleasant odor. Irritates eyes and skin. Anaesthetic. Causes dizziness, mental dullness, nausea, confusion, headache, fatigue, anesthesia, and enlarged liver. Also attacks kidneys and heart. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Chloromethane	50	50	2,000	10-100	11.28	Colorless gas with a sweet taste and a faint, sweet odor not noticeable at

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TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL [a/] (ppm)	TLV [b/] (ppm)	IDLH [c/] (ppm)	Odor Threshold [d/] (ppm)	Ionization Potential [e/] (eV)	Physical Description/Health Effects/Symptoms
(Methyl Chloride)		(skin)				dangerous concentrations. Causes dizziness, nausea, vomiting, visual disturbances, staggering, slurred speech, convulsions, coma, frostbite (liquid), reproductive and teratogenic effects, and CNS, liver, and kidney damage. In animals, causes lung, kidney, and forestomach tumors. Mutagen, experimental teratogen, and carcinogen.
Dibutylphthalate (Di-n-butylphthalate)	5 mg/m^3 [i/]	5 mg/m^3	4,000 mg/m^3	0.26	NA [j/]	Colorless to faint-yellow, oily liquid with a slight, aromatic odor and strong, bitter taste. Irritates eyes, upper respiratory system, and stomach. Causes hallucinations, distorted perceptions, nausea or vomiting, and kidney, urethra or bladder changes. Mutagen and experimental teratogen.
1,2-Dichloroethane (DCA) (Ethylene Dichloride, EDC)	1	10	50	100	11.05	Colorless liquid with a pleasant, chloroform-like odor. Strong narcotic. Irritates eyes. Causes corneal opaqueness, nausea, CNS depression, vomiting, dermatitis, and damage to liver, kidneys, and cardiovascular system. In animals, causes cancer of the forestomach, mammary gland, and circulatory system. Mutagen, experimental teratogen, and carcinogen.
1,1-Dichloroethene (DCE) (Vinylidene Chloride)	1	5	NA	NA	10.00	Colorless liquid or gas (>89°F) with a mild, sweet, chloroform-like odor. Irritates eyes, skin, and throat. Causes dizziness, headaches, nausea, shortness of breath, liver and kidney dysfunctions, and lung inflammation. Mutagen and carcinogen.
1,2-Dichloroethene (DCE) (cis- and trans-isomers)	200	200	1,000	0.085-500	9.65	Colorless liquid (usually a mixture of cis- and trans- isomers), with a slightly acrid, chloroform-like odor. Irritates eyes and respiratory system. CNS depressant. Cis- isomer is a mutagen.
Ethylbenzene	100	100	800 (10% LEL) [k/]	0.25-200	8.76	Colorless liquid with an aromatic odor. Irritates eyes, skin, and mucous membranes. Causes dermatitis, headaches, narcosis, and coma. Mutagen and experimental teratogen.
Bis(2-Ethylhexyl)Phthalate (Di-sec Octyl Phthalate)	5 mg/m^3	5 mg/m^3	5,000 mg/m^3	NA	NA	Colorless to light-colored, oily liquid with slight odor. Irritates eyes and mucous membranes. Also affects respiratory system, CNS, and gastrointestinal tract. In animals, causes liver damage, liver tumors, and teratogenic effects. Carcinogen.
Methylene Chloride (Dichloromethane, Methylene Dichloride)	25	50	2,300	25-320	11.32	Colorless liquid (gas>104°F) with a sweet, chloroform-like odor (not noticeable at dangerous concentrations). Irritates eyes and skin. Causes nausea, vomiting, fatigue, weakness, unnatural drowsiness, light-headedness, numbness, tingling limbs, and nausea. In animals, causes lung, liver, salivary and mammary gland tumors. Mutagen, experimental

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
						teratogen, and carcinogen.
Tetrachloroethene (PCE) (Perchlorethylene)	25 [f]	25	150	5-50	9.32	Colorless liquid with a mild chloroform odor. Eye, nose, skin and throat irritant. Causes nausea, flushed face and neck, vertigo, dizziness, headaches, hallucinations, incoordination, drowsiness, coma, pulmonary changes, and skin redness. Cumulative liver, kidney, and CNS damage. In animals, causes liver tumors. Mutagen, experimental teratogen, and carcinogen.
Toluene	100	50 (skin)	500	0.2-40 [h]	8.82	Colorless liquid with sweet, pungent, benzene-like odor. Irritates eyes and nose. Causes fatigue, weakness, dizziness, headaches, hallucinations or distorted perceptions, confusion, euphoria, dilated pupils, nervousness, tearing, muscle fatigue, insomnia, skin tingling, dermatitis, bone marrow changes, and liver and kidney damage. Mutagen and experimental teratogen.
1,1,1-Trichloroethane (TCA) (Methyl Chloroform)	350	350	700	20-500	11.00	Colorless liquid with a mild chloroform-like odor. Irritates eyes and skin. Causes headaches, exhaustion, CNS depression, poor equilibrium, dermatitis, liver damage, cardiac arrhythmia, hallucinations or distorted perceptions, motor activity changes, aggression, diarrhea, and nausea or vomiting. Mutagen, experimental teratogen, and questionable carcinogen.
Trichloroethene (TCE)	50	50	1,000	21.4-400	9.45	Clear, colorless or blue liquid with chloroform-like odor. Irritates skin and eyes. Causes fatigue, giddiness, headaches, vertigo, visual disturbances, tremors, nausea, vomiting, drowsiness, dermatitis, skin tingling, cardiac arrhythmia, and liver injury. In animals, causes liver and kidney cancer. Mutagen, experimental teratogen, and carcinogen.
Vinyl Chloride	1 (29 CFR 1910.1017) [f]	5	NA	260	9.99	Colorless gas (liquid<7°F) with a pleasant odor at high concentrations. Severe irritant to skin, eyes, and mucous membranes. Causes weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or blue skin on the extremities, liver cancer, and frostbite (liquid). Also attacks lymphatic system. Mutagen, experimental teratogen, and carcinogen.
Xylene	100	100	900	0.05-200 [h]	8.56	Colorless liquid with aromatic odor. P-isomer is a solid <56°F. Irritates

TABLE 5.1.2 HEALTH HAZARD QUALITIES OF HAZARDOUS SUBSTANCES OF CONCERN - ALTUS AFB

Compound	PEL [a] (ppm)	TLV [b] (ppm)	IDLH [c] (ppm)	Odor Threshold [d] (ppm)	Ionization Potential [e] (eV)	Physical Description/Health Effects/Symptoms
(o-, m-, and p-isomers)					8.44 (p)	eyes, skin, nose, and throat. Causes dizziness, drowsiness, staggered gait, incoordination, irritability, excitement, corneal irregularities, conjunctivitis, dermatitis, anorexia, nausea, vomiting, abdominal pain, and olfactory and pulmonary changes. Also targets blood, liver, and kidneys. Mutagen and experimental teratogen.

a/ PEL = Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. Expressed as parts per million (ppm) unless noted otherwise. PELs are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997. Some states (such as California) may have more restrictive PELs. Check state regulations.

b/ TLV = Threshold Limit Value - Time-Weighted Average. Average air concentration (same definition as PEL, above) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH), *1997 TLVs® and BEIs®*.

c/ IDLH = Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise. IDLH values are published in the *NIOSH Pocket Guide to Chemical Hazards*, 1997.

d/ When a range is given, use the highest concentration.

e/ Ionization Potential, measured in electron volts (eV), used to determine if field air monitoring equipment can detect substance. Values are published in the *NIOSH Pocket Guide to Chemical Hazards*, June 1997.

f/ Refer to expanded rules for this compound.

g/ (skin) = Refers to the potential contribution to the overall exposure by the cutaneous route.

h/ Olfactory fatigue has been reported for the compound and odor may not serve as an adequate warning property.

i/ mg/m^3 = milligrams per cubic meter.

j/ NA = Not available.

k/ Indicates that the IDLH value was based on 10% of the lower explosive limit for safety considerations, even though relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations *(NIOSH Pocket Guide to Chemical Hazards, 1997)*.

l/ NIOSH recommends reducing exposure to the lowest feasible concentration, and limiting the number of workers exposed.

5.2.1 General Vehicle Operations

The following safety procedures will be followed when operating a motor vehicle within a USAF installation:

- Seat belts will be worn at all times.
- Obey all traffic and speed limit signs.
- Park in designated areas.
- Be aware of construction equipment and other vehicles operating in the area.
- Be aware of pedestrian traffic.
- Acquire eye contact and permission from the vehicle/equipment operator to enter an area around operating vehicles.
- Never crouch down in front of or behind a vehicle.
- Drivers must visually check around the vehicle before moving it.
- Vehicles will never be loaded beyond the designed passenger capacity or beyond the rated load capacity.
- Vehicles will never be loaded in a manner that obscure the driver's front or side views.

The daily vehicle maintenance report located in Appendix A must be completed by the vehicle drivers for all field vehicles (including rented vehicles) upon initial receipt of the vehicle and every morning thereafter, prior to use, that the vehicle is used on a Parsons ES project.

5.2.2 Large Motor Vehicles including Drilling Rigs

Working with large motor vehicles could be a major hazard at these sites. Injuries can result from equipment dislodging and striking unsuspecting personnel, and impacts from flying objects or overturning of vehicles. Vehicles and heavy equipment design and operation will be in accordance with 29 CFR, Subpart O, 1926.600 through 1926.602. In particular, the following precautions will be used to help prevent injuries and accidents:

- Do not back up large motor vehicles unless the vehicle has backup warning lights and a reverse signal alarm audible above the surrounding noise level, or an observer signals it is safe to do so.
- Motor vehicle cabs will be kept free of all nonessential items and all loose items will be secured.

- Drilling rig masts will be lowered to the ground and parking brakes will be set before shutting off the vehicle.

- Drilling rig brakes, cables, kill switches, hydraulic lines, light signals, fire extinguishers, fluid levels, steering, tires, horn, and other safety devices will be inspected daily.

- All personnel working at and around the drilling rig must be informed of the locations of the kill switches.

- Only qualified operators will be allowed to operate the drilling rig or other heavy equipment.

- When working near a backhoe, field personnel will maintain sight contact with the operator.

- The limits of the swing radius of the backhoe must be marked on the ground with cones or boundary tape. Personnel will not enter this bounded area until the backhoe has been shut down, and the operator signals that it is acceptable to enter. Backhoe operations will resume only after personnel have left the area within the swing radius.

5.2.3 Hazards Associated with the Geoprobe® Unit

The Geoprobe® unit consists of a hydraulically-driven press mounted on the bed of a pick-up truck, with power supplied to the cylinder via a power-take-off on the truck. A list of safety instructions provided by the Geoprobe® manufacturer is provided below, and will be followed by all Parsons ES and subcontractor personnel.

- Never operate the controls without proper training.

- Always take the vehicle out of gear and set the emergency brake before engaging the remote ignition.

- If the vehicle is parked on a loose or soft surface, do not fully raise the rear of the vehicle with the probe foot, as the vehicle may fall or move, causing injury.

- Always extend the probe unit out from the vehicle, and deploy the foot to clear the vehicle roof line before folding the probe unit out.

- Operators must wear OSHA-approved steel-toed shoes, and keep feet clear of the probe foot.

- Only one person should operate the probe machine and assemble/disassemble the probe rods and accessories.

- Never place hands on top of a rod while it is under the machine.

- Turn off the hydraulic system while changing rods, inserting the hammer anvil or attaching accessories.

- While operating the controls, the operator must stand to the control side of the probe machine, clear of the probe foot and mast.

- Wear safety glasses at all times during the operation of this machine.

- Never exert down pressure on the probe rod so as to lift the machine base over six inches off the ground.

5.2.4 Subsurface Hazards

Before intrusive field activities are performed, efforts must be made to determine if underground installations (i.e., sewers, and telephone, water, fuel, and electrical lines) will be encountered and if so, where such underground installations are located. The site manager will ensure that all underground installations have been identified prior to any intrusive operations.

5.2.5 Electrical Hazards

Some of the equipment used during the phytostabilization demonstrations is powered by electricity. Maintenance and daily activities require personnel to use, handle, and control this equipment. Safe work practices must be strictly observed to avoid serious injury and death.

According to 29 CFR 1910.269(l), only qualified employees may work on or with exposed energized lines or parts of equipment, or in areas containing unguarded, uninsulated, energized lines or parts of equipment operating at 50 volts (V) or more. Qualified employees must be trained in accordance with 29 CFR 1910.269(a) and certified as such by the employer.

Ordinary 120 V electricity may be fatal. Extensive studies have shown that currents as low as 10 to 15 milliamps (mA) can cause loss of muscle control and that 12 V may, on good contact, cause injury. Therefore, all voltages should be considered dangerous.

Electricity can paralyze the nervous system and stop muscular action. Frequently, electricity may affect the breathing center at the base of the brain and interrupt the transmission of the nerve impulses to the muscles responsible for breathing. In other cases, the electrical current directly affects the heart, causing it to cease pumping blood. Death follows due to a lack of oxygen in the body. Therefore, a victim must be freed from the live conductor promptly by use of a nonconducting implement, such as a piece of wood, or by turning off the electricity to at least this point of contact. Bare hands should never be used to remove a live wire from a victim or a victim from an electrical source. Artificial respiration or CPR should be applied immediately and continuously until breathing is restored, or until a physician or emergency medical technician arrives.

General rules for recognizing electrical safety are provided below.

- Only authorized and qualified personnel will perform electrical installations or repairs.

- All electrical wires and circuits will be assumed to be "live," unless it can be positively determined they are not.

- Appropriate protective clothing will be worn by personnel performing electrical work.

- All electrical equipment will be properly grounded and class-approved for the location.

- Ground fault circuit interrupter receptacles and circuit breakers will be installed where required by the National Electric Code and 29 CFR 1926.404.

- Electrical control panels will not be opened unless necessary.

- No safety device will be made inoperative by removing guards, using oversized fuses, or by blocking or bypassing protective devices, unless it is absolutely essential to the repair or maintenance activity, and then only after alerting operating personnel and the maintenance supervisor.

- All power tools will have insulated handles, be electrically grounded, or be double insulated.

- Fuse pullers will be used to change fuses.

- Metal ladders, metal tape measures, and other metal tools will not be used around electrical equipment or overhead electrical lines.

- Wires and extension cords will be placed or arranged so as to not pose a tripping hazard.

5.2.6 Slip, Trip, and Fall Hazards

Existing site conditions may pose a number of slip, trip, and fall hazards, such as:

- Open excavations, pits, or trenches;

- Slippery surfaces;

- Steep or uneven grades;

- Surface obstructions; and

- Construction materials or debris.

The extension cords connecting pumps to power supplies also provide a trip and fall hazard. Caution must be exercised and unnecessary personnel should avoid the area of the cord.

All field team members will be instructed to be cognizant of potential safety hazards and immediately inform the SHSO or the site manager about any new hazards. If the hazard cannot be immediately removed, actions must be taken to warn site workers about the hazard. The site will be kept in a neat, organized, and orderly fashion. Rubbish, trash, or debris generated by the project team shall be picked up and properly disposed of on a daily basis. Items such as tools, equipment, and hoses will be properly stored when not in use.

5.2.7 Noise-Induced Hearing Loss

Work onsite may involve the use of equipment such as drilling rigs, pumps, and generators. The exposure of unprotected site workers to this noise or to aircraft noise during site activities can result in noise-induced hearing loss. Heavy equipment can emit noise levels exceeding the federal OSHA time-weighted average (TWA) limit of 85 decibels (dB). Noise levels in the area of the drilling rig and Geoprobe® unit will be presumed in exceedance of the OSHA TWA, and hearing protection will be required. Foam ear plugs will generally provide adequate protection. The SHSO will ensure that either ear muffs or disposable foam earplugs are made available to, and are used by, all personnel in the vicinity of the operation of equipment, aircraft noise or other sources of high intensity noise.

5.2.8 Fire or Explosion Hazards

Fuels and solvents have been released into the soils at Travis and Altus AFBs and vapors from these fuels may be flammable or explosive. In addition, drilling or other intrinsic activities may be performed in former or existing landfill areas. Therefore, precautions will be taken when performing phytostabilization demonstration activities to ensure that combustible or explosive vapors have not accumulated, or that an ignition source is not introduced into a flammable atmosphere.

OSHA standards for fire protection and prevention are included in 29 CFR Subpart F, 1926.150 through 1926.154. Of particular concern on these sites are:

- Proper storage of flammables;
- Adequate numbers and types of fire extinguishers;
- Use of intrinsically safe (explosion-proof) equipment where appropriate; and
- Monitoring for development of an explosive atmosphere.

The SHSO will ensure that the above concerns are adequately mitigated.

5.2.9 Electric Power Line Clearance and Thunderstorms

Extra precautions will be exercised when drilling near overhead electrical lines. As stated in 29 CFR 1926.550, the minimum clearance between overhead electrical lines of 50 kilovolts (kV) or less and the drill rig is 10 feet. For lines rated over 50 kV, the minimum clearance between the lines and any part of the rig is 10 feet plus 0.4 inches for each kV over 50 kV. Drilling operations must cease during thunderstorms.

The SHSO will provide onsite surveillance of the drilling subcontractor to ensure that personnel meet these requirements. If deficiencies are noted, work will be stopped and corrective actions implemented. Reports of health and safety deficiencies and the corrective actions taken will be forwarded to the installation manager by the SHSO.

5.2.10 Effects and Prevention of Heat Stress

Adverse weather conditions are important considerations in planning and conducting site operations. Hot or cold weather can cause physical discomfort, loss of efficiency, and personal injury. These condition are discussed further below.

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur. They can range from mild symptoms such as fatigue; irritability; anxiety; and decreased concentration, dexterity, or movement; to death. Medical help must be obtained for the more serious cases of heat stress. One or more of the following actions will help reduce heat stress:

- Provide plenty of liquids. To replace body fluids (water and electrolytes) lost due to perspiration, each employee must drink 1 to 1.5 gallons of water or commercial electrolyte mix per day. Workers are encouraged to frequently drink small amounts, i.e. one cup every 15-20 minutes.

- Field personnel are cautioned to minimize alcohol intake during off-duty hours.

- Provide cooling devices (e.g., water jackets or ice vests) to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker mobility.

- Wear long cotton underwear, which acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.

- Install portable emergency showers and/or hose-down facilities to reduce body temperature and to cool protective clothing.

- In extremely hot weather, conduct non-emergency response operations in the early morning or evening.

- Ensure that adequate shelter is available to protect personnel against sun, heat, or other adverse weather conditions which decrease physical efficiency and increase the probability of accidents.

- In hot weather, rotate workers wearing protective clothing.

- Maintain good hygienic standards by frequent changing of clothing and daily showering. Clothing should be permitted to dry during rest periods. Workers who notice skin problems should immediately consult the SHSO.

5.2.10.1 Heat-Related Problems

- Heat rash: Caused by continuous exposure to heat and humid air, and aggravated by chafing clothes. Decreases ability to tolerate heat and is a nuisance.
- Heat cramps: Caused by profuse perspiration with inadequate fluid intake and chemical replacement, especially salts. Signs include muscle spasms and pain in the extremities and abdomen.
- Heat exhaustion: Caused by increased stress on various organs to meet increased demands to cool the body. Signs include shortness of breath; increased pulse rate (120-200 beats per minute); pale, cool, moist skin; profuse sweating; and dizziness and exhaustion.
- Heat stroke: The most severe form of heat stress. Body must be cooled immediately to prevent severe injury and/or death. Signs include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and possibly coma. Medical help must be obtained immediately.

5.2.10.2 Heat-Stress Monitoring

Monitoring of personnel wearing impermeable clothing will begin when the ambient temperature is 70°F (21°C) or above. Table 5.2 presents the suggested frequency for such monitoring. Monitoring frequency will increase as the ambient temperature increases or as slow recovery rates are observed. Heat-stress monitoring will be performed by a person with current first-aid certification who is trained to recognize heat-stress symptoms. For monitoring the body's recuperative capabilities in response to excess heat, one or more of the techniques listed below will be used. Other methods of heat-stress monitoring may also be used, such as the wet-bulb globe temperature index from the American Conference of Governmental Industrial Hygienists (ACGIH) (1997) TLV and BEI booklet.

To monitor the worker, measure:

- Heart rate: Count the radial pulse during a 30-second period as early as possible during the rest period.
  - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, the next work cycle will be shortened by one-third and the rest period will remain the same.
  - If the heart rate still exceeds 110 beats per minute at the next rest period, the following work cycle will be reduced by one-third.
- Oral temperature: Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
  - If oral temperature exceeds 99.6° (37.6°C), the next work cycle will be reduced by one-third without changing the rest period.

TABLE 5.2
SUGGESTED FREQUENCY OF PHYSIOLOGICAL MONITORING FOR FIT AND ACCLIMATIZED WORKERS[a/]

Adjusted Temperature[b/]	Normal Work Ensemble[c/]	Impermeable Ensemble[d/]
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5° - 90°F (30.8°- 32.2° C)	After each 60 minutes of work	After each 30 minutes of work
82.5° -87.5° F (28.1°- 30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5°-82.5° F (25.3°- 28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5°-77.5°F (22.5°- 25.3°C)	After each 150 minutes of work	After each 120 minutes of work

a/ For work levels of 250 kilocalories/per hour.

b/ Calculate the adjusted air temperature (ta adj) by using this equation: ta adj = ta °F + (13 x sunshine multiplier [i.e., 50 percent sunshine equals a .5 multiplier]). Measure air temperature (ta) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate the sunshine multiplier by judging what percent of time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine - no cloud cover and a sharp, distinct shadow; 0 percent sunshine = no shadows).

c/ A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and trousers.

d/ Saranex®, Poly-Coated Tyvek®, Etc.

- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, the following work cycle will be reduced by one-third.

- No worker will be permitted to wear a semipermeable or impermeable garment when oral temperature exceeds 100.6°F (38.1°C).

5.2.11 Cold Exposure

It is possible that work on this project may be conducted during the winter months; therefore, injury due to cold exposure may become a problem for field personnel. Cold exposure symptoms, including hypothermia and frostbite, will be monitored when personnel are exposed to low temperatures for extended periods of time.

Persons working outdoors in temperatures at or below freezing may suffer from cold exposure. During prolonged outdoor periods with inadequate clothing, effects of cold exposure may even occur at temperatures well above freezing. Cold exposure may cause severe injury by freezing exposed body surfaces (frostbite), or may result in profound generalized cooling (hypothermia), possibly causing death. Areas of the body which have high surface area-to-volume ratios such as fingers, toes, and ears are the most susceptible to frostbite.

Two factors influence the development of a cold injury: ambient temperature and wind velocity. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. For example, 14°F with a wind speed of 15 miles per hour (mph) is equivalent in chilling effect to still air at -18°F. Cold exposure is particularly a threat to site workers if the body cools suddenly when chemical-protective equipment is removed, and the clothing underneath is perspiration-soaked. The presence of wind greatly increases the rate of cooling.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: characterized by suddenly blanching or whitening of skin.

- Superficial frostbite: skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.

- Deep frostbite: tissues are cold, pale, and solid; an extremely serious injury.

Systemic hypothermia, or lowering of the core body temperature, is caused by exposure to freezing or rapidly dropping temperatures. Symptoms are usually exhibited in five stages:

- Shivering and uncoordination;
- Apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F (35°C);
- Unconsciousness, glassy stare, slow pulse, and slow respiratory rate;

- Freezing of the extremities; and
- Death.

5.2.11.1 Evaluation and Control

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 5.3. For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.3°F) regardless of wind speed.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents. If fine work is to be performed with bare hands for more than 10 to 20 minutes in an environment below 16°C (60.8°F), special provisions should be established for keeping the workers' hands warm. For this purpose, warm air jets, radiant heaters (fuel burner or electric radiator), or contact warm plates may be used. At temperatures below -1°C (30.2°F), metal handles of tools and control bars should be covered by thermal insulating material.

To prevent contact frostbite, workers should wear gloves. When cold surfaces below -7°C (19.4°F) are within reach, a warning will be given to the workers by the supervisor or SHSO to prevent inadvertent contact with bare skin. If the air temperature is -17.5°C (0°F) or less, the hands should be protected by mittens. Machine controls and tools for use in cold conditions should be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers will wear cold protective clothing appropriate for the level of cold and physical activity. If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work will be modified or suspended until adequate clothing is made available or until weather conditions improve.

5.2.11.2 Work-Warming Regimen

If work is performed continuously in the cold at an equivalent chill temperature (ECT) below -7°C (19.4°F), heated warming shelters (tents, cabins, rest rooms) will be made available nearby. The workers will be encouraged to use these shelters at regular intervals, the frequency depending on the severity of the environmental exposure. The onset of heavy shivering, frostnip, the feeling of excessive fatigue, drowsiness, irritability, or euphoria are indications for immediate return to the shelter. When entering the heated shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit sweat evaporation, or a change of dry work clothing should be provided. A change of dry work clothing may be necessary to prevent workers from returning to work with wet clothing. Dehydration, or the loss of body fluids, occurs insidiously in the cold environment and may increase the susceptibility of the worker to cold injury due to a significant change in blood flow to

TABLE 5.3
THRESHOLD LIMIT VALUES WORK/ WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT

Air Temperature-Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C(approx.)	°F (approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28 °	-15° to -19 °	(Norm Breaks)	1	(Norm Breaks)		75 min	2	55 min	3	40 min	4
-29° to -31°	-20° to -24 °	(Norm Breaks)	1	75 min	2	55 min	3	40 min	4	30 min	5
-32° to -34°	-25° to -29 °	75 min	2	55 min	3	40 min	4	30 min	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min	3	40 min	4	30 min	5	Non-emergency work should cease		↓	
-38° to -39°	-35° to -39°	40 min	4	30 min	5	Non-emergency work should cease		↓		↓	
-40° to -42°	-40° to -44°	30 min	5	Non-emergency work should cease		↓		↓		↓	
-43° & below	-45° & below	Non-emergency work should cease		↓		↓		↓		↓	

Notes for Tables 5.3

1. Schedule applies to any 4-hour work period with moderate to heavy work activity, with warm-up periods in a warm location and with an extended break (e.g., lunch) at the end of the 4-hour work period in a warm location. For light-to-moderate (limited physical movement): apply the schedule one step lower. For example, at -35°C (-30°F) with no noticeable wind (Step 4), a worker at a job with little physical movement should have a maximum work period of 40 minutes with 4 breaks in a 4-hour period (Step 5)

2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph; light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.

3. In general the warm-up schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.

4. TLVs apply only for workers in dry clothing.

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the extremities. Warm sweet drinks and soups should be provided at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of the diuretic and circulatory effects.

For work practices at or below -12°C (10.4°F) ECT, the following should apply:

- The workers will be under constant protective observation (buddy system or supervision).
- The work rate should not be so high as to cause heavy sweating that will result in wet clothing; if heavy work must be done, rest periods will be taken in unheated shelters, and the opportunity for changing into dry clothing should be provided.
- New employees should not be required to work full-time in the cold during the first days of employment until they become accustomed to the working conditions and required protective clothing.
- The weight and bulkiness of clothing should be included in estimating the required work performances and weights to be lifted by the worker.
- The work should be arranged in such a way that sitting still or standing still for long periods is minimized. Unprotected metal chair seats will not be used. The worker should be protected from drafts to the greatest extent possible.
- The workers will be instructed in safety and health procedures relative to cold exposures.

5.3 BIOLOGICAL HAZARDS

Various biological hazards may be encountered at Travis and Altus AFBs. These hazards include pathogenic organisms or diseases such as Bubonic Plague, Equine Encephalitis, and Lyme Disease. Other biological hazards include insects, snakes, spiders, and cactuses.

Bubonic plague is a bacterial disease which is spread to humans by fleas that have bitten an infected animal. Bubonic plague displays symptoms rapidly. Chills and fever are soon accompanied by swelling of the lymph nodes, usually on one side of the body. These painful swellings are usually dark blue to black, hence the other common name for this disease, black death. The disease is treatable with antibiotics. Field personnel must wear Tyvek® suits with leg seams taped to boots or boot covers to minimize contact with fleas while working in prairie dog towns.

Equine encephalitis, an inflammation of the brain, can be carried by mosquitoes. Field personnel must wear long-sleeved clothing and/or use insect repellents if they are working in areas of mosquito infestations.

Bites from wood ticks may result in the transmission of Lyme disease - a serious and often fatal bacterial disease. The Borrelia burgdorferi bacteria infects wood ticks, which can bite humans and transfer the bacteria into the bloodstream. Transmission of Lyme disease is most likely in late spring, summer, and early fall.

There are three stages of Lyme disease, although not everyone will proceed through all the stages or experience all the symptoms. The initial symptoms may include a red rash that is circular and blotchy and expands around the tick bite, and flu-like symptoms such as fatigue, headaches, fever, swollen glands, and stiffness and pain in muscles and joints. The next stage can occur from a few days to a few weeks after the initial stage. Symptoms of this phase may include irregular heartbeat, facial paralysis, joint pain, irritability, headaches, dizziness, poor coordination, weakness, severe fatigue, and memory loss. The third stage may occur weeks to years after the second stage. Arthritis, often in the knees, is the most common symptom of this stage. The arthritis may disappear and recur many times, and chronic arthritis may develop.

Prompt medical treatment with antibiotics is usually successful in preventing further complications from this disease. Lyme disease becomes more difficult to treat the longer treatment is delayed. Long-sleeved shirts with snug collar and cuffs, pants tucked into socks, and personal protective equipment will offer some protection. However, the use of tick repellent may also be warranted. Personnel should perform self-checks for ticks at the end of each work day.

The potential exists for contact with snakes or insects which may cause injury or disease when performing phytostabilization demonstration activities at Travis and Altus AFBs. There are plants which may be injurious (i.e., thorns) as well. Sturdy work clothes and shoes will be worn by field personnel to help prevent injuries. Personnel should be aware that rattlesnakes, water moccasins or alligators may be present in an area and should therefore exercise caution, especially when working in previously undisturbed areas and locations around animal dens and wetland habitats.

An abundance of red fire ants may be observed at Travis and Altus AFBs, especially in the vicinity of the existing monitoring wells. Do not stand on, place equipment on or otherwise disturb the ant hills. It is also advisable to place a four foot square piece of plywood where personnel need to stand. An insect repellent may be used if it does not interfere with the desired groundwater sampling analyses. Latex booties taped at the top or Tyvek® suits may also be used. Frequent self-checks for crawling ants should also be performed.

Poison ivy, poison oak, and poison sumac can be encountered at Travis and Altus AFBs. Poison ivy is a woody vine leaves are divided into three leaflets. Poison oak is a low branching shrub with leaflets also in threes. Poison sumac is a shrub or small tree occurring in swamps. Poison sumac have 7 to 13 leaflets which resemble those of green ash trees. All of these species are poisonous and can cause contact dermatitis. Personnel must wear Tyvek® suits or other protective clothing when working in areas containing these plant species.

Black widow spiders and scorpions may also be present onsite. The black widow spider has a shiny black body about the size of a pea, with a red or yellow hourglass-shaped mark on its abdomen. It weaves shapeless diffuse webs in undisturbed areas. A bite may result in severe pain, illness, and possible death from complications, but usually not from the bite itself. There are several types of scorpions native to the United States. Scorpions may be brown to yellowish in color, and range from 1/2 inch to 8 inches in length. Their bodies are divided into two parts: a short, thick upper body, and a long abdomen with a six-segment tail. A scorpion has six pairs of jointed appendages: one pair of small pincers, one pair of large claws, and four pairs of jointed legs. They are most active at night. A scorpion sting is very painful, but usually will not result in death.

In addition to spiders and scorpions, bees and wasps may be nuisances to field personnel. Properly trained personnel will administer first aid should a bee or wasp sting occur.

SECTION 7

LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

7.1 PERSONAL PROTECTIVE EQUIPMENT

The personal protection level prescribed for the phytostabilization demonstrations is OSHA Level D (no respiratory or chemical protective clothing), with a contingency for the use of OSHA Level C or B as site conditions require (Figure 7.1). Unless certain compounds are ruled out through use of appropriate air monitoring techniques such as Dräger® tubes, portable sampling pumps, or an onsite gas chromatograph (GC), Level C respiratory protection (air-purifying respirator [APR]) cannot be used. Level C protection may only be used on this project when vapors in air are adequately identified and quantified and Level C respirator-use criteria are met. Level B (supplied air) respiratory protection must be used on this project in the presence of unknown vapor constituents or if benzene is detected at or above 1 part per million, volume per volume (ppmv). This is based on the toxicity and warning properties (high odor threshold) for benzene. Air monitoring must be conducted in the worker breathing zone when the potential occurrence of these compounds exists.

Ambient air monitoring of organic gases/vapors (using photoionization detectors such as an HNU® or Photovac® MicroTIP®, or by colorimetric analysis with Dräger® tubes) will be used to select the appropriate level of personal protection. The flow chart presented in Figure 7.1 will be used to select respiratory protection against volatile hydrocarbon constituents. If the portable air monitoring equipment indicates organic vapor concentrations of 0-5 meter units (mu), site workers will continue air monitoring in a Level D ensemble. If organic vapors reach 5-25 mu for more than 30 seconds, and benzene concentrations exceed 1 ppmv, site workers will evacuate the area or upgrade to Level B ensemble, if trained to do so. If benzene concentrations are less than 1 ppmv in the breathing zone, and vapors are in the range of 5-25 mu, the site crews may continue in Level D ensembles with periodic air monitoring. If organic vapor concentrations reach 25-50 mu for more than 30 seconds and benzene concentrations exceed 1 ppmv in the worker breathing zone, site crews will evacuate the area or upgrade to Level B ensembles. If benzene concentrations are less than 1 ppmv, and vapors are in the range of 25-50 mu, site workers will don full facepiece APRs equipped with organic vapor cartridges (National Institute for Occupational Safety and Health [NIOSH]-approved), and continue periodic monitoring. If organic vapor concentrations reach 50-500 mu for more than 30 seconds, site crews will evacuate the site or upgrade to Level B ensembles. If organic vapor concentrations exceed 500 mu for more than 30 seconds, site crews will evacuate the site.

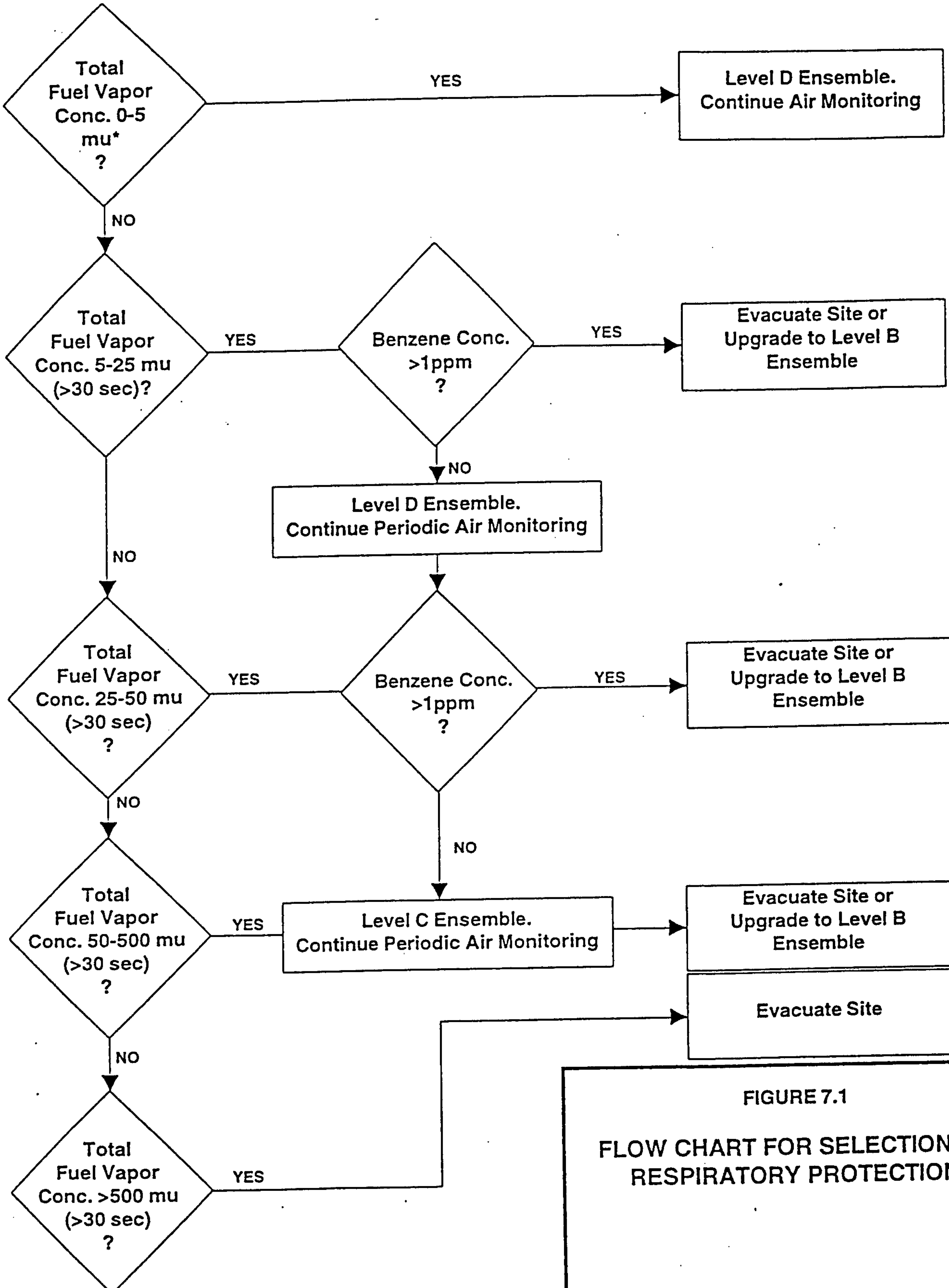

FIGURE 7.1

FLOW CHART FOR SELECTION OF RESPIRATORY PROTECTION

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* mu = Meter Units

For respiratory protection against chlorinated compounds at Travis and Altus AFBs, the procedures below will be followed.

A reading of 1 part per million (ppm) above background in the worker breathing zone as indicated by a photoionization detector (PID) will require the use of a Dräger® tube or the equivalent to determine if vinyl chloride is present at a concentration greater than or equal to the permissible exposure limit (PEL) of 1 ppm. Due to the inadequate warning properties of vinyl chloride, Level B protection must be used if concentrations of vinyl chloride exceed 1 ppm above background in the worker breathing zone.

Similarly, a reading of 2 ppm above background in the worker breathing zone will require the use of Drager® tubes or the equivalent to determine if carbon tetrachloride and/or chloroform are/is present. Level B protection must also be used if concentrations of carbon tetrachloride and/or chloroform meet or exceed 2 ppm above background in the worker breathing zone.

Based on previous investigations at Travis and Altus AFBs, the contaminants of concern are not expected to pose an inhalation problem. However, since there are no Drager® tubes for 1,2-dichloroethane, 1,1-dichloroethene, and 2-hexanone (Travis AFB only), the following will occur. If sustained air monitoring readings in the worker breathing zone indicate vapor concentrations greater than or equal to 1 ppm above background for 30 seconds or longer, the field crew will be forced to evacuate and ventilate the area until readings are less than 1 ppm in the worker breathing zone. If ventilation is inadequate, air samples will be taken to confirm or deny the existence of the contaminants of concern and/or the crew will upgrade to Level B respiratory protection. These air samples will be sent to a lab to be analyzed by Environmental Protection Agency (EPA) Compendium Method TO-14 or the equivalent.

Periodic testing of vapor concentrations for the presence of vinyl chloride will be performed if concentrations persist above 1 ppm above background in the worker breathing zone, as indicated by the PID.

Before work can be performed in Level B respiratory protection, the project manager must be notified. He will initiate the change order process with the USAF or decide to halt activities at that site. (Level B operations require approval from Parsons ES corporate health and safety.) The SHSO will determine whether it is safe to continue activities without respiratory protection or assign an upgrade to Level C protection.

The use of PPE will be required when handling contaminated samples and working with potentially contaminated materials. The SHSO must ensure that all field personnel are properly trained in use, maintenance, limitations (including breakthrough time), and disposal of PPE assigned to them, in accordance with federal OSHA regulations in 29 CFR 1910.132. Disposable PPE will be used whenever possible to simplify decontamination, to reduce generation of contaminated washwater, and to avoid potential problems with chemical permeation (breakthrough). Single-use PPE (such as Tyvek®) will be disposed of whenever personnel go through decontamination. At most, a single item of disposable PPE (including respirator cartridges) will be used for no more than one day and will then be disposed of. Double layers of gloves will be used when personnel are handling contaminated soil or water, or equipment to minimize breakthrough. If personnel note chemical odors on their hands, clothing or skin after wearing PPE, or develop skin irritation or rashes, consult with the SHSO and decide on alternate actions and/or seek medical attention.

Hard hats will be worn in the vicinity of the auger drilling rig and Geoprobe® unit. Steel-toed, steel-shank leather workboots will be worn by all field personnel.

The following personal protective ensemble is required only when handling contaminated samples or equipment.

Mandatory Equipment

- Vinyl or latex inner gloves
- 4H or SilverShield® outer gloves

Optional Equipment

- Air-purifying respirator (equipped with organic vapor/high-efficiency particulate air [HEPA] cartridges)
- Self-contained breathing apparatus or air-line respirator in pressure-demand mode
- Rubber safety boots
- Disposable Tyvek® coveralls
- Outer disposable boot covers
- Saranex® suits
- Chemical goggles

7.2 EQUIPMENT NEEDS

Each field team will have the following items readily available:

- Copy of this program health and safety plan, site-specific addendum, and a separate list of emergency contacts;
- First aid kit which includes PPE for bloodborne pathogens;
- Eyewash bottle;
- Paper towels;
- Duct tape;
- Water (for drinking and washing);
- Plastic garbage bags;
- Fire extinguisher; and
- Earplugs.

7.3 EQUIPMENT DISPOSAL

All reusable PPE (such as hard hats and respirators), if contaminated, will be decontaminated in accordance with procedures specified in Section 10 of this health and safety plan. Contaminated single-use PPE (such as Tyvek® suits and protective gloves) will be properly disposed of according to USAF requirements.

SECTION 8

FREQUENCY AND TYPES OF AIR MONITORING

Air monitoring will be used to identify and quantify airborne levels of hazardous substances. Periodic monitoring is required during on site activities. The types of monitoring and equipment to be used are as follows:

Type of Equipment	Minimum Calibration Frequency	Parameter(s) to be Measured	Minimum Sampling Frequency	Sampling Locations
Photoionization Detector	1/day	Benzene Organic Vapors	2/hour for general site activities	Breathing Zone
Explosivity Meter	1/day	Combustible Gases	2/hour	Soil Borings Monitoring Wells
Sensidyne® or Drager® Tubes	None (check manufacturer's requirements)	Benzene Organic Vapors	When PID exceeds lowest PEL of the contaminants of concern	Breathing Zone
Dosimeter Badges	None	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone
Portable Air Sampling Pumps	Prior to and after each use	Benzene Organic Vapors	As needed on workers with greatest exposure to contamination initially detected by Drager® tubes	Breathing Zone

During phytostabilization demonstration activities, a photoionization detector (such as an HNU® or MicroTIP®) with a 11.7 electron volt (eV) (HNU®) or equivalent will be used to measure ambient air concentrations in the worker breathing zone. The size of the PID lamp was determined based on the ionization potential of the contaminants.

Evacuation may be necessary if the lowest PEL of a contaminant of concern is exceeded above background in the breathing zone of the site workers. This evacuation will be necessary until the area is well ventilated or the respiratory protection is upgraded, if possible. Any detectable concentration above background concentrations in the breathing zone will necessitate following the respiratory protection flowchart (Figure 7.1). The explosivity meter will be used at last twice per hour to measure combustible gas levels at the wellhead or borehole when a potential exists for combustible vapors. During drilling or other intrinsic activities in former or existing landfill areas, monitoring with an explosivity meter will be performed at the ground surface and in the worker breathing zone. At 10 percent of the LEL, evacuate the area and allow the borehole to ventilate.

Worker exposure monitoring will be conducted to document any exposures of Parsons ES site personnel to organic vapors. Portable air sampling pumps or dosimeter badges will be used for personal exposure monitoring, if necessary. The following general protocols will be followed if badges or pumps are used.

Passive Dosimeter Badges

An organic vapor monitoring badge will be attached in the worker's breathing zone for an eight-hour period when the potential for exposure exists. The exposed badges and a blank will be sent to the laboratory for analysis. These personal dosimeter badges work by means of diffusion eliminating the need for a pump, calibration or batteries.

Portable Sampling Pumps

- The portable pump will be calibrated to the required flow rate (in liters per minute) following the manufacturer's calibration procedures.
- The pump will be equipped with the appropriate sorbent tube for the particular organic compounds to be monitored (e.g., charcoal for volatile organics).
- A personal air monitoring data sheet (provided in Appendix A) listing pump flow rates, start and stop times, sorbent tube used, etc. will be completed.
- The pump will undergo a post calibration to determine final flow rates.
- The laboratory analytical results will be disclosed to the employee(s) monitored.
- The analytical results will be placed in the employee's permanent medical file for documentation of any exposures received.

SECTION 9

SITE CONTROL MEASURES

The following site control measures will be followed to minimize potential contamination of workers, protect the public from potential site hazards, and control access to the sites. Site control involves the physical arrangement and control of the operation zones and the methods for removing contaminants from workers and equipment. The first aspect, site organization, is discussed in this section. The second aspect, decontamination, is considered in the next section.

9.1 SITE ORGANIZATION-OPERATION ZONES

The following organization-operation zones will be established on the site or around a particular site feature (e.g., the drill rig).

- Exclusion Zone (Contamination Zone),
- Contamination Reduction Zone, and
- Support Zone.

The site manager and/or SHSO will be responsible for establishing the size and distance between zones at the site or around the site feature. Considerable judgment is required to ensure safe working distances for each zone are balanced against practical work considerations.

9.1.1 Exclusion Zone (Contamination Zone)

The exclusion zone includes the areas where active investigation or cleanup operations take place. Within the exclusion zone, prescribed levels of PPE must be worn by all personnel. The hotline, or exclusion zone boundary, is initially established based upon the presence of actual wastes or apparent spilled material, or through air monitoring, and is placed around all physical indicators of hazardous substances. For drilling operations, the hotline will be located at a distance equal to the drilling rig boom height or 25 feet, whichever is greater, from the drill rig. For backhoe operations, the hotline will be located at a distance from the backhoe equal to the limits of the swing radius. The hotline will consist of an easily identifiable physical boundary (e.g., cones or bright orange or yellow flagging attached to stakes, and may be readjusted based upon subsequent observations and measurements. This boundary will be physically secured and posted or well-defined by physical and geographic boundaries.

Under some circumstances, the exclusion zone may be subdivided into zones based upon environmental measurements or expected onsite work conditions.

9.1.2 Contamination Reduction Zone

If decontamination is required, a contamination reduction zone will be established between the exclusion zone and the support zone. This zone provides an area to prevent or reduce the transfer of hazardous materials which may have been picked up by personnel or equipment leaving the exclusion area. All decontamination activities occur in this area. The organization of the contamination reduction zone, and the control of decontamination operations, are described in Section 10.

9.1.3 Support Zone

The support zone is the outermost area of the site and is considered a noncontaminated or clean area. The support zone contains the command post for field operations, first-aid stations, and other investigation and cleanup support. Normal work clothes are appropriate apparel within this zone; potentially contaminated personnel, clothing or equipment are not permitted.

9.2 SITE SECURITY

Site security is necessary to prevent exposure of unauthorized, unprotected individuals in the work area. The areas immediately surrounding the work area will be clearly marked through use of warning signs, traffic cones, barrier tape, rope, or other suitable means.

Site security will be enforced by the SHSO or a designated alternate who will ensure that only authorized personnel are allowed in the work area and that entry personnel have the required level of PPE, are trained under the requirements of 29 CFR 1910.120, and are on a current medical monitoring program.

9.3 SITE COMMUNICATION

Internal site communication is necessary to alert field team members in the exclusion and contamination reduction zones to:

- Emergency conditions;
- To convey safety information; and
- Communicate changes or clarification in the work to be performed.

For internal site communication, the field team members will use prearranged hand signals (and responses). Radios and/or compressed air horns may also be used for communication.

External site communication is necessary to coordinate emergency response teams and to maintain contact with essential offsite personnel. A telephone will be available for use in external site communication. A list of emergency contact telephone numbers will be provided in subsequent addenda.

9.4 SAFE WORK PRACTICES

To ensure a strong safety-awareness program during field operations, field personnel will be adequately trained for their particular tasks. In addition, standing work orders will be developed and communicated to all field personnel, as will the provisions of this program health and safety plan and the appropriate addenda. Sample standing work orders for personnel entering the contamination reduction zone and exclusion zone are as follows:

- No smoking, eating, drinking or chewing of tobacco or gum;
- No matches or lighters;
- No personal vehicles;
- Check in/check out at access control points;
- Use the buddy system;
- Wear appropriate PPE;
- Avoid walking through puddles or stained soil;
- Upon discovery of unusual or unexpected conditions, immediately evacuate and reassess the site conditions and health and safety practices;
- Conduct safety briefings prior to onsite work;
- Conduct daily safety meetings; and
- Take precautions to reduce injuries resulting from heavy equipment and other tools.

SECTION 10

DECONTAMINATION PROCEDURES

10.1 PERSONNEL DECONTAMINATION PROCEDURES

An exclusion zone, contamination reduction zone, and support zone will be established whenever field personnel are using PPE. Decontamination station layout will be made on a site-specific basis and will be based on the level of PPE used, the types of chemical hazards encountered, and the site conditions, including topography, wind direction, and traffic patterns. Defined site access and egress points will be established and personnel will enter and exit only through these points. As a general rule, persons assisting in the decontamination station may be in one level lower of respiratory protection than required in the work zone.

A guideline for personnel decontamination is presented in Figure 10.1. This procedure may be modified by the SHSO if necessary.

If personnel are in Level D-modified protection (no respirator but using protective gloves and/or suits and other equipment), a portable decontamination station will be set up at the site. The decontamination station will include provisions for collecting disposable PPE (e.g., garbage bags); washing boots, gloves, vinyl rain suits, field instruments and tools; and washing hands, face, and other exposed body parts. Onsite personnel will shower at the end of the work day. Refuse from decontamination will be properly disposed of in accordance with USAF installation protocols.

Decontamination equipment will include:

- Plastic buckets and pails;
- Scrub brushes and long-handle brushes;
- Detergent;
- Containers of water;
- Paper towels;
- Plastic garbage bags;
- Plastic or steel 55-gallon barrels;
- Distilled water; and
- An eyewash station.

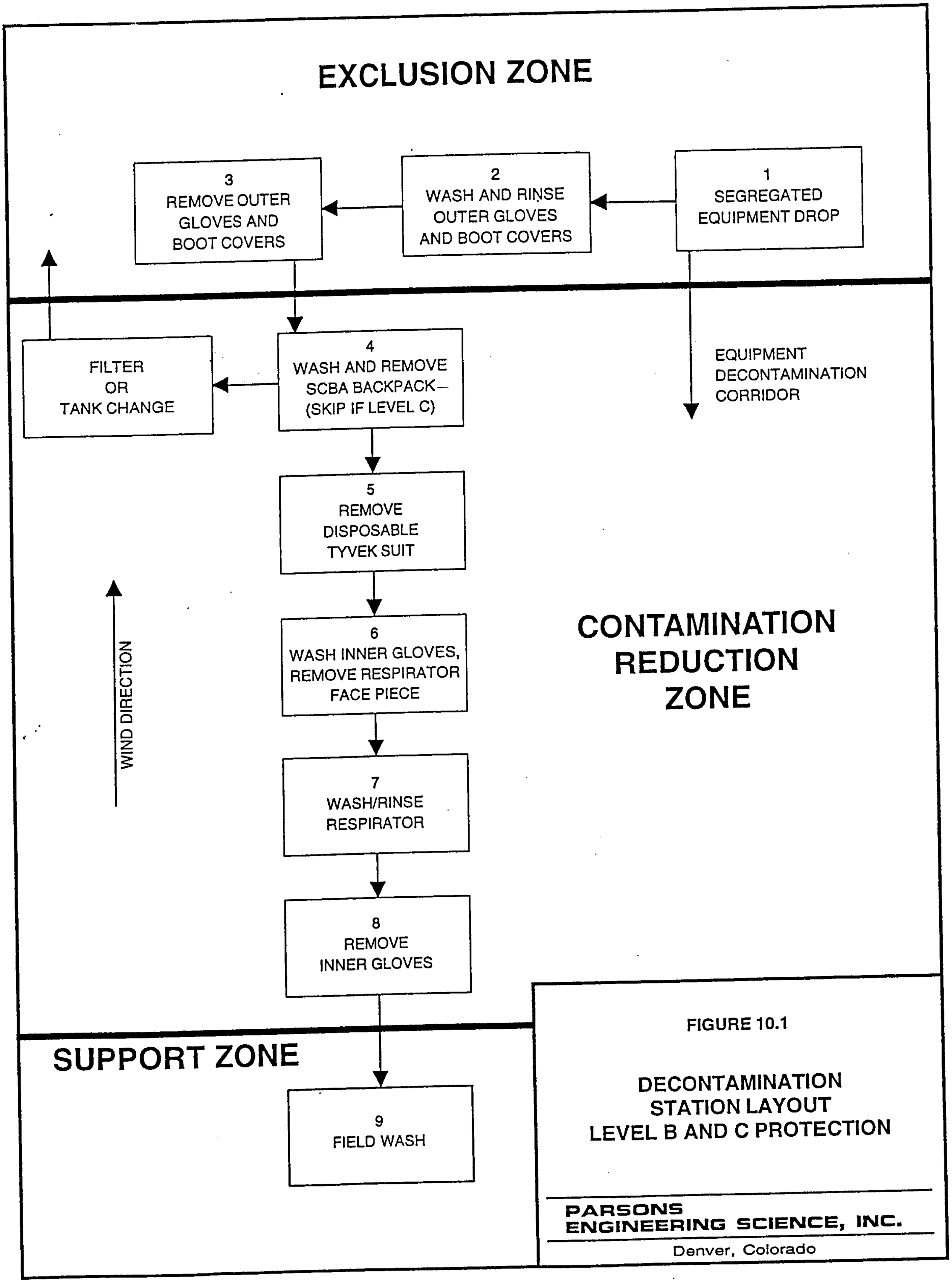

FIGURE 10.1

DECONTAMINATION
STATION LAYOUT
LEVEL B AND C PROTECTION

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10.2 DECONTAMINATION OF EQUIPMENT

Decontamination of drilling rigs will be conducted at a designated location. High-pressure steam-cleaning of the rig will be necessary prior to the beginning of the drilling operation, between borehole locations, and before the drilling rig leaves the project site. All sampling equipment will be decontaminated prior to use, between samples, and between sampling locations.

SECTION 11

AIR MONITORING EQUIPMENT USE AND CALIBRATION PROCEDURES

11.1 PHOTOVAC MICROTIP® AIR ANALYZER

The MicroTIP® is a direct-reading instrument used in conjunction with the span gas kit. To calibrate the MicroTIP® press the power switch. Allow the MicroTIP® to warm up; the display will read Ready. Press the calibration switch; the display will read Connect zero gas then press enter. Connect the bag of zero gas to the MicroTIP® inlet (or allow the MicroTIP® to sample clean air) and press enter; the display will read Calibrating now please wait. The display will then read "Span Conc.?" Enter the span concentration (usually 100 ppmv isobutylene). Connect the bag of span gas to the tip inlet and press enter; the display will read Connect span gas then press enter. The MicroTIP® will then calibrate. When the display reads Ready, the MicroTIP® has completed the calibration and is ready for use. Repeat the calibration daily.

To use the MicroTIP®, press the power switch and wait for the instrument to display the date, time, event number, current detected concentrations, and instrument status ready. The minimum, maximum, and average concentrations measured in each 15-second period are automatically recorded in memory. The keyboard also allows for direct numeric entry.

Since a calibration gas (i.e., isobutylene) is used which typically differs from the contaminants of concern, it may be necessary to combine the instrument reading with a response factor to more closely approximate the concentration of the contaminants of concern.

Relative response factors are found in Table 11.1 for MicroTIP® models MP-100 and HL-200 with a 10.6 eV lamp. For these instruments, a more accurate concentration may be obtained by dividing the instrument reading by the appropriate relative response factor from Table 11.1 for the contaminant of concern.

For MicroTIP® instrument models MP-1000, HL-2000, IS-3000, and EX-4000 with a 10.6 eV lamp, the instrument reading is multiplied by the appropriate response factor from Table 11.2 for the contaminant of concern.

TABLE 11.1
MICROTIP® RELATIVE RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-100 & HL-200

Compound	Relative Response Factor	Compound	Relative Response Factor
Acetaldehyde	0.17	Hydrogen Sulfide	0.25
Acetic Acid	0.09	Isobutyl Acetate	0.52
Acetone	0.86	Isobutyraldehyde	1.02
Acetone Cyanohydrin	0.93	Isopentane	0.12
Acrolein	0.28	Isoprene	2.12
Allyl Chloride	0.26	Isopropyl Acetate	0.43
Ammonia	0.10	Isopropyl Alcohol	0.23
Benzene	1.78	Methyl Bromide	0.45
1,3-Butadiene	1.43	Methyl tert-Butyl Ether	1.22
n-Butanol	0.27	Methyl Ethyl Ketone	1.10
see-Butanol	0.36	Methyl Isobutyl Ketone	0.87
n-Butyl Acetate	0.35	Methyl Mercaptan	1.60
n-Butyl Acrylate	0.53	Methyl Methacrylate	0.67
n-Butyl Mercaptan	1.36	Monoethylamine	1.25
n-Butylaldehyde	0.65	Monomethylamine	1.06
Carbon Disulfide	0.65	n-Octane	0.39
Chlorobenzene	2.24	n-Pentane	0.09
Cyclohexane	0.53	Perchloroethylene	1.40
Cyclohexanone	1.11	n-Propyl Acetate	0.31
1,2-Dichlorobenzene (ortho)	2.25	n-Propyl Alcohol	0.18
cis-1,2-Dichloroethylene	1.20	Propionaldehyde	0.56
trans-1,2-Dichloroethylene	2.21	Propylene	0.87
Diisobutylene	2.10	Propylene Oxide	0.13
1,4-Dioxane	0.83	Styrene	2.20
Epichlorohydrin	0.11	Tetrahydrofuran	0.65
Ethyl Alcohol	0.13	Toluene	1.91
Ethyl Acetate	0.25	Trichloroethylene	1.61
Ethyl Acrylate	0.30	Trimethylamine	1.35
Ethylene	0.09	Vinyl Acetate	0.84
Ethyl Mercaptan	1.82	Vinyl Bromide	2.24
Furfuryl Alcohol	1.43	Vinyl Chloride	0.51
n-Heptane	0.27	Vinylidene Chloride (1,1-DCE)	1.16
n-Hexane	0.20		

Note: Concentration = $\frac{\text{Instrument Reading}}{\text{Relative Response Factor}}$

TABLE 11.2
MICROTIP® RESPONSE FACTORS (10.6 eV LAMP)
INSTRUMENT MODELS MP-1000, HL-2000, IS-3000 & EX-4000

Compound	Response Factor	Compound	Response Factor
Acetaldehyde	6.6	n-Hexane	5.6
Acetic Acid	18.9	Hydrogen Sulfide	3.7
Acetone	1.2	Isobutyl Acetate	2.3
Acetone Cyanohydrin	1.2	Isobutyraldehyde	1.1
Acrolein	3.7	Isopentane	7.8
Allyl Chloride	4.3	Isoprene	0.6
Ammonia	10.1	Isopropyl Acetate	2.4
Benzene	0.6	Isopropyl Alcohol	4.5
1,3-Butadiene	0.7	Methyl Bromide	2.3
n-Butanol	4.6	Methyl tert-Butyl Ether	0.8
see-Butanol	3.0	Methyl Ethyl Ketone	0.9
n-Butyl Acetate	2.9	Methyl Isobutyl Ketone	1.1
n-Butyl Acrylate	1.9	Methyl Mercaptan	0.6
n-Butyl Mercaptan	0.7	Methyl Methacrylate	1.5
n-Butylaldehyde	1.9	Monoethylamine	0.8
Carbon Disulfide	1.4	Monomethylamine	1.0
Chlorobenzene	0.4	n-Octane	2.6
Cyclohexane	1.9	n-Pentane	10.8
Cyclohexanone	0.9	Perchloroethylene	0.7
1,2-Dichlorobenzene (ortho)	0.4	n-Propyl Acetate	3.5
cis-1,2-Dichloroethylene	0.8	n-Propyl Alcohol	6.3
trans-1,2-Dichloroethylene	0.4	Propionaldehyde	1.9
Diisobutylene	0.6	Propylene Oxide	7.1
Dimethylamine	1.5	Styrene	0.5
Di-n-propylamine	0.5	Tetrahydrofuran	1.5
1,4-Dioxane	1.2	Toluene	0.5
Epichlorohydrin	10.3	Trichloroethylene	0.6
Ethanol	11.1	Trimethylamine	0.9
Ethyl Acetate	4.2	Vinyl Acetate	1.2
Ethyl Acrylate	3.3	Vinyl Bromide	0.4
Ethylene	10.0	Vinyl Chloride	2.0
Ethyl Mercaptan	0.6	Vinylidene Chloride (1,1-DCE)	0.9
n-Heptane	3.7		

Note: Concentration = Instrument Reading x Response Factor

11.2 HNU® PHOTOIONIZATION DETECTOR

To calibrate the HNU®, turn the function switch to the standby mode and use the zero control to zero the instrument. Connect a bag of span gas (usually 100 ppmv isobutylene). Turn the function switch to the 0-200 range position and adjust the span control setting to read the ppmv concentration of the standard. Recheck the zero setting as previously described. If readjustment is needed, repeat the calibration step. This provides a two-point calibration to zero and the gas-standard point. Repeat the calibration daily. If the span setting from calibration is 0.0 or if calibration cannot be achieved, then the lamp must be cleaned.

To use the HNU® connect the probe to the instrument by matching the alignment slot in the probe connector to the key in the 12-pin connector on the control panel. Twist the probe connector until a distinct snap and lock is felt. Turn the function switch to battery check position. The needle should read within or above the green battery arc on the scale plate. If the needle is in the lower position of the battery arc, the instrument should be recharged before use. If the red light comes on, the battery ®

11.3 EXPLOSIVITY METER

An explosivity meter is used to measure oxygen and combustible gas levels. The instrument provides characteristic warning signals when deficient oxygen conditions or unacceptable levels of combustible gas are detected.

To use the explosivity meter, turn the unit on and wait a few seconds for the readings to stabilize. Check the battery charge and the alarms before using the instrument. Set the LEL indicator to zero and the oxygen indicator to 20.9 percent.

To calibrate the instrument, attach a bag, bulb or balloon of span gas and wait for the readings to stabilize. Adjust the instrument to read the LEL percent of the calibration gas. Remove the span gas and allow the instrument to exhaust. The combustible sensor will read 000-percent LEL in clean air.

11.4 SENSIDYNE® OR DRÄGER® COLORIMETRIC GAS ANALYSIS TUBES

Colorimetric tubes can be used to give an instantaneous reading of various organic compounds. Their aim is to determine very small concentrations of a compound in the shortest amount of time. To sample with a colorimetric tube use the Dräger® or Sensidyne®bellows pump and select the appropriate tube (for example, a tube marked benzene to look for benzene). Break off both ends on the pump's break-off plate. Insert the tube into the pump head (the tube should be inserted with the arrow pointing towards the pump). There is a specific number of suction strokes for each tube/compound. Each box of tubes will have instructions for how many suction strokes are required for that compound.

APPENDIX A

PROJECT HEALTH AND SAFETY FORMS

PLAN ACCEPTANCE FORM

PROJECT HEALTH AND SAFETY PLAN

Instructions: This form is to be completed by each person to work on the subject project work site and returned to the safety manager.

I have read and agree to abide by the contents of the Health and Safety Plan for the following project:

____

____

____

Signed

____

Date

RETURN TO:

Office Health and
Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, CO 80290

SITE SPECIFIC TRAINING RECORD

Project:______________________________
Project No.:___________________________
Date:_________________________________
Trainer:_______________________________

On this date, the following individuals were provided site-specific training in accordance with OSHA regulations contained in 29CFR1910.120(e):

Name (Print)	Employee No.	Employee Signature

Forward this form to:

Office Health and Safety Representative
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

PARSONS ENGINEERING SCIENCE, INC.

FIELD EXPERIENCE

DOCUMENTATION FORM

OSHA requires (29CFR1910.120(e)) that personnel involved in hazardous waste operations have 40-hours of initial training and a minimum of three days field experience working under the direction of a trained and experienced supervisor. This form serves to document the three days of additional field training/experience.

Employee Name:____

Employee Number (or Social Security No.):________________________

Project Name(s):____

Project Number(s):______________________________________

Dates of Field Training:___________________________________

Summary of Activities Performed:______________________________

____

____

Levels of Respiratory Protection Used:___________________________

____

Comments:

Field Supervisor Signature:_________________________________

Date:____

Return this form to the Office Health and Safety Representative

AIR PURIFYING RESPIRATOR
(APR)

LOG

SITE:

LOCATION:

DATES OF INVESTIGATION:

User	Date of Use	Cleaned and Inspected Prior To Use (Initials)	Cartridges Changed Prior to Use (Yes, No, N/A)	Total Hours on Cartridge

APR Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date

Return to the Office Health and Safety Representative
at the Completion of field activities.

SUPPLIED AIR RESPIRATOR
(SAR)

LOG

SITE:

LOCATION:

DATES OF INVESTIGATION:

User	Date of Use	SAR#	Satisfactory (Yes/No)	Check-Out Initials	Date Cleaned

SAR Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date

Return to Office Health and Safety Representative
at the completion of field activities.

022/722426/7.WW6

SELF-CONTAINED BREATHING APPARATUS
(SCBA)

LOG

SITE:

LOCATION:

DATES OF INVESTIGATION:

User	Date of Use	SCBA#	Satisfactory (Yes/No)	Check-Out Initials	Date Cleaned

SCBA Performance Comments:

Project H&S Officer
or
Parsons ES Project Manager

Date

Return to Office Health and Safety Representative
at the completion of field activities.

PARSONS ENGINEERING SCIENCE COMPANIES

ACCIDENT REPORT FORM

Project: ______________________________

EMPLOYER

1. Name: ______________________________
2. Mail Address: ______________________________
   (No. and Street) (City or Town) (State and Zip)
3. Location (if different from mail address: ______________________________
   ____

INJURED OR ILL EMPLOYEE

4. Name: ______________________________ Social Security No.: ______________
   (first) (middle) (last)
5. Home Address: ______________________________
   (No. and Street) (City or Town) (State and Zip)
6. Age: ________ 7. Sex: male ( ) female ( )
8. Occupation: ______________________________
   (specific job title, not the specific activity employee was performing at time of injury)
9. Department: ______________________________
   (enter name of department in which injured person is employed, even though they may have been temporarily working in another department at the time of injury)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident of exposure: ______________________________
    (No. and Street) (City or Town) (State and Zip)
11. Was place of accident or exposure on employer's premises? Yes ( ) No ( )
12. What was the employee doing when injured? ______________________________
    (be specific--was employee using tools or equipment
    ____
    or handling material?)
    ____
13. How did the accident occur? ______________________________
    (describe fully the events that resulted in the injury or occupational illness.
    ____
    Tell what happened and how. Name objects and substances involved. Give details on all factors that led to
    ____
    accident. Use separate sheet for additional space).
14. Time of accident: ______________________

15. ES WITNESS TO ACCIDENT

____
(Name) (Affiliation) (Phone No.)

____
(Name) (Affiliation) (Phone No.)

____
(Name) (Affiliation) (Phone No.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

16. Describe injury or illness in detail; indicate part of body affected:

____

____

17. Name the object or substance that directly injured the employee. (for example, object that struck employee; the vapor or poison inhaled or swallowed; the chemical or radiation that irritated the skin; or in cases of strains, hernias, etc., the object the employee was lifting, pulling, etc.).

____

____

18. Date of injury or initial diagnosis of occupational illness: ____________________
(date)

19. Did the accident result in employee fatality? Yes ( ) No ( )

20. Number of lost days ____/restricted workdays _____ resulting from injury or illness?

OTHER

21. Name and address of physician:_______________________________
(No. and Street) (City or Town) (State and Zip)

22. If hospitalized, name and address:_____________________________
(No. and Street) (City or Town) (State and Zip)

Date of report: ____________ Prepared by:______________________

Official position:______________________

“NEAR MISS” INCIDENT INVESTIGATION REPORT FORM

1) Project name and number:______________________________

2) “Near miss” location:______________________________

3) Incident date and time:______________________________

4) Personnel present (optional):______________________________

5) Describe incident:______________________________
____
____
____
____

6) What action or condition contributed to incident?______________________________
____
____
____

7) What action was taken or suggested to prevent reoccurrence?______________________________
____
____
____

8) Comments______________________________
____
____

9) Date of report________________ Prepared by______________________________

10) Office health and safety representative review:

______________________________ ______________________________
Signature Date

022/OH/43/66.WW6

PARSONS ENGINEERING SCIENCE

SHIPPING PAPER

Shipping Paper No.:________

Page __1__ of ________   __Parsons Engineering Science__ (name of carrier)   Date:______________

Consignee: Phone:		Shipper: Phone:	
Street:		Street:	
City: State: Zip:		City: State: Zip:	
Route		Vehicle License	

No. of Units and Packaging Type	HM	Basic Description (proper shipping name, hazard class, subsidiary risk, identification No. [UN], and packaging group)	Total Quantity (weight, volume, etc.)

PLACARDS TENDERED: yes ☐ no ☐

I HEREBY DECLARE THAT THE CONTENTS OF THIS CONSIGNMENT ARE FULLY AND ACCURATELY DESCRIBED ABOVE BY PROPER SHIPPING NAME AND ARE CLASSIFIED, PACKED, MARKED, AND LABELED, AND ARE IN ALL RESPECTS IN PROPER CONDITION FOR TRANSPORT ACCORDING TO THE APPLICABLE INTERNATIONAL AND NATIONAL GOVERNMENT REGULATIONS.

Name and Title of Shipper	Place and date
Emergency Telephone Number CHEM-TEL, 800/255-3924	Signature of Shipper

ATTACH MATERIAL SAFETY DATA SHEETS

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ENGINEERING-SCIENCE, INC.
AIR MONITORING DATA FORM

Project: ____________ Date: ____________

Project No.: ____________ Name(s): ____________

Sample No	Pump No.	Sorbant/ Cartridge	Initial Flow Rate	Final Flow Rate	Ave. Flow Rate	Start Time	Stop Time	Total Elapsed Time	Total Volume Air	Analyses Performed	Notes

PARSONS ENGINEERING SCIENCE, INC.
PERSONAL AIR MONITORING DATA FORM

PROJECT NAME______________________ PROJECT NUMBER:______________________

Person Sampling	Person(s) Sampled/Location	Date	Time	PID/BG** (PPM)	Dräger (PPM)	LEL/BG (%)	O_2/BG (%)	Other	Notes

PID	Explosimeter	Other
Model______	Model______	Model______
Serial #______	Serial #______	Serial #______
Cal.* Gas______	Cal Gas______	Cal Gas______
Cal. Reading______	Cal. Reading______	Cal. Reading______
BG Reading______	BG Reading______	BG Reading______

* Cal = Calibration
**BG = Background

022/FORMS/ES-3-38.WW6

PARSONS ENGINEERING SCIENCE, INC.
DAILY VEHICLE INSPECTION REPORT

☑ = OK   ☒ = Adjustment Made   [R] = Repair Needed

Date: ____________   Time: __________   License Plate Number: __________

Vehicle Make and Type: ______________   Rental Agency ______________

General Vehicle Inspection:

1. Windshield ☐   3. Vehicle Interior ☐
2. Vehicle Exterior ☐   4. Leaks under Vehicle ☐

Check that the following are in proper working order:

1. Lights:
   a. Headlights ☐
   b. Taillights ☐
   c. Turn Signals ☐
   d. Brake Lights ☐
   e. Back-up Lights ☐
   f. Interior Lights ☐
2. Brakes ☐
3. Horn ☐
4. Tires properly inflated (refer to sticker on door or vehicle manual) ☐
5. Spare tire present and properly inflated ☐
6. Windshield wipers ☐
7. Windshield washers ☐
8. Defrosters/Defoggers ☐
9. Battery terminals free of corrosion ☐
10. Cooling system hoses ☐
11. Belts ☐
12. Fluid levels: (Circle approximate level)
   a. Oil: Full   1 Quart low   Does not register
   b. Coolant: Full cool   Needs some coolant   Does not register
   c. Transmission: Full   1 Pint low   Does not register
   (NOTE: Check transmission fluid while vehicle is running!)
   d. Fuel: E   1/4   1/2   3/4   F

Please note any problems, unusual conditions, repairs made or fluids added (except fuel):

____

____

____

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