



## BLACK & VEATCH

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Sparton Technology, Inc.

B&V Project 026602.0100

May 13, 1996

Mr. Ronald Crossland, Chief  
Technical Section (6H-CX)  
RCRA Enforcement Branch  
U.S. EPA Region 6  
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Dallas, Texas 75202-27733



Subject: Draft Final Corrective Measures Study Report  
Sparton Technology, Inc.  
Coors Road Facility  
Albuquerque, New Mexico

Dear Mr. Crossland:

In accordance with the terms of the Administrative Order on Consent, as amended, enclosed are six copies of the Draft Final Corrective Measures Study Report. This Report is being submitted in accordance with the U.S. EPA letter of May 3, 1996. This Report has been revised in response to comments from the U.S. EPA dated March 1, 1996 and in response to comments from subsequent meetings and discussions with U.S. EPA, State of New Mexico, City of Albuquerque and with New Mexico Utilities.

This Report is being submitted on behalf of Mr. Richard D. Mico, Vice-President and General Manager of Sparton Technologies, Inc. Additional copies are being transmitted to parties indicated on the Distribution List contained in the Report.

Sincerely,

BLACK & VEATCH

Pierce L. Chandler, Jr.  
Senior Project Manager

Enclosure

**DRAFT FINAL  
CORRECTIVE MEASURES STUDY REPORT**

**SPARTON  
TECHNOLOGY, INC.**

**COORS ROAD FACILITY  
ALBUQUERQUE, NEW MEXICO**

**MAY 1996**

**B&V**

A Report Prepared for:

Sparton Technology, Inc.  
4901 Rockaway Boulevard, SE  
Rio Rancho, New Mexico

DRAFT FINAL  
CORRECTIVE MEASURE STUDY  
Sparton Technology, Inc.  
Coors Road Facility  
Albuquerque, New Mexico

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May 6, 1996



Pierce L. Chandler, Jr.  
Senior Project Manager  
Black & Veatch

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## I INTRODUCTION

This --- report presents the results of a Corrective Measures Study (CMS) conducted as the second part of a Corrective Action Plan (CAP) for the Sparton Technology, Inc. (Sparton) facility located at 9621 Coors Road, NW, in Albuquerque, New Mexico.

This CMS is based on the results of the RCRA Facility Investigation (RFI) submitted to the U.S. Environmental Protection Agency (U.S. EPA) May 14, 1992 and subsequently approved by U.S. EPA on July 1, 1992, in correspondence received by Sparton Technology, Inc., on July 8, 1992. A draft CMS report was submitted to U.S. EPA on November, 1992. The draft CMS report has been revised in response to comments received from U.S. EPA dated March 1 and March 29, 1996.

This CMS was conducted under the conditions of an Administrative Order on Consent entered into by Sparton and U.S. EPA which became effective October 1, 1988. This --- final CMS report is being submitted in accordance with the provisions of that Consent Order.

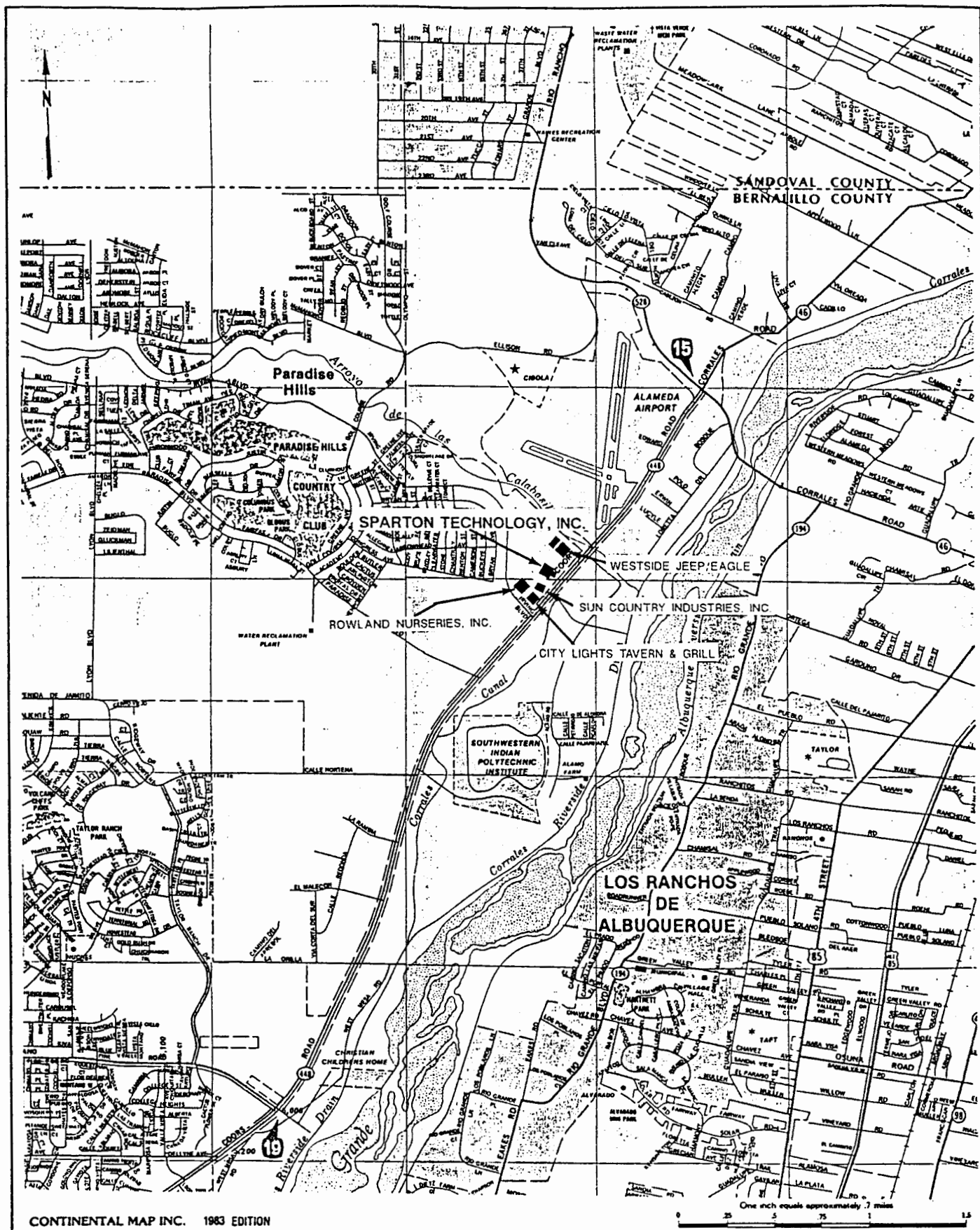
## II BACKGROUND

The Sparton facility is sited on an approximate twelve-acre parcel of land located on the northwest side of Albuquerque, on State Highway 448, known locally as Coors Road, approximately 0.75 miles north of the intersection of Coors Road and Paseo del Norte (See Figure 1)(RFI Figure 1).

The Sparton facility began operation in 1961. Through 1994, electronic components, including printed circuit boards were manufactured at the site. Since 1994, Sparton has continued to operate the machine shop at the facility in support of manufacturing conducted at the company's Rio Rancho plant and other locations. The manufacturing process generated two waste streams which were managed as hazardous wastes: an aqueous metal plating waste stream and a solvent waste stream. The plating wastes were stored in an in-ground concrete basin until approximately 1975. This basin was replaced by a lined surface impoundment in 1975, termed the "West Pond". A second lined surface impoundment was installed circa 1977. This pond was termed the "East Pond". Accumulated wastewater was periodically removed from the ponds via vacuum truck for off-site disposal at a permitted facility. Figure 2 (RFI Figure 2) shows the facility layout.

After the installation of the East Pond, the West Pond was not used again until January 1981. At that time, the West Pond was refurbished by providing a new liner and by constructing concrete sidewalls for liner support. From 1981 through August 1983, use of the two ponds was alternated so that each pond could be regularly inspected. No significant liner damage was identified during any of these inspections. In August 1983,





**Harding Lawson Associates**  
Engineering and  
Environmental Services

**LOCATION MAP**  
**SPARTON TECHNOLOGY, INC.**  
9621 COORS ROAD NW  
ALBUQUERQUE, NEW MEXICO

FIGURE

**1**

DRAWN

JOB NUMBER  
06310,039.12

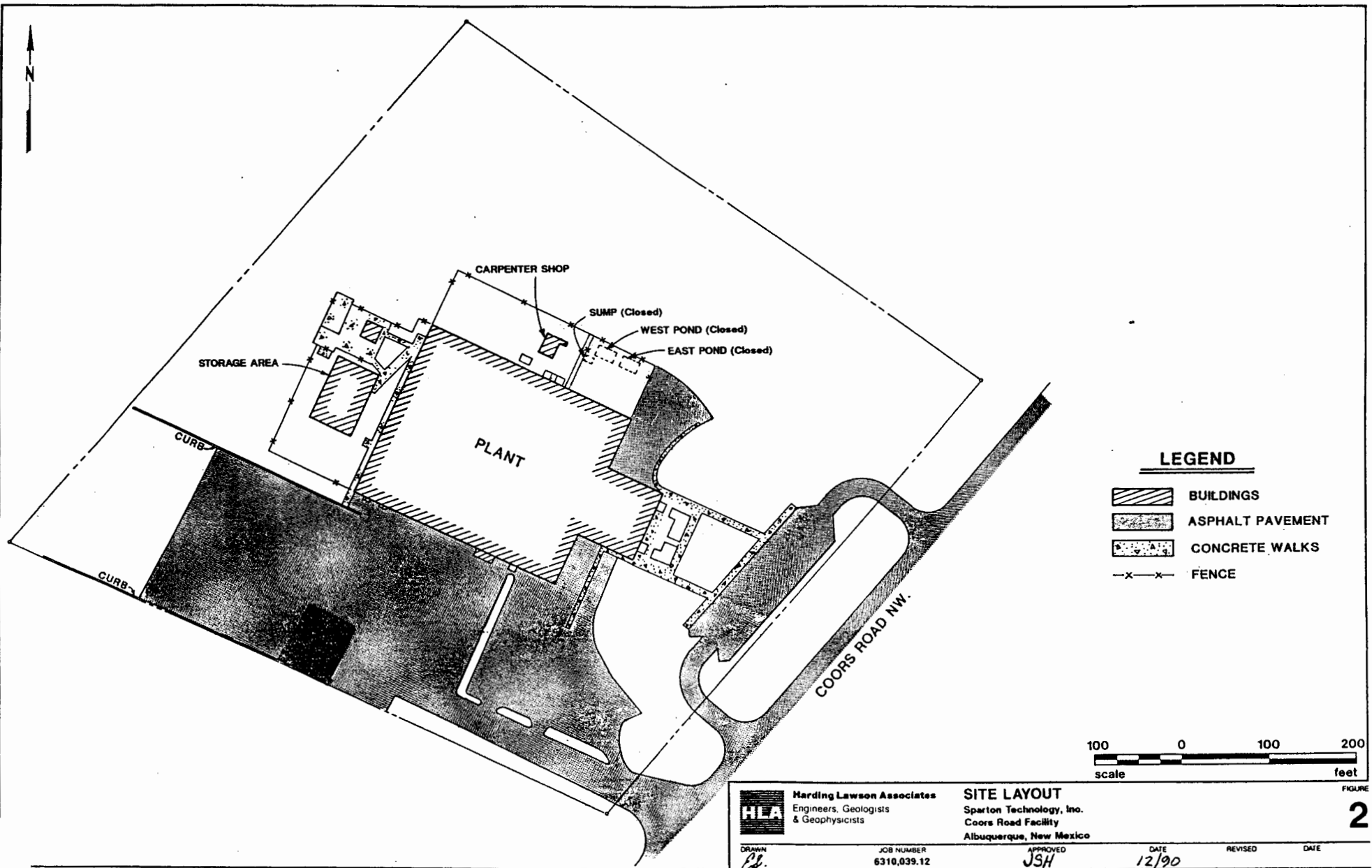
APPROVED  
DJU

DATE  
12-21-89

REVISED

DATE

Draft Final CMS-Sparton  
May 6, 1996



Sparton ceased discharging to either pond and removed the plating wastes which were in the ponds at that time. The ponds have not been used since that time. Plating wastes were subsequently accumulated in drums in an on-site "less than ninety day" storage facility prior to shipment to a permitted off-site disposal facility.

Waste solvents were accumulated in an on-site concrete sump and allowed to evaporate. Use of this sump was discontinued in 1980, at which time Sparton began to accumulate the waste solvents in drums prior to off-site disposal at a permitted facility.

In 1983, several groundwater monitoring wells were installed around the pond and sump area to determine whether there had been a release of hazardous constituents from the ponds or the sump. Analytical results from groundwater samples taken from these wells indicated concentrations of several constituents above state standards.

Since this initial finding in 1983, investigation of the nature and extent of the contamination has continued through 1992. The wastes which were stored in the pond and sump area were typical of electronic manufacturing facilities. The waste stream stored in the ponds was an aqueous stream from the metal plating process which contained a variety of metal ions. The sump was used to store a mixture of waste solvents from process and degreasing operations. Historical analyses of the contents of either the ponds or sump are not available; however, the predominant constituents can be inferred from subsequent sampling and analysis of subsurface soils and groundwater. Based on groundwater analyses, the primary hazardous constituents appear to include trichloroethylene (TCE) and 1,1,1-trichloroethane (TCA), with lesser amounts of methylene chloride (MeCl), acetone, and 1,1-dichloroethylene (DCE). Based on these analytical

results from groundwater samples taken from on-site monitoring wells, it is apparent that the contaminant release originated primarily from the solvent storage sump.

Various metals have also been detected in both soil and groundwater samples. Historically, chromium has the highest frequency of occurrence at elevated concentration.

Aromatic petroleum hydrocarbon constituents including benzene, toluene, ethylbenzene, and xylene (BTEX) have been detected in a single well. The source of the BTEX constituents is unknown; however they are inconsistent with, and potentially anomalous to, the historical operation at this site and the constituent data base of all sampling and analysis conducted to date.

During the period 1983 to 1987, Sparton worked closely with the New Mexico Environmental Improvement Division (EID). Also during this period, the ponds were closed, and the entire pond and sump area was capped under a state-approved closure plan.

In 1987, when it became apparent that contaminants had migrated beyond facility boundaries, the EPA commenced negotiations with Sparton to develop an Administrative Order on Consent. This Order was signed and became effective on October 1, 1988. Under the provisions of this Order, Sparton implemented an Interim Measure (IM) consisting of a groundwater recovery and treatment system in December, 1988. The purpose of the IM was to remove contaminants from the more concentrated areas of the contaminant plume in the uppermost flow zone.

Since 1983, the results of the ongoing investigation have been published in a number of reports, copies of which have been previously furnished to EPA and EID. A list of these reports is included in Figure 3. The most recent of these reports, the RFI and the Interim Measure Effectiveness, are the basis for the Corrective Measure Study (CMS).

As described earlier, the ponds were used from approximately 1961 until August 1983, at which time discharge to the ponds ceased, and the ponds were emptied. The sump was originally closed in October 1980 by removing the remaining wastes and filling the sump with sand. Final pond and sump area closure was conducted in December 1986 under a State-approved closure plan. This closure consisted of backfilling the ponds, and the construction of an asphaltic concrete cap over the entire area to divert rainfall and surface water run on, thus minimizing infiltration of surface water into the ground in this area (See Figure 4) (RFI Figure 4).

Sparton is committed to preserving environmental quality. Sparton has demonstrated its commitment at this facility by undertaking voluntary corrective actions and by working with U.S. EPA and the State of New Mexico to mitigate the effects of contaminant release. Sparton has further demonstrated its commitment by expending over \$5.3 million at this facility for various corrective actions and investigative work from 1983 to the present time.

### FIGURE 3

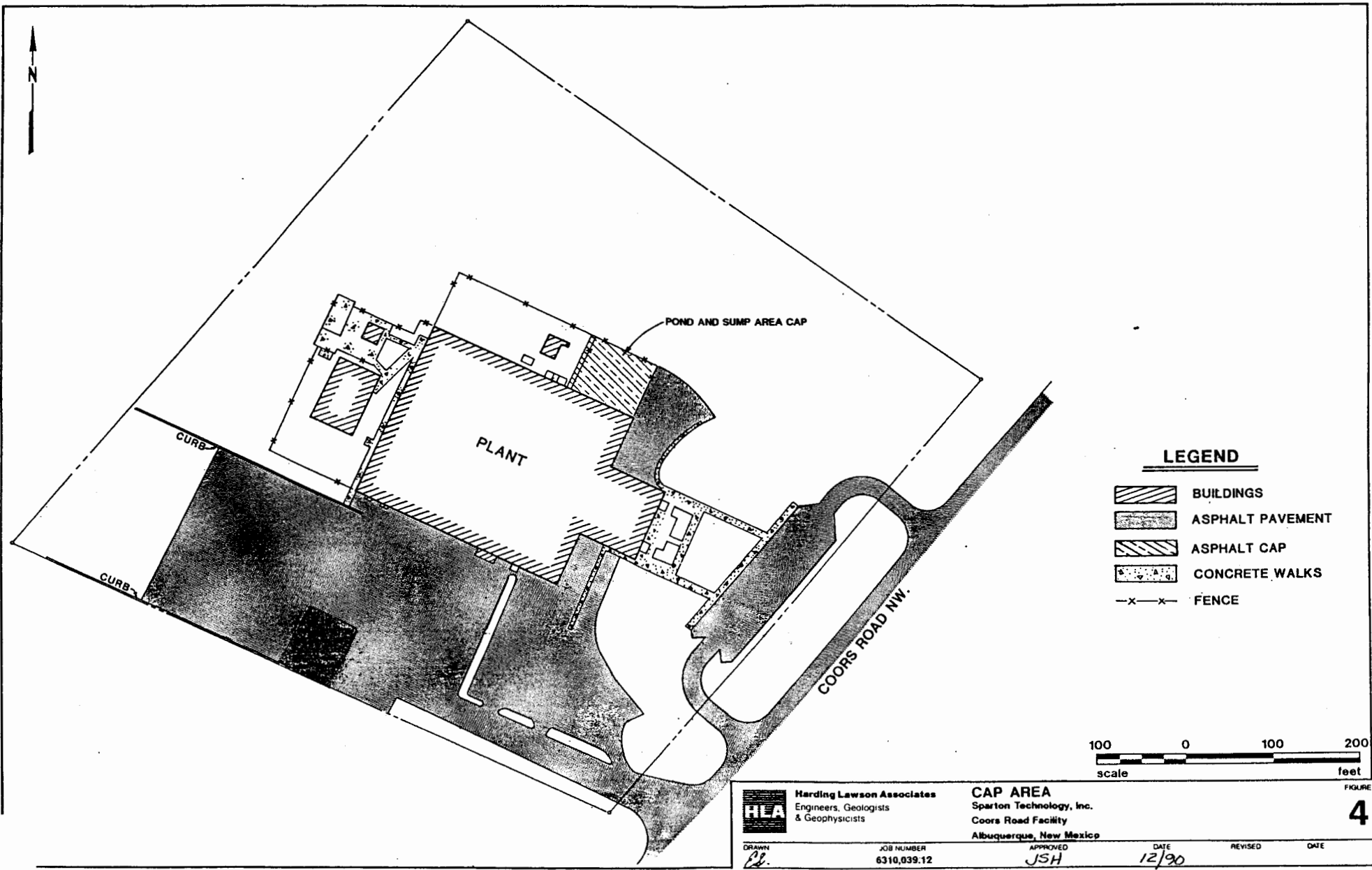
#### SUMMARY OF PREVIOUSLY PUBLISHED REPORTS

Date of Publication -----	Report Title -----
6/29/83	Groundwater Monitoring Program, Sparton Southwest, Inc., 9261 Coors Road, North-west, Albuquerque, New Mexico 87114; Harding Lawson Associates
3/19/84	Investigation of Soil and Groundwater Contamination, Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; Harding Lawson Associates
3/13/85	Hydrogeologic Characterization and Remedial Investigation, Sparton Technology, Inc., 9621 Coors Road, Northwest, Albuquerque, New Mexico 87114; Harding Lawson Associates
6/30/86	Soil Investigation of the Unsaturated and Upper Saturated Zones, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
7/15/86 (Rev. 9/22/86) (Rev. 10/3/86)	Vertical Profiling Program, Sparton Technology, Inc. Albuquerque, New Mexico; Harding Lawson Associates
4/87	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation
7/23/87	Corrective Measures Study Report, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
10/19/87	Off-Site Investigation, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
5/88	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation

### FIGURE 3

#### SUMMARY OF PREVIOUSLY PUBLISHED REPORTS (Continued)

Date of Publication -----	Report Title -----
11/18/88	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation
10/26/89 (Revised 2/23/90)	Effectiveness of the Groundwater Recovery Well System, Coors Road Facility, Albuquerque, New Mexico; Harding Lawson Associates
12/27/89	Preliminary Environmental Assessment-Properties Surrounding Sparton Technology, Inc., 9621 Coors Road, N.W., Albuquerque, New Mexico; Harding Lawson Associates
7/6/90	Areal Extent of the Zones of Relatively Lower Permeability; Sparton Technology, Inc., 9621 Coors Road, N.W., Albuquerque, New Mexico; Harding Lawson Associates
12/1/91	Bench-Scale Report, Available Corrective Measures Technologies; Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; HDR Engineering, Inc.
5/20/92	RCRA Facility Investigation; Sparton Technology, Inc. Coors Road Facility, Albuquerque, New Mexico; HDR Engineering Inc., in conjunction with Metric Corporation
8/1/92	Report on the Effectiveness of the Groundwater Recovery Well System in the Upper Flow Zone; Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; HDR Engineering, Inc.
2/28/96	Revised Report on the Effectiveness of the Groundwater Recovery Well System in the Upper Flow Zone; Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; Black & Veatch.





### **III DESCRIPTION OF CURRENT SITUATION**

#### **A. Physiography, Geology, Hydrogeology, Climatology**

##### **1. Regional Setting**

###### **a. Physiography**

The Sparton Technology facility is centrally located within the Albuquerque Basin of central New Mexico and is in the middle part of the Rio Grande Valley which extends through the length of New Mexico. The site is situated on the edge of a terrace next to the river flood plain at about elevation 5050 feet. The Rio Grande is located approximately 3000 feet east of the site at an elevation of approximately 4990 feet. Also, the Corrales Main Canal, a man-made hydraulic structure, is located approximately 300 feet east of the site and contains flowing water (Rio Grande source water) eight months out of the year. The canal is used primarily for irrigation. West of the facility, the elevation increases to about 5300 feet.

###### **b. Geology**

The Albuquerque Basin fill is estimated to be approximately 10,000 feet thick along the axis with sediment thickness varying throughout the basin boundaries. A generalized description of the sediments in the basin is presented in ascending order by age as follows:

- The Precambrian bedrock is overlain by Paleozoic and Mesozoic age sedimentary rocks which are comprised primarily of sandstones, shales, and

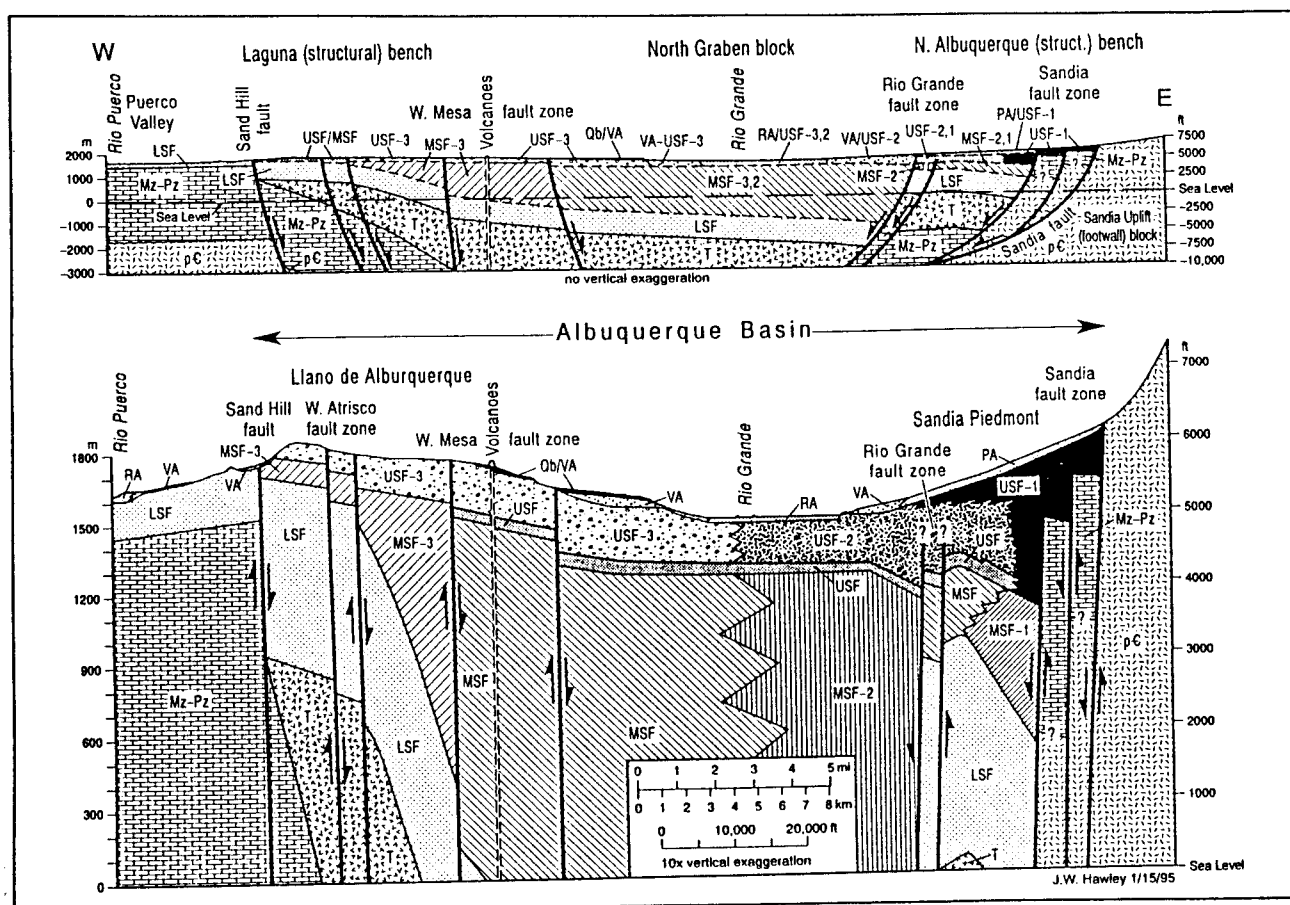
marine limestones. The upper section consists mainly of continental and marine shale, and of sandstone with some gypsum, coal, and conglomerate. Both Paleozoic and Mesozoic rocks outcrop east of Albuquerque in the Sandia and Manzano Mountains. Only Mesozoic age rocks outcrop to the west in the Rio Puerco Valley.

- Sedimentary rocks of the Tertiary and Quaternary age sequence unconformably overlie the rocks of pre-Tertiary age. They are generally composed of unconsolidated to loosely consolidated fluvial deposits of gravel, sand, and silt interbedded with some volcanic basalts and tuffs.
- The Galisteo Formation consists of Eocene and Oligocene(?) age beds of variegated sandstone, sand, clay, shale, minor amounts of conglomerate, tuff, and limestone.
- The Miocene-Pliocene basin fill consists of up to 10,000 feet of sandstone, mudstone, and gravel of the Santa Fe Formation or Group. Facies changes of the Santa Fe occur throughout the area and are, in some cases, divided into different units within the Santa Fe Formation. The Santa Fe Group is divided into two formations, both of which underlie the surficial deposits in the Rio Grande Valley. Before the Santa Fe was raised from formation to group status, Bryan and McCann (1937) had divided it into three members -- the Lower Gray, the Middle Red, and the Upper Buff. The units within the Santa Fe Formation were later reclassified as the Ceja Member (upper Pliocene), Middle Red Member (Pliocene), and the Zia Member (Miocene). All units are overlain by the Pleistocene age Ortiz gravel, (Kelly 1977).

The foregoing description is consistent with information from Hawley & Haase, 1992, New Mexico WRRI 1995, and the USGS Albuquerque Basin Model (USGS, 1995). A depiction of subsurface geology is given along Paseo Del Norte Boulevard west-east cross section approximately one half mile south of the facility in Figures 5 and 5A (Hawley & Haase, NMWRRI 1994).

Figure 5

# Paseo Del Norte Stratigraphic Section



Reference : The Water Future of Albuquerque and Middle Rio Grande Basin - May 1995  
 New Mexico Water Resources Research Institute  
 Report No. 290

Figure 5A

## Key to Stratigraphic Units

TABLE 1. HYDROSTRATIGRAPHIC UNITS AND THEIR RELATIONSHIP TO LITHOFACIES SUBDIVISIONS

Unit	Description
RA	River alluvium; channel, floodplain, and lower terraces deposits of inner Rio Grande and Puerco valleys; as much as 120 ft thick. Map unit "Qp" (Kelley 1977). Forms upper part of the "shallow aquifer" system. Hydrogeologic (lithofacies) subdivision Iv. Age: <i>Holocene to late Pleistocene</i> .
VA	Valley-border alluvium; tributary-arroyo; and thin eolian deposits in areas bordering inner Rio Grande and Puerco valleys, with locally extensive river-terrace deposits, as much as 200 ft thick. Includes older, sandy to silty, valley fill in the vicinity of Calabacillas Arroyo and the Atrisco area. Map units "Qa" and "Qt" (Kelley 1977), and "Edith, Menaul, and Los Duranes" (alluvial-terrace) units (Lambert 1968). Includes hydrogeologic (lithofacies) subdivisions Iv, II, and V. Most of unit is in the vadose (unsaturated) zone. Age: <i>Holocene to middle Pleistocene</i> .
PA	Piedmont-slope alluvium; coarse-grained alluvium, mainly deposited as coalescent fans extending basinward from mountain fronts on the eastern and southwestern margins of the basin; as much as 150 ft thick; includes surficial deposits mantling piedmont erosion surfaces (including rock pediments). Includes deposits of ancestral Tijeras Arroyo system in the depression between I-40 and the SE Central-Ridgecrest Blvd. area (Lambert et al. 1982). Map units "Qfa" and "Qp" (Kelley 1977), and hydrogeologic (lithofacies) subdivisions Vf, Vd, and VI. Most of unit is in vadose zone. Age: <i>Holocene to middle Pleistocene</i> .
SF	Santa Fe Group - undivided; fill of intermontane basins of the Rio Grande rift in New Mexico and adjacent parts of Colorado, Texas, and Chihuahua (Mexico). Includes alluvial, eolian and lacustrine deposits; and interbedded extrusive volcanic rocks (basalts to silicic tuffs). In the Albuquerque Basin, the Santa Fe is as much as 15,000 ft thick. It is mapped both as a formation (member subdivisions) (Kelley 1977), and as a group (formation and member subdivisions) (Hawley 1978; Machette 1978a, b; Lozinsky and Tedford 1991). Sand and gravel facies form the major aquifers in Albuquerque basin (and elsewhere in basins of the Rio Grande rift). The group is subdivided into three (informal) hydrostratigraphic units:
USF	Upper Santa Fe Unit; coarse- to fine-grained (fluvial) deposits of ancestral Rio Grande and Puerco systems that intertongue toward basin margins with piedmont-alluvial facies; volcanic rocks (including basalt, andesite and rhyolite flow and pyroclastic units) and thin, sandy eolian deposits are locally present. Unit is less than 1000 ft thick in most areas, but locally exceeds 2000 ft in thickness. Subunit USF-1 is primarily coarse-grained fan alluvium derived from the Sandia, Manzanita and Manzano uplifts. USF-2 includes ancestral-Rio Grande and interbedded fine- to medium-grained sediments of diverse (alluvial-lacustrine-eolian) origin deposited in a rapidly aggrading basin-floor environment. Thick alluvial and thin eolian deposits capping the Llano de Albuquerque (West Mesa) between the Rio Grande and Puerco Valleys form subunit USF-3. These gravely to sandy, piedmont and basin-floor facies are mainly derived from the Southern Rocky Mountain and southeastern Colorado Plateau provinces.
USF-1	
USF-2	
USF-3	
	Unit includes Ceja Member of the Santa Fe "Formation" (Kelley 1977), and Sierra Ladrone Formation (Machette 1978a, b; Lozinsky and Tedford 1991); and locally, upper Cochiti and Popotosa Formation correlatives (Manley 1978). It forms lower part of "shallow aquifer" below river-floodplain areas, and main part of basin-fill aquifer system in City of Albuquerque well fields. Includes hydrogeologic (lithofacies) subdivisions Ib, II, III, V, Vd, Vf, VI, VIII and IX. Much of this unit is in vadose zone. Age: <i>Early Pleistocene to late Miocene, mainly Pliocene</i> .
MSF	Middle Santa Fe Unit; alluvial, eolian, and playa-lake deposits; partly indurated, coarse- to fine-grained piedmont alluvium that intertongues basinward with fine-grained to sandy basin-floor facies, including playa-lake and local braided-stream deposits. Basaltic to silicic volcanics are also locally present. The Rio Grande rift region extending from central New Mexico into south-central Colorado is a major sediment source area for Albuquerque Basin Fill. The unit is as much as 10,000 ft thick near the Isleta volcanic center, and commonly is at least 5,000 ft thick in central basin areas. Subunit MSF-1 is primarily coarse-grained fan alluvium derived from early-stage Sandia, Manzanita and Manzano uplifts including the ancestral Tijeras Canyon drainage basin. MSF-2 comprises sandy to fine-grained basin-floor sediments of mixed (alluvial-lacustrine-eolian) origin that intertongue eastward with subunit MSF-1, and westward and northward (beneath the Llano de Albuquerque) with subunit MSF-3. The latter subunit includes coarse- to fine-grained alluvium derived from the southeastern Colorado Plateau and Nacimiento-Jemez Mountain area. Includes much of the Popotosa Formation (Machette 1978a, b; Lozinsky and Tedford 1991) in southern Albuquerque Basin, and part of Cochiti Formation (Manley 1978) and "middle red" formation (Spiegel 1961; Lambert 1968; Kelley 1977) in northern part of basin. Forms lower part of main aquifer system in the north-central part of basin. Includes hydrogeologic (lithofacies) subdivisions II, III, IV, V, Vd, Vf, VI, VII, VIII and IX. Age: <i>Late to middle Miocene</i> .
MSF-1	
MSF-2	
MSF-3	
LSF	Lower Santa Fe Unit; alluvial, eolian, and playa-lake facies. Sandy to fine-grained basin-floor sediments, including thick dune sands and gypsiferous sandy mudstones, grade to conglomeratic sandstones and mudstones near basin margins (early-stage piedmont alluvial deposits). The unit is as much as 3500 ft thick in the central basin areas, where it is locally thousands of feet below sea level. Includes lower part of Popotosa Formation (Machette 1978a, b; Lozinsky and Tedford 1991) in southern Albuquerque (Belen) Basin, and Zia (Sand) Formation (Galusha 1966; Kelley 1977) in northern part of basin. Eolian sand facies of the Zia Formation are an important part of the deep aquifer system beneath the Llano de Albuquerque in northwestern Rio Rancho. Due to deep burial and abundance of silt-clay, the unit is not known to form a major part of the aquifer system in other parts of the basin. Includes hydrogeologic (lithofacies) subdivisions IV, VII, VIII, IX and X. Age: <i>Middle Miocene to late Oligocene</i> .

\*Lithofacies subdivisions illustrated on Figure 6.

Reference : The Water Future of Albuquerque and Middle Rio Grande Basin - May 1995  
New Mexico Water Resources Research Institute - Report No. 290

c. Hydrogeology

Regional water table fluctuations occur as water is added to or withdrawn from the groundwater reservoir in the Albuquerque area. Long term water level declines may be attributed to heavy pumping from industrial and municipal wells in the Albuquerque area. Seasonal fluctuations are due to heavy precipitation and irrigation by surface water diverted from streams which tends to raise the water table. High water levels occur during the summer months in the inner valley when land is irrigated by water diverted from the Rio Grande or where inundation by flood runoff is common. The lowest water levels in the area typically occur in the early spring before the first application of irrigation water.

d. Groundwater Flow Direction

The shape and slope of the water table throughout the valley fill, in most instances, is not uniformly planate. The irregularities in the surface occur as a result of lithologic facies changes which directly affect permeabilities and saturated thickness. This may cause mounding, coning, or troughing with the addition or withdrawal of water.

Because of groundwater extraction through municipal wells, it is estimated that the regional water table has declined forty feet in the last fifty years in this area. However, the influence that these wells have on the water table does not extend to the region around the Sparton facility. Groundwater pumping does not affect the water table in this area because large municipal and industrial wells are infrequent and widely spaced.

In addition, recent studies at Intel Rio Rancho have shown that deep, high-production

water wells have little impact on shallow groundwater (Shomaker, 1996). The regional groundwater movement is generally to the southwest. The contour lines in Figure 6 (RFI Figure 9) show the configuration of the water table and the direction of movement of groundwater. Current information and model extrapolations indicate south to southwestward flow direction (USGS 1995) as shown on Figure 6A.

e. Groundwater Recharge

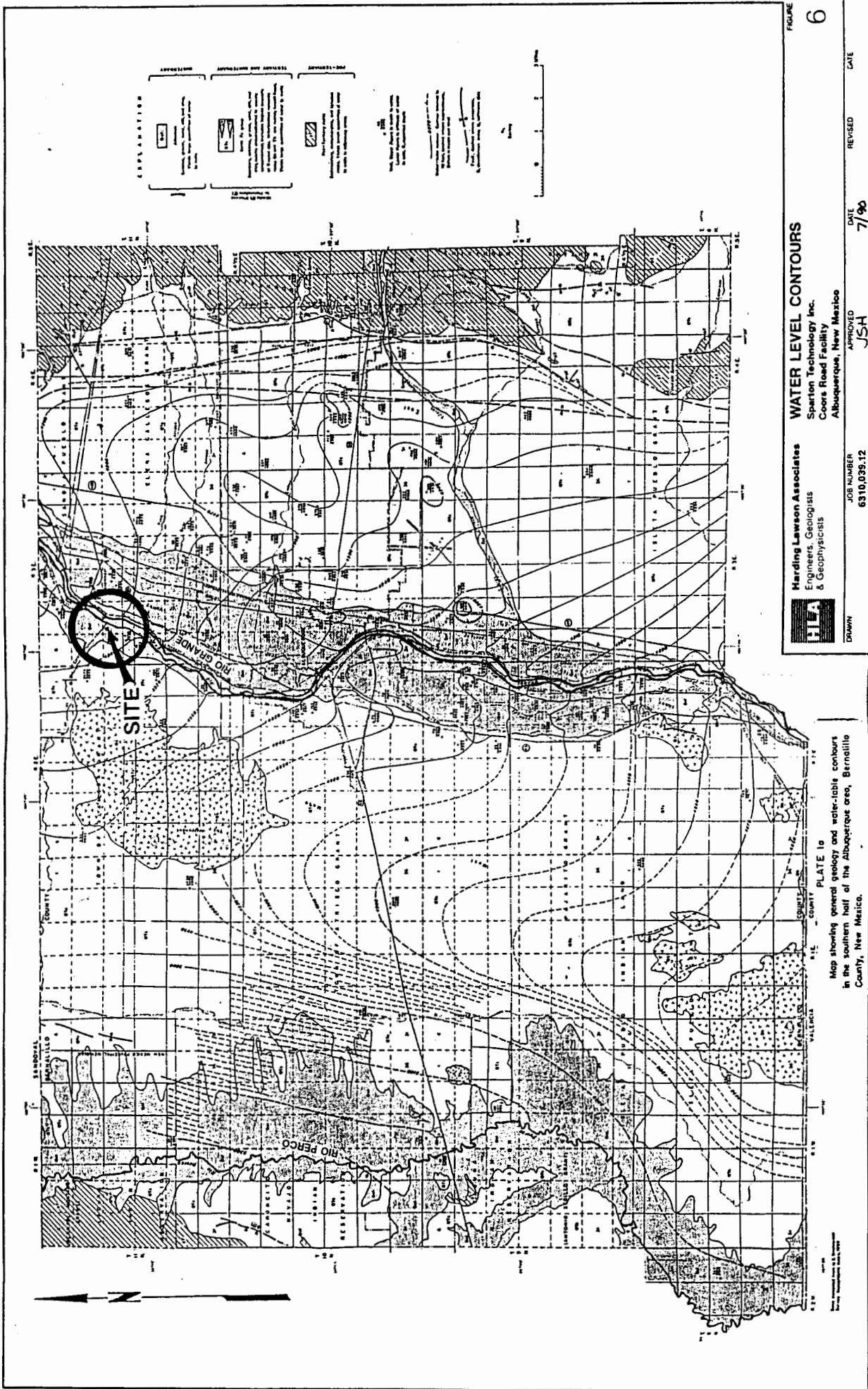
The groundwater reservoir in the Albuquerque area is recharged from many sources which include precipitation, underflow of groundwater from adjacent areas, applied irrigation water, seepage from streams, springs, seeps, drains, and canals.

Discharge from the groundwater reservoir in the Albuquerque area occurs by means of evapotranspiration, springs and seeps, drains, water wells, and as base flow of the Rio Grande.

2. Site-Specific Conditions

a. Geology/Hydrogeology

Several reports have been issued since 1983 describing various aspects of the site geologic and hydrogeologic regimes (See Figure 3). Copies of these reports have been previously furnished to EPA. Figure 7 (RFI Figure 11) shows the locations of all on- and off-site groundwater monitoring wells installed to date.



**FIGURE 6**

**WATER LEVEL CONTOURS**

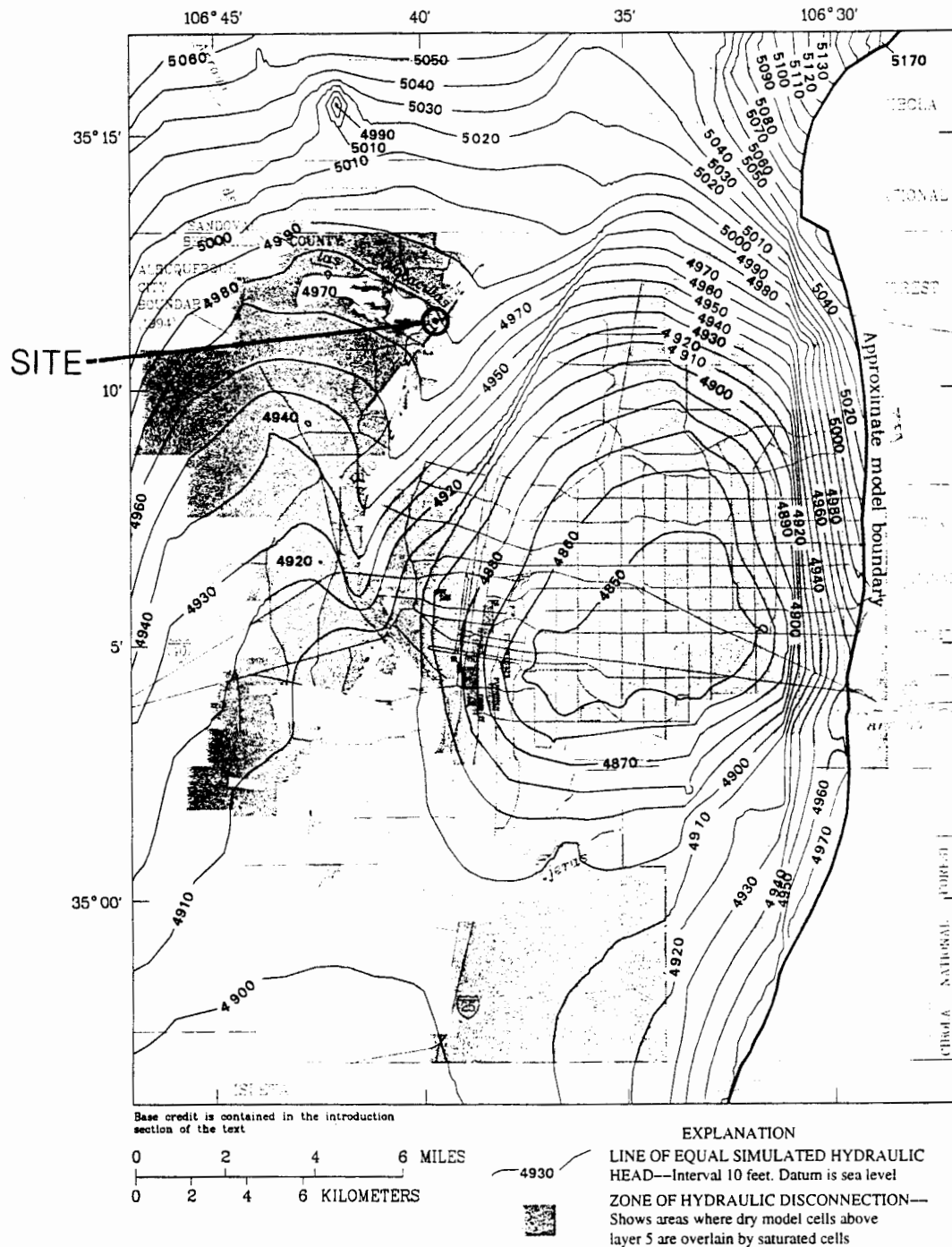
**Harding Lawson Associates**  
Engineers, Geologists  
& Geophysicists

**Sparton Technology Inc.**  
Coors Road Facility  
Albuquerque, New Mexico

**DATE** 7/90  
**REVISION**  
**APPROVED** JSH  
**JOB NUMBER** 6310.099.12  
**DRAWN**

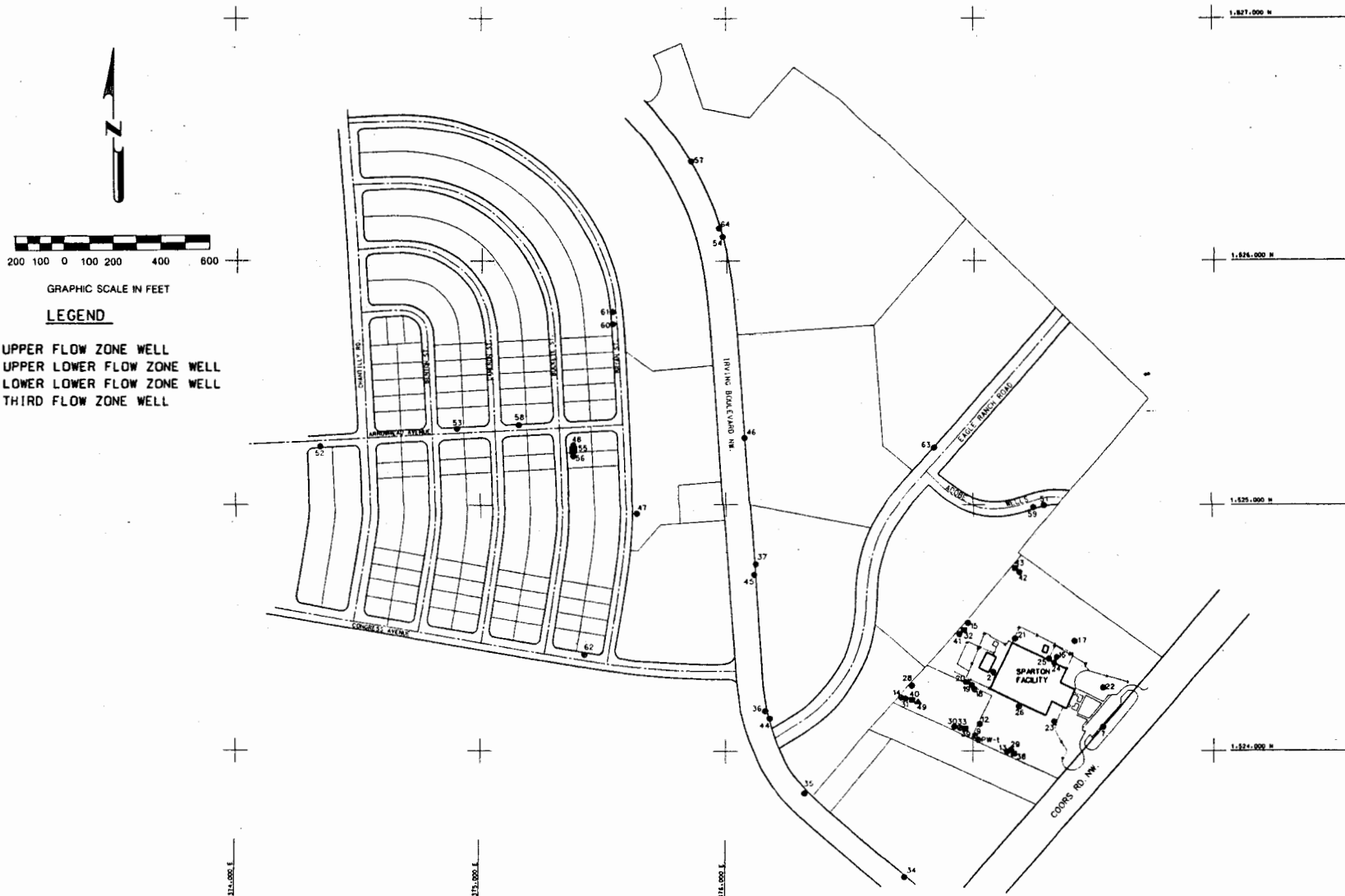
Figure 6A

Current Water Level Contours



Reference: Simulation of Ground-Water Flow in the Albuquerque Basin, Central New Mexico, 1901-1994, With Projections to 2020  
U.S. Geological Survey  
Water-Resources Investigations Report 94-4251





DATE										REVIEWS AND RECORD OF LEASE										MO	BY	CL	APP



**Black & Veatch**  
Engineers - Architects  
Dallas, Texas

DESIGNED	_____
DETAILED	_____
CHECKED	_____
APPROVED	_____
DATE	_____

PROJECT NO.  
26602

## MONITOR WELL LOCATION PLAN

SPARTON TECHNOLOGY, INC.  
COORS ROAD FACILITY  
ALBUQUERQUE, NEW MEXICO

FIGURE 7

b. Site Stratigraphy

The Sparton RCRA facility investigation area is situated within the Albuquerque Basin, a fault trough defined by Bryan (1938) as a component of the Rio Grande depression. Several structural benches are delineated within the basin; fault scarps striking north-south face the trough.

Geologic materials of the Albuquerque Basin are Precambrian to Holocene (Recent age). The bulk of the basin fill, estimated to be as much as 10,000 feet in depth, is represented by the Santa Fe Group of Tertiary age overlain by Quaternary fill deposits. These deposits together comprise the local aquifer relevant to the Sparton facility.

Kelley (1977) characterized the Santa Fe Group as three stratigraphic members; the lower Zia Sandstone Member, the middle Red Member, and the Ceja Member (uppermost part). Monitoring wells of the RCRA facility investigation area are estimated to be completed above the top of the Ceja Member. Lambert (1968) described the upper part of the Ceja as being "dominantly yellowish to grayish sandy pebble gravel and pebbly sand with lesser amounts of interbedded clay, mud, and sand". Two major sediment types were encountered in borings at the Sparton facility. These sediment types include clays and sandy muds interbedded with gravelly sands. The gravelly sands predominate in the upper and lower flow zones. Both sediment types are found in every boring; however, correlation from boring to boring is not consistent because the depositional environment changes vertically as well as horizontally. Even at cluster well

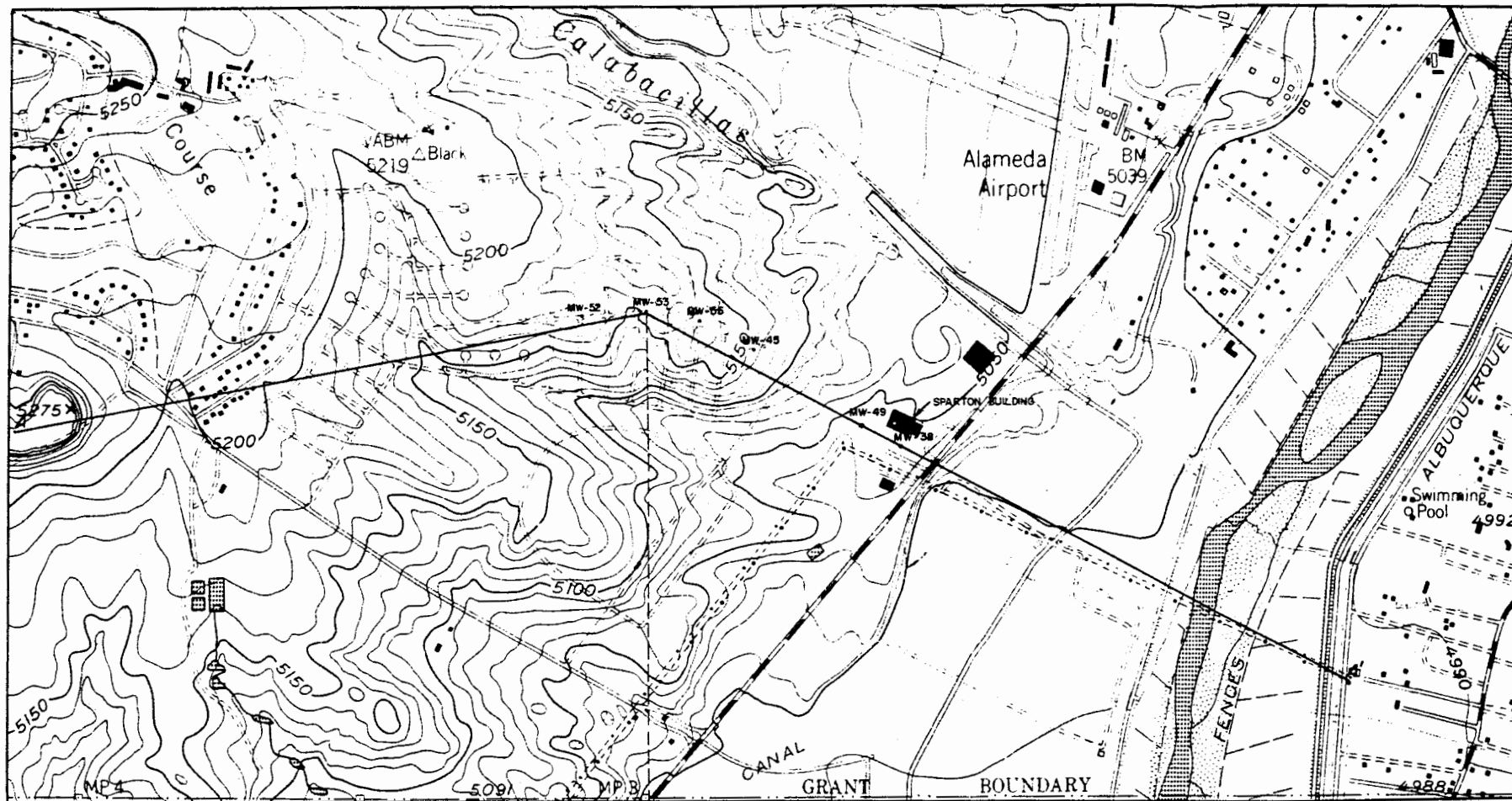
locations, where borings are in close proximity, significant lithologic variation has been observed.

The heterogeneity and anisotropy observed on site is consistent with regional description (Hawley & Haase, 1994), the current USGS Model for the Albuquerque Basin (USGS 1995), and recent investigation and analyses of the Intel Rio Rancho well field north of the Sparton Facility (Shomaker, 1994). The USGS has modeled vertical hydraulic conductivity as 1/200 of the harmonic mean of the horizontal hydraulic conductivity. Shomaker used extensive geophysical logging information to show a  $10^4$  or four order magnitude range in hydraulic conductivity occurring over short vertical distances.

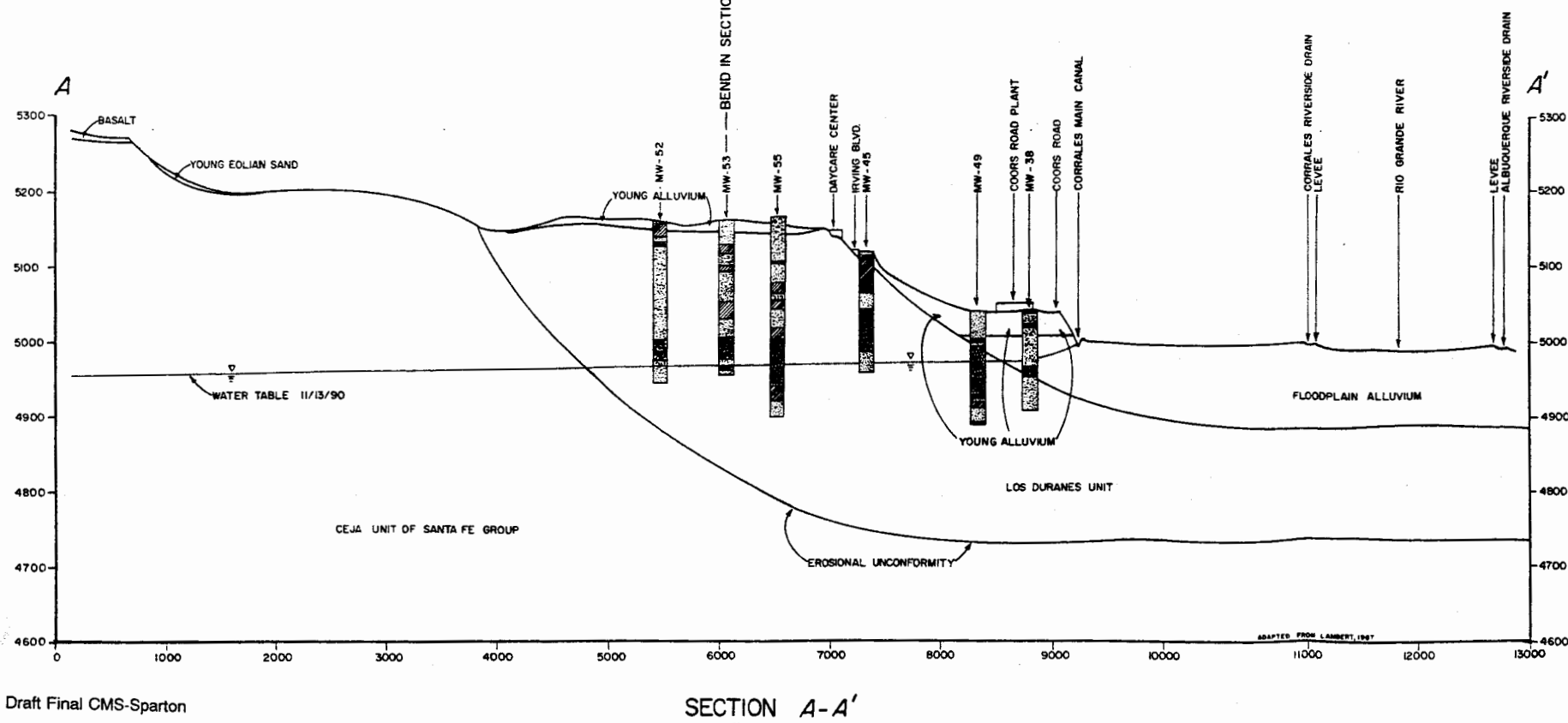
Figure 8 (RFI Figure 13) provides a characterization of site specific stratigraphy by section through the project vicinity. For complete details on the description of Site Stratigraphy refer to the Final RCRA Facility Investigation Report (RFI Report), dated May 14, 1992.

c. Project Hydrogeology

Early reports for this project have used three flow zones to describe site-specific hydrogeology. These flow zones were identified as the upper, lower, and third flow zones. The lower flow zone was divided into two members; the upper lower flow zone and the lower lower flow zone. These flow zone divisions were based on stratigraphic and potentiometric differences observed on site. However, as investigation continued off-site, the stratigraphic, and particularly the potentiometric, bases for these flow zone divisions were no longer encountered.



PLAN



SECTION A-A'



LEGEND



FIGURE 8

METRIC Corporation	
STRATIGRAPHIC SECTION	
SPARTON TECHNOLOGY, INC. Albuquerque, New Mexico	
Date 7/29/91	

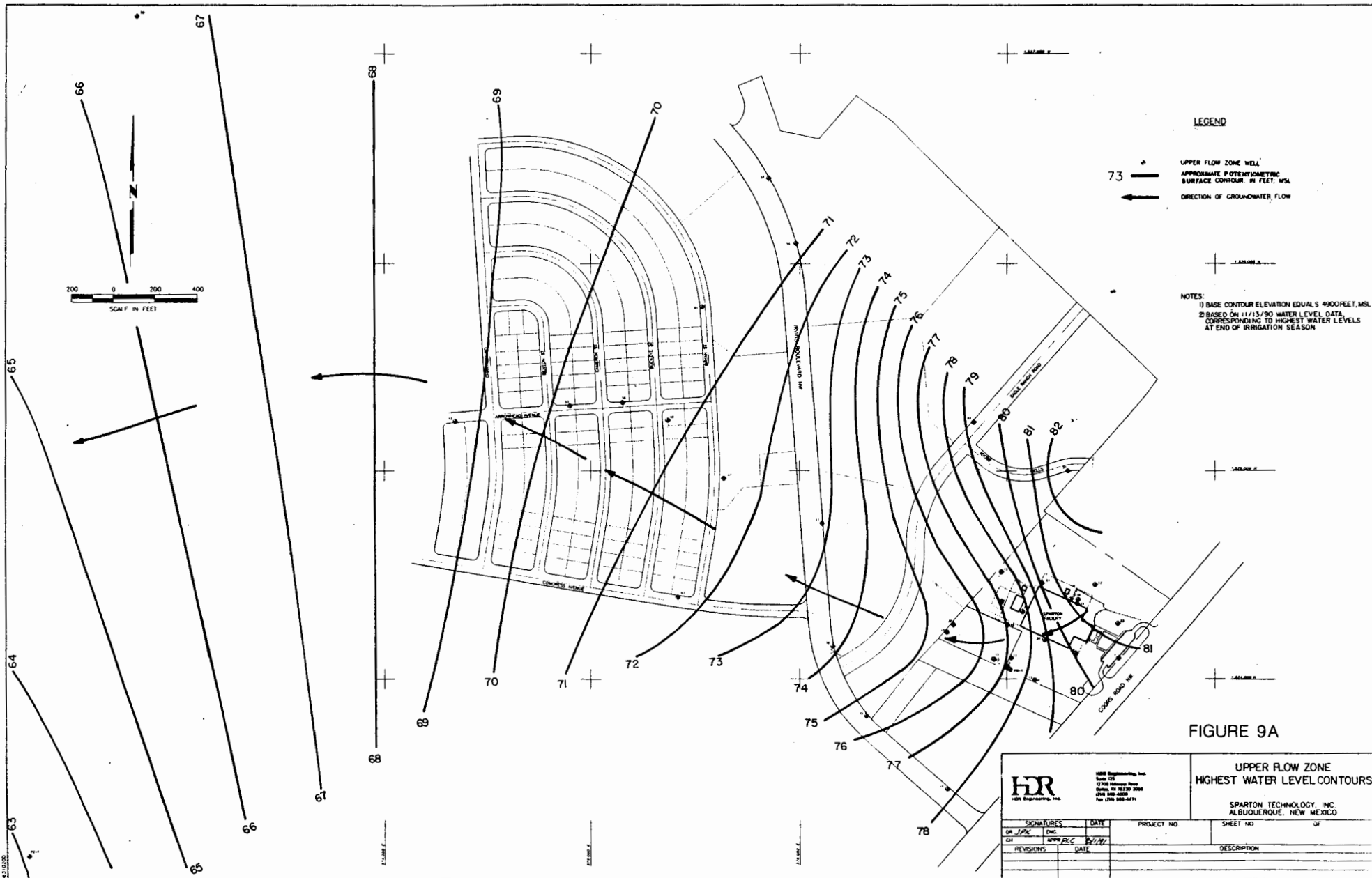
Investigative work to date indicates that all of the referenced flow zones are hydraulically connected and constitute a single groundwater unit. However, due to the saturated thickness and the heterogeneous, anisotropic nature of this single groundwater unit, retention of this flow zone identification is very useful for vertical location purposes and assisting in three-dimensional descriptions of the hydrogeology. For this reason and to maintain continuity with the previous reports and correspondence, the flow zone distinctions have been retained.

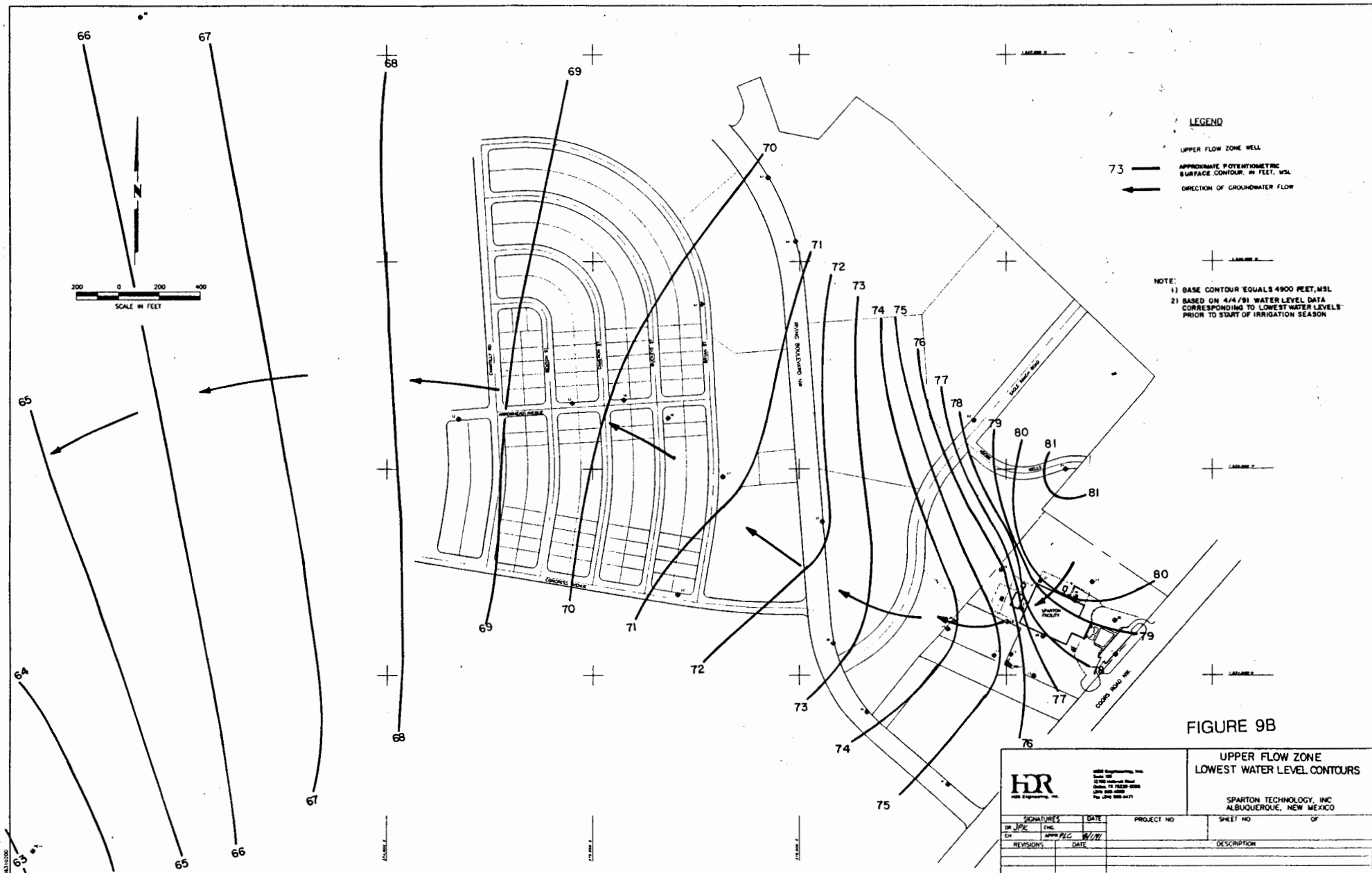
An evaluation of the extent of interconnection of the upper and lower flow zones was conducted in late 1989 and the results were issued in a report titled "Areal Extent of the Zones of Relatively Lower Permeability" (Figure 3). This report evaluated the presence of various fine-grained layers at the facility. These fine-grained layers, described as the "zones of relatively lower permeability" or ZORLP, generally range from clays to compacted silty sands that act somewhat like a barrier between the upper and lower flow zones. The ZORLP is thought to be the cause for the difference in potentiometric surfaces between the upper and lower flow zones observed on site. The ZORLP was not encountered off site.

As noted under Site Stratigraphy, significant heterogeneity/anisotropy occurs over short vertical and horizontal distance due to the layered, lenticular nature of the depositional environment. A comparison of boring log descriptions at cluster well locations graphically illustrates the heterogeneity onsite.

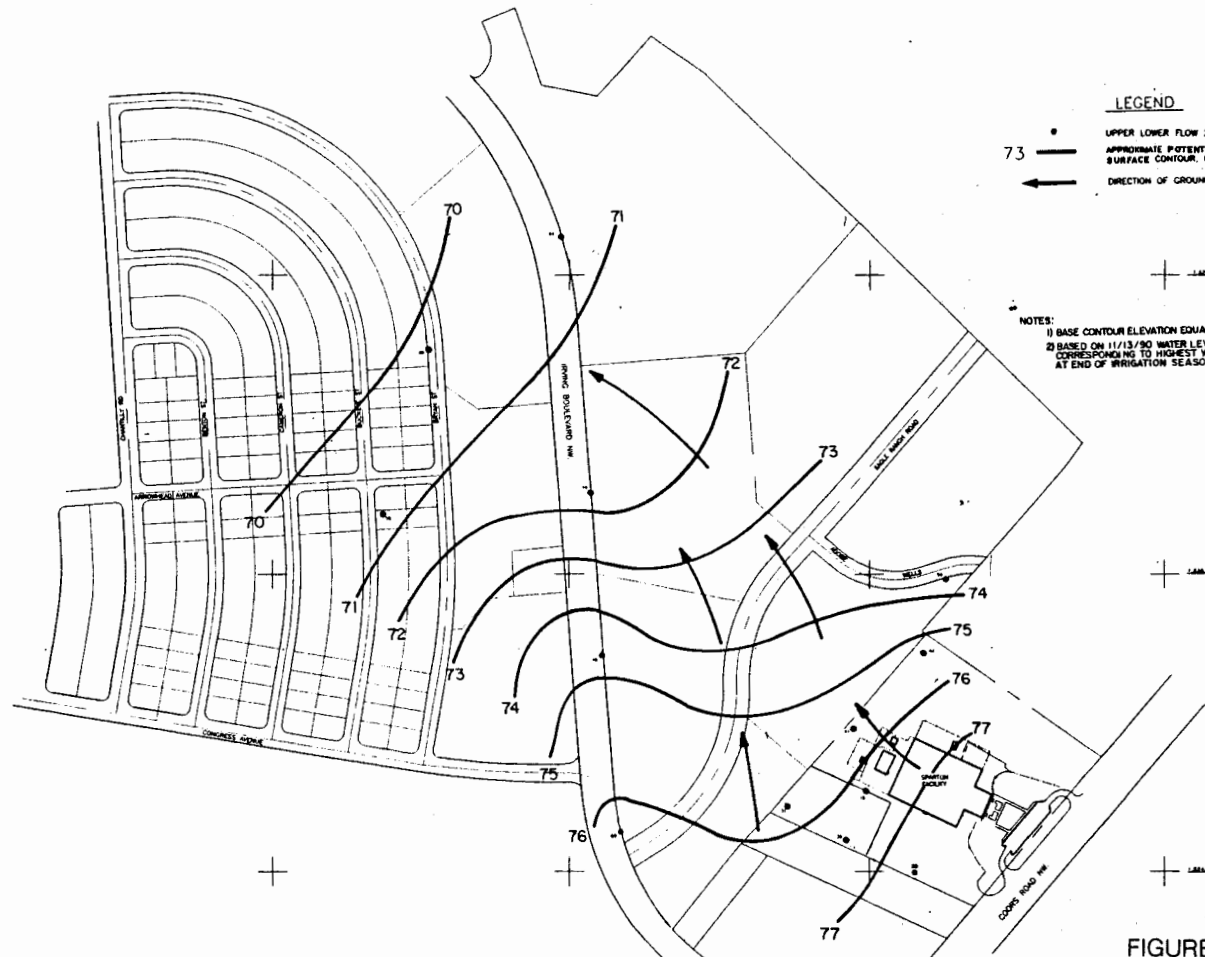
The depth to groundwater varies from approximately 65 to 75 feet at the facility to approximately 200 feet in the hills to the west. On site, groundwater elevation varies as much as two to three feet as a result of recharge from irrigated fields and the Corrales Main Canal which is located approximately 300 feet east of the facility. -- Potentiometric contour maps illustrating the groundwater elevations and gradients for the various flow zones during highest and lowest water levels are presented on Figures 9A-9F (RFI Figures 25-30). Since the RFI Report, potentiometric levels have dropped one to two feet over the entire site. Post-RFI water level data is included in Appendix 1.

To the west of Irving Boulevard, hydraulic gradients are relatively flat and vary from 1:350 to 1:780 in a generally westward direction. Under the Sparton facility, gradients range from 1:50 to the southwest in the upper flow zone to 1:200 to 1:350 to the northwest in the lower flow zone.









**LEGEND**

• UPPER LOWER FLOW ZONE WELL  
— APPROXIMATE POTENTIOMETRIC SURFACE CONTOUR, IN FEET, MSL  
— DIRECTION OF GROUNDWATER FLOW

**NOTES:**  
1) BASE CONTOUR ELEVATION EQUALS 4900 FEET, MSL.  
2) BASED ON 11/13/90 WATER LEVEL DATA CORRESPONDING TO HIGHEST WATER LEVELS AT END OF IRRIGATION SEASON

FIGURE 9C

<b>HDR</b>		HDR Engineering, Inc. 1200 University Blvd. Albuquerque, NM 87102 505 263-8800 Fax: 505 263-8871		PROJECT NO.	
Sparton Technology, Inc. Albuquerque, New Mexico		SHEET NO.		OF	
SIGNATURES	DATE	DESCRIPTION			
OR: JWC	ENG.				
CH	APP: PLC				
REVISIONS	DATE				

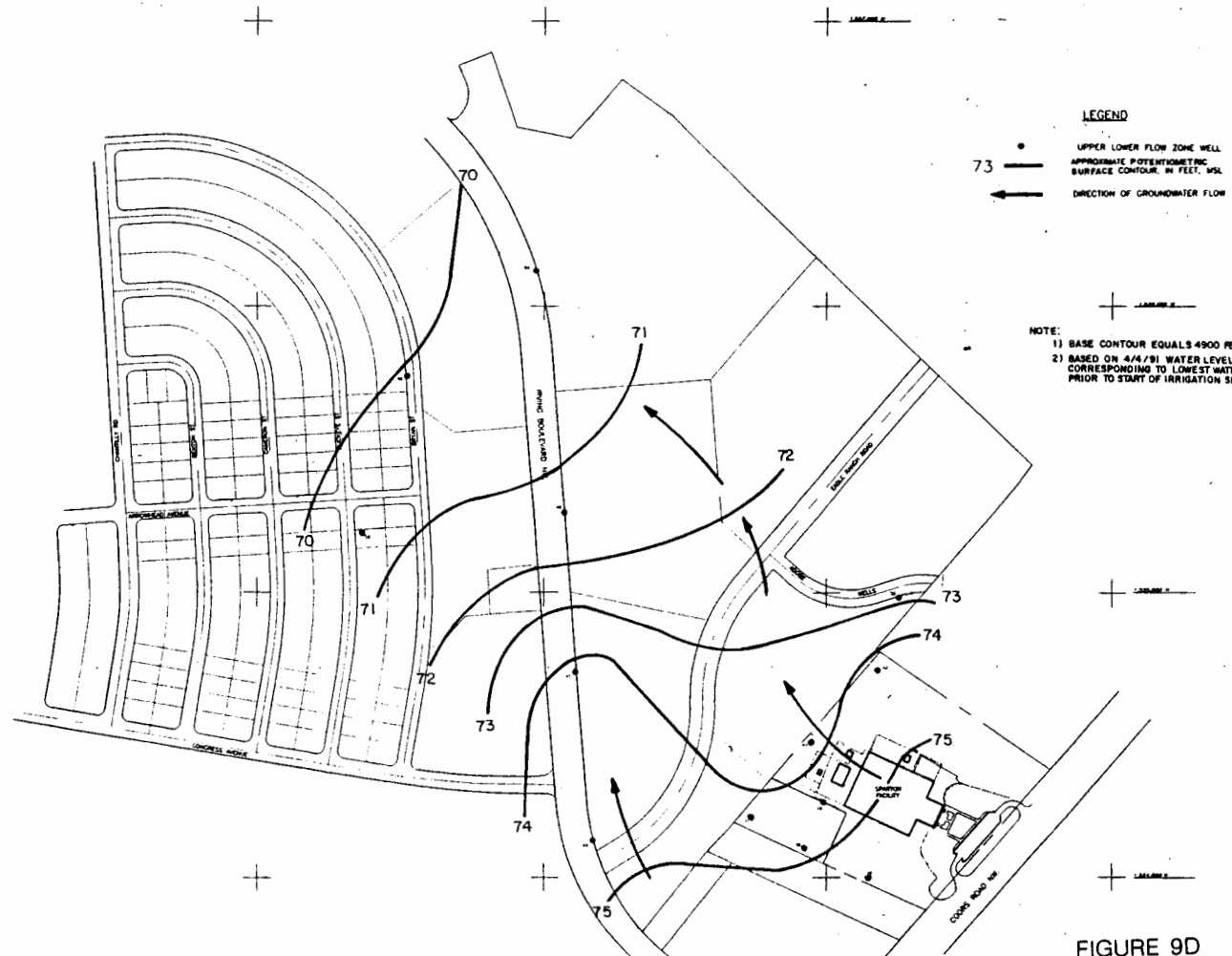
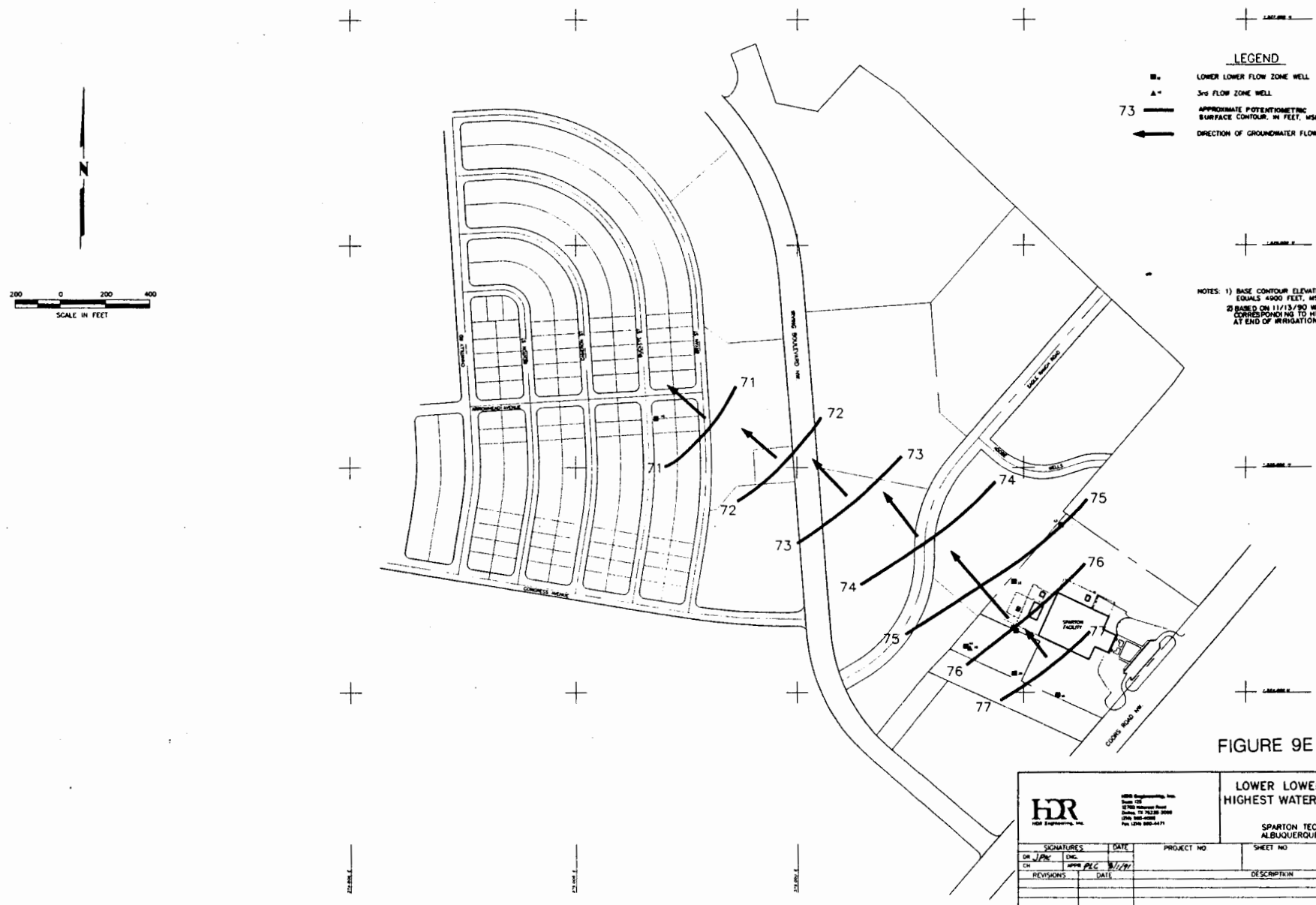


FIGURE 9D

		UPPER LOWER FLOW ZONE LOWEST WATER LEVEL CONTOURS	
		SPARTON TECHNOLOGY, INC. ALBUQUERQUE, NEW MEXICO	
SHEET NO. 18 OF 18	PROJECT NO.	DATE	
REVISIONS	DATE	DESCRIPTION	



<b>HR</b> HR Engineering, Inc. 1700 University Blvd. Suite 100 Albuquerque, NM 87102 505-263-0000 Fax 505-263-0001		<b>LOWER LOWER FLOW ZONE HIGHEST WATER LEVEL CONTOURS</b>	
SIGNATURES		DATE	PROJECT NO.
BY <i>JPL</i>	CHK <i>PLC</i>	DATE <i>5/1/97</i>	SHEET NO. <i>1</i> OF <i>1</i>
REVISIONS	DATE	DESCRIPTION	

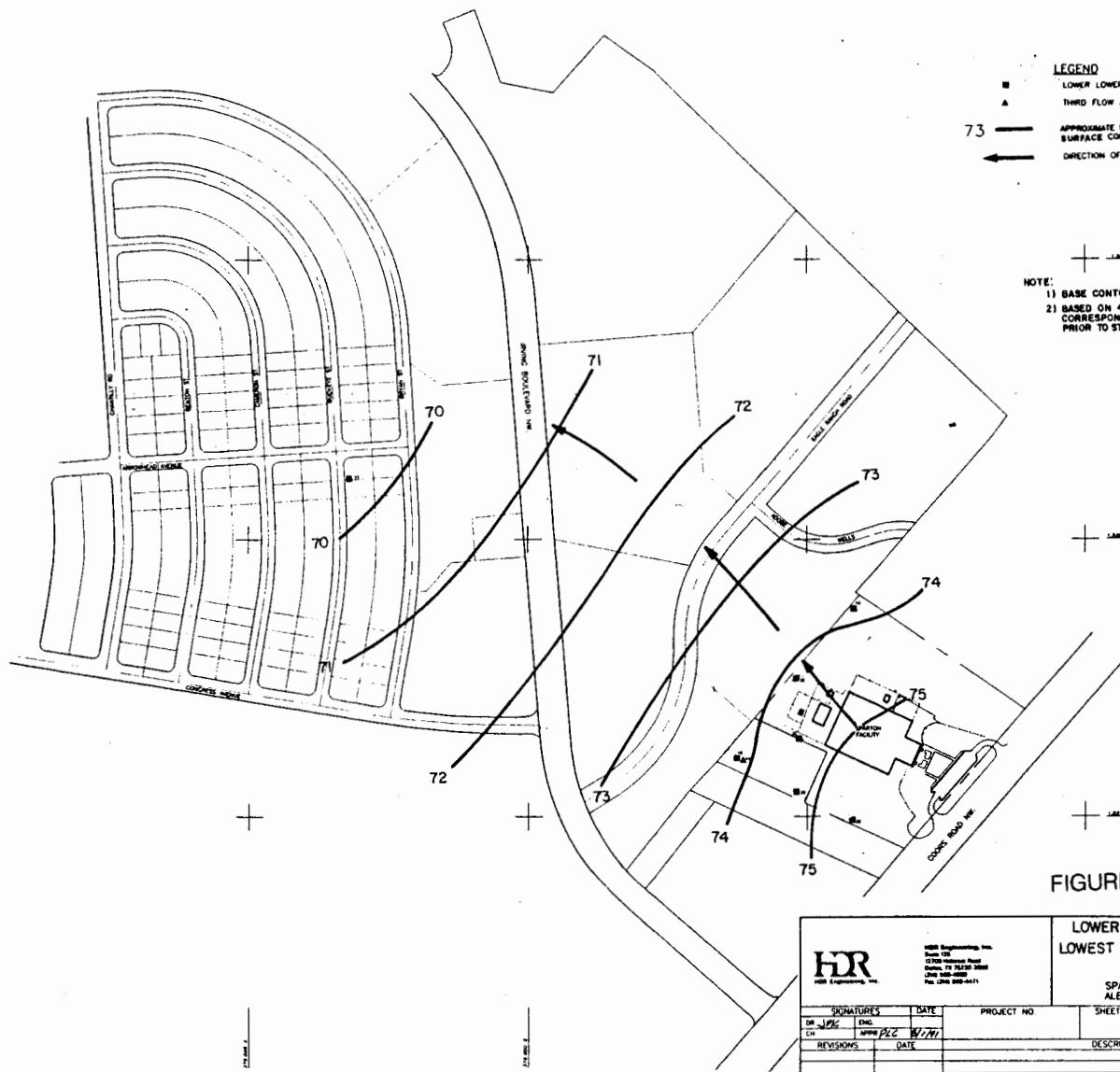


FIGURE 9F

		SPARTON TECHNOLOGY, INC. ALBUQUERQUE, NEW MEXICO	
		PROJECT NO. _____ SHEET NO. _____ OF _____	
SIGNATURES DR. <i>[Signature]</i> CH. <i>[Signature]</i>	DATE APR 22 1996	DESCRIPTION _____	

Based on the results of field work and interpretations of pumping tests and water level data, the following aquifer parameters have been calculated for the Sparton site:

	<b>Aquifer Parameters*</b>
	T = 12,000-18,000 gpd/ft
	K = 0.0075-0.011 cm/sec 160-240 gpd/ft <sup>2</sup>
	S = 0.002-0.003
	N = 0.25-0.40

\* RFI Report, Page 63

T = Transmissivity  
K = Hydraulic Conductivity  
S = Storativity (dimensionless)  
N = Porosity (dimensionless)

Only one well boring, MW-49, has been drilled into the third flow zone, consequently there is limited data for the third flow zone. Between the lower flow zone and the third flow zone, a stratum of clayey sand is present from a depth of 120 feet to 129 feet. Silty sands with clay lamination underlie this clayey sand layer to a depth of 138 feet. Below 138 feet are medium- to coarse-grained sands and sandy gravels to a depth of 148 feet. Monitoring well MW-49 is screened from 138 to 148 feet.

Monitoring wells MW-34, 35, 36, 37, 47, 48, 50, 51, 52, 53, 54, 57, 58, 61, 62, 63, and PZ-1 are screened in the upper flow zone. Monitoring wells MW-44, 45, 46,

56, 59, 60 and 64 are screened in the upper lower flow zone. Monitoring well MW-55 is the only off-site well screened in the lower lower flow zone (See Figure 7) (RFI Figure 11).

The aquifer hydraulic conductivity range reported in the RFI is both consistent with, and conservative to, hydraulic conductivity used in the latest USGS Albuquerque Basin Model (USGS 1995). The RFI hydraulic conductivity value of 21.4 to 32.1 feet/day compares well to the 15 feet/day used by the USGS to represent a large area/extent of the aquifer west of the Rio Grande (including the Sparton plume area) in the upper 580 feet of the saturated zone. The USGS indicated that localized areas with hydraulic conductivity of 25 feet/day are also present. Since the layered, heterogeneous and anisotropic conditions occur over the entire plume area, extension of aquifer parameters from detailed on-site pumping tests is reasonable, valid, and consistent with all available documented information. Therefore, aquifer parameters reported in the RFI are adequate for CMS purposes.

d. Summary of Recent Groundwater Levels and Flow Direction

Figures 9A-9F (RFI Figures 25-30) are potentiometric contour maps for the upper, upper lower and lower lower flow zones based upon November 13, 1990 data. This data is representative of both highest groundwater conditions corresponding to the end of the irrigation (recharge) season and lowest groundwater conditions. Maximum water levels occur to the north of the Sparton facility. Gradients are generally to the southwest across the Sparton property. Between the facility and Irving Boulevard, the gradients are generally

to the west and northwest. Beyond Irving Boulevard the gradients begin a gradual arc back to the established southwestward regional gradient.

The effect of irrigation results in a two- to three-foot change in potentiometric elevation to the south of the facility. However, west of Irving Boulevard the potentiometric elevation is relatively unaffected. As noted in the previous section, water levels have dropped some one to two feet across the site since the RFI Report; however, RFI conclusions remain valid. A summary of water level readings for the post-RFI period through January 1996 is given in Appendix 1.

No gradient direction can be determined for the third flow zone as only one well has been set in that zone.

### 3. Surface Waters

Surface waters in the vicinity of the Sparton facility include the Rio Grande, Las Calabacillas Arroyo, and Corrales Main Canal. The Rio Grande is located approximately 3,000 feet east of the Sparton facility. Las Calabacillas Arroyo, located approximately 1,200 feet north of the site, is an ephemeral stream. The Corrales Main Canal, a man-made hydraulic structure, is located approximately 300 feet east of the site and contains flowing water (Rio Grande source water) eight months out of the year. The canal is used primarily for irrigation.

The level of the Rio Grande through most of the Albuquerque area is controlled by levees which maintain the river level above the level of the inner valley floor and the

surrounding water table. The natural buildup of sediment which raises the river level allows some recharge of the water table through downward movement. As the water table rises under the riverbed, the water spreads out to the surrounding water table. This recharge by surface waters contributes to the irregularities of the gradient and flow direction of the shallow groundwater.

#### 4. Climate

Albuquerque is located in Bernalillo County. The Rio Grande flows southward through the county, which is in the central part of New Mexico. The land rises on both sides of the river and forms mesas that have elevations of about 5,500 feet. The valley and mesa areas are arid, having average annual precipitation near eight inches. Summer is the rainy season. An average of 44 storms occur each year, mostly during this period. The average number of days having 0.10 inch or more precipitation is 22.

The average annual temperature in Albuquerque is 57°F. The temperature reaches 90°F on an average of 75 days a year, and freezing temperatures occur on an average of 105 days a year. The average frost-free season at Albuquerque is 190 days, from mid-April to late October. Average annual relative humidity in Albuquerque is 43 percent, but ranges from near 60 percent early in the morning to nearly 30 percent in the afternoon.



The average annual windspeed is 9 miles per hour. Spring is the windy season. Winds blow most frequently from the north in winter, and from the south along the river valley in summer.

#### B. Contamination Characterization

By their approval of the RFI Report on July 1, 1992, U.S. EPA approved both the hydrogeologic characterization and contamination characterization contained in the RFI Report. In accordance with §1.3. of the Consent Order, approval of the RFI Report incorporated the document into the Consent Order. However, almost five years have elapsed since the final sampling and analysis (June 1991) used to complete the approved RFI Report. In accordance with Task VII of Exhibit I to the Consent Order, sampling and analysis conducted in the post-RFI period is being used to update the characterization information in the RFI Report. Information on post-RFI changes to contamination characterization is based on multiple results from 43 groundwater monitoring wells, recent results from two additional wells not sampled since the RFI, and recent deep soil-gas results from 13 UFZ monitoring wells screened across the top of the saturated zone.

In the great majority (75%) of groundwater sampling locations with detection histories, contamination is decreasing; however, the leading edge of the contaminant plume has moved past several down-gradient wells showing non-detection in the RFI Report. With the exception of eight wells near the leading edge of the plume, the remaining 37 wells

show either decreasing time histories (24 wells) or continuing non-detect (13 wells). At the current time, four hydraulically down-gradient wells continue to show non-detect.

All on-site monitoring wells show either a decrease in contamination or continue to show non-detect. Further, recent deep soil-gas investigation indicated elevated VOC concentration occurring only under the interior of the Sparton Facility.

All information developed to date indicates that, with the exception of the leading edge of the plume, the contamination characterization contained in the RFI Report is still valid. Even with the movement of the plume leading edge noted since the RFI Report, the plume is adequately characterized for CMS purposes.

1. Soil Contamination

- a. Vadose Zone Investigation

The results of PID field screening during the RFI drilling program, analytical testing of borehole soil samples, multiple surface soil gas screenings, and recently conducted deep soil gas analyses indicate that contaminants migrated downward from the ponds and sump. The vertical migration was influenced by the relative location of fine grained silt and/or clay lenses and the presence of more porous coarse-grained sand and gravel layers. Interpretation of the results indicates both sorption and some lateral spreading occurred due to silt/clay layers. Based on available results, most of the contaminant release has completed its migration to the water table, leaving behind only scattered residual levels primarily in the vadose zone underneath the pond and sump area.

Soil gas screening (RFI borehole screening) indicated a general increase in soil gas concentrations of volatile organic constituents (VOC) with depth with the highest concentrations observed under the sump/pond area. Isolated occurrences of higher soil gas concentrations were also observed at depths corresponding to clay/silt lenses. These localized soil gas concentrations are believed to be related to residual VOC sorbed onto the finer-grained soil materials. Recent deep soil gas analyses conducted in April 1996 indicate that, with the exception of the immediate source area, VOC were in the low single-digit ppm (volume or ppmv) range to no detect. In the immediate source area (UFZ monitor well MW-17), VOC were elevated with 184 ppmv TCE and 122 ppmv TCA.

With the exception of TCA concentration in MW-17, deep soil gas results included in Appendix 2 are below equilibrium concentrations with respect to groundwater concentrations predicted by published Henry's Law constants. Based on the deep soil gas results, Henry's Law calculations and considering vapor densities for TCE and TCA are approximately 4-1/2 times air density, the soil gas concentrations indicate that any remaining source material in the unsaturated zone is not migrating to any degree to the ground water. In fact, the observed soil gas concentrations may, in fact, be the result of dissolution from ground water.

Total metals analyses were conducted to assess concentrations of cadmium, chromium, lead, and nickel. Analytical results on several samples indicated that chromium exceeded nominal background levels (2-3 milligrams per kilogram (mg/kg)). Maximum chromium concentration exceeded 3000 mg/kg underneath the sump/pond area. Evaluation

of the data indicates sorption onto silts and clays is probably the dominant process affecting chromium concentration.

b. Surface Soil Gas Investigations

Three surface soil gas investigations have been conducted at the Sparton facility. The first soil gas investigation was conducted in 1984, and involved primarily on-site locations. The second investigation was conducted in 1987, and involved both on-site and off-site locations for soil gas measurements. The third investigation was conducted in June 1991, and covered both on-site and off-site locations (See Figure 3 for Report identification).

The purpose of these investigations was to obtain an estimate of the areal extent of the contaminant plume and to examine the impact of the Interim Measure (IM) on soil gas VOC concentration. All soil gas samples were taken in the shallow subsurface, approximately five to six feet below ground surface. Contour plots of soil gas concentrations from all three investigations are given in Appendix 2.

Based on these surface soil gas surveys, it appeared that the contaminant plume had moved a short distance beyond the facility boundaries. The shape of the surface soil gas plumes also seem to suggest dispersion and diffusion as the predominant plume transport mechanisms with a lesser advection influence.

Based on the results of the 1987 and 1991 surface soil gas surveys, TCA and TCE were detected in the surface soil gas over approximately the same area. However,

within the facility boundary, the 1991 TCE concentration dropped approximately an order of magnitude with only a single sampling point south of the building above 10 micrograms per liter ( $\mu\text{g/l}$ ). The 1991 TCA concentration also decreased approximately thirty to fifty percent within the property boundary to a single peak level above 10  $\mu\text{g/l}$ . Comparison of 1991 data to 1984 on-site data indicate over a thirtyfold decrease in TCA and a fiftyfold decrease in TCE. The surface soil gas results indicate a significant change in soil gas concentration due to both source removal and initiation of the upper flow zone IM in 1988.

c. Deep Soil Gas Investigation

In April 1996, soil gas samples were obtained from a number of upper flow zone wells screened across the top of the saturated zone. Soil gas was purged from the wells until stable, replicate soil gas concentrations were indicated on a photoionization detector field screening instrument calibrated to TCE. Negative pressure and purge rate were also recorded. After purging was completed, soil gas samples were collected using Tedlar<sup>®</sup> bags installed in a vacuum box. The soil gas samples were analyzed on the following day at a local laboratory using EPA Method 8010/8020 procedures. Results are given in Appendix 2.

The deep soil gas results are consistent with the earlier surface soil gas results:

- Highest soil gas concentration occurs in the source area.
- Soil gas concentration is negligible off-site.

The deep soil gas results also indicate that, with the possible exception of TCA in the pond sump area, soil gas is not a source of constituents to the ground water and, in fact, ground water may be the source for deep soil gas VOC detections.

## 2. Surface Water and Sediment Contamination

There are three surface water bodies in the vicinity of the Sparton facility. The Rio Grande is located approximately 3,000 feet east of the Sparton facility, the Las Calabacillas Arroyo is located approximately 1,200 feet north of the facility and the Corrales Main Canal, an irrigation channel, is located approximately 300 feet east of the facility.

Based on regional and site-specific groundwater gradients, each of these surface water bodies is either upgradient or cross-gradient from the source area at the Sparton facility. In addition, the elevations of the water bodies are well above groundwater elevations beneath the Sparton facility and hence would not be affected by the contaminant plume.

## 3. Air Contamination

Soil gas concentrations measured in 1991, approximately five to six feet below ground surface, indicated average TCE and TCA soil gas concentrations of less than 10 µg/l (2.2 ppmv) on-site at the Sparton facility, tapering off to 0.001 µg/l (0.00022ppmv) approximately 1/2 mile away. The mass flux rate of these constituents into the

atmosphere, while not measured, is believed to be minimal due to the low concentrations of soil gas measured during the 1991 survey.

#### 4. Groundwater Contamination

##### a. Definition of Plume

A total of fifty-six groundwater monitoring wells have been installed to assess groundwater elevations and to collect representative groundwater samples for chemical analyses in an effort to evaluate the horizontal and vertical limits of the contaminant plume. Figure 10 (RFI Figure 53) presents pertinent well screen data for the wells. TCE and TCA concentration values have been used to define the plume configuration because they represent the major constituents of the groundwater contamination. Based on concentration data and plume contouring given in the RFI Report, an average TCE concentration of 844 µg/l was calculated for the UFZ and an average concentration of 606 µg/l considering all three flow zones. Using results of the 1996 sampling information (included in Appendix 1) and 1996 plume contouring included in this report, the average UFZ TCE concentration is 372 µg/l and the three-flow-zone TCE average concentration is 366 µg/l. TCA has been observed to occur at concentrations of approximately one third of TCE concentration. Analytical results through January 1996 are summarized in Appendix 1.

FIGURE 10

## WELL SUMMARY

WELL NUMBER	ZONE *	MEASURING POINT ELEVATION	DEPTH TO TOP OF SCREEN (FT.)	DEPTH TO BOTTOM OF SCREEN (FT.)	ELEVATION AT TOP OF SCREEN (FT.,MSL)	ELEVATION AT BOTTOM OF SCREEN (FT.,MSL)	LENGTH OF SCREEN (FT.)
PW-1	UFZ	5044.54	60.0	70.0	4984.54	4974.54	10.0
7	UFZ	5044.80	63.5	68.5	4981.30	4976.30	5.0
9	UFZ	5044.11	62.5	67.5	4981.61	4976.61	5.0
12	UFZ	5042.58	64.0	74.0	4978.58	4968.58	10.0
13	UFZ	5043.25	60.0	70.0	4983.25	4973.25	10.0
14	UFZ	5041.91	61.5	71.5	4980.41	4970.41	10.0
15	UFZ	5047.49	60.0	70.0	4987.49	4977.49	10.0
16	UFZ	5047.50	68.0	73.0	4979.50	4974.50	5.0
17	UFZ	5049.28	67.0	72.0	4982.28	4977.28	5.0
18	UFZ	5045.58	68.0	78.0	4977.58	4967.58	10.0
19	ULFZ	5046.25	97.0	107.0	4949.25	4939.25	10.0
20	LLFZ	5045.79	125.0	138.0	4920.79	4907.79	13.0
21	UFZ	5048.36	64.5	69.5	4983.86	4978.86	5.0
22	UFZ	5048.06	72.0	77.0	4976.06	4971.06	5.0
23	UFZ	5048.51	72.0	77.0	4976.51	4971.51	5.0
24	UFZ	5048.70	68.4	73.4	4980.30	4975.30	5.0
25	UFZ	5049.00	67.7	72.7	4981.30	4976.30	5.0
26	UFZ	5045.71	73.0	78.0	4972.71	4967.71	5.0
27	UFZ	5045.50	67.0	72.0	4978.50	4973.50	5.0
28	UFZ	5042.69	65.0	70.0	4977.69	4972.69	5.0
29	ULFZ	5044.51	103.0	113.0	4941.51	4931.51	10.0
30	ULFZ	5044.70	97.0	107.0	4947.70	4937.70	10.0
31	ULFZ	5043.53	96.0	106.0	4947.53	4937.53	10.0
32	LLFZ	5048.05	108.0	118.0	4940.05	4930.05	10.0
33	UFZ	5044.29	63.0	73.0	4981.29	4971.29	10.0
34	UFZ	5034.49	56.5	66.5	4977.99	4967.99	10.0
35	UFZ	5042.50	63.2	73.2	4979.30	4969.30	10.0
36	UFZ	5059.35	82.3	92.3	4977.05	4967.05	10.0
37	UFZ	5091.66	115.0	125.0	4976.66	4966.66	10.0
38	LLFZ	5044.32	126.5	136.5	4917.82	4907.82	10.0
39	LLFZ	5044.06	123.0	133.0	4921.06	4911.06	10.0
40	LLFZ	5043.35	117.0	127.0	4926.35	4916.35	10.0
41	ULFZ	5046.77	92.0	97.0	4954.77	4949.77	5.0
42	ULFZ	5057.33	105.0	115.0	4952.33	4942.33	10.0
43	LLFZ	5057.74	127.0	137.0	4930.74	4920.74	10.0
44	ULFZ	5058.71	106.0	116.0	4952.71	4942.71	10.0
45	ULFZ	5090.11	143.0	153.0	4947.11	4937.11	10.0
46	ULFZ	5118.98	170.0	180.0	4948.98	4938.98	10.0
47	UFZ	5155.83	180.0	195.0	4975.83	4960.83	15.0
48	UFZ	5168.31	192.0	207.0	4976.31	4961.31	15.0
49	3rdFZ	5043.67	137.7	147.7	4905.97	4895.97	10.0
50	UFZ	5211.51	235.0	250.0	4976.51	4961.51	15.0
51	UFZ	5058.86	75.0	85.0	4983.86	4973.86	10.0
52	UFZ	5165.81	190.8	206.0	4975.01	4959.81	15.2
53	UFZ	5164.24	189.8	204.0	4974.44	4960.24	14.2
(**) 54	UFZ	5097.64	117.0	132.0	4980.64	4965.64	15.0
55	LLFZ	5168.61	255.0	265.0	4913.61	4903.61	10.0
56	ULFZ	5168.61	220.0	230.0	4948.61	4938.61	10.0
57	UFZ	5103.54	126.0	141.0	4977.54	4962.54	15.0
58	UFZ	5168.89	194.0	209.0	4974.89	4959.89	15.0



FIGURE 10

## WELL SUMMARY (cont'd)

WELL NUMBER	ZONE *	MEASURING POINT ELEVATION	DEPTH TO TOP OF SCREEN (FT.)	DEPTH TO BOTTOM OF SCREEN (FT.)	ELEVATION AT TOP OF SCREEN (FT.,MSL)	ELEVATION AT BOTTOM OF SCREEN (FT.,MSL)	LENGTH OF SCREEN (FT.)
59	ULFZ	5059.18	104.5	115.0	4954.68	4944.18	10.5
60	ULFZ	5133.62	185.0	195.0	4948.62	4938.62	10.0
61	UPZ	5133.98	158.0	173.0	4975.98	4960.98	15.0
62	UPZ	5075.00	95.0	110.0	4980.00	4965.00	15.0
63	UPZ	5065.74	83.0	98.0	4982.74	4967.74	15.0
64	ULFZ	5097.84	138.8	149.0	4959.04	4948.84	10.2
PZ-1	UPZ	5144.22	182.7	198.0	4961.52	4946.22	15.3

(\*) UPZ = UPPER FLOW ZONE  
 ULFZ = UPPER LOWER FLOW ZONE  
 LLFZ = LOWER LOWER FLOW ZONE  
 3rdPZ = THIRD FLOW ZONE

(\*\*) WELL # 54 IS NONFUNCTIONAL

THE FOLLOWING WELLS HAVE BEEN MODIFIED OR COMPLETELY PLUGGED:

Well Number	Status
PW-1	Plugged back to upper flow zone+ - Converted to recovery well
P-1	Plugged
1	Plugged
2	Plugged
3	Plugged
4	Plugged
5	Plugged
6	Plugged
8	Plugged
10	Plugged
11	Plugged
12	Plugged back to upper flow zone+
13	Plugged back to upper flow zone+
14	Plugged back to upper flow zone+
15	Plugged back to upper flow zone+
18	Converted to recovery well
23	Converted to recovery well
24	Converted to recovery well
25	Converted to recovery well
26	Converted to recovery well
27	Converted to recovery well
28	Converted to recovery well
54	Used only for water level measurements

+ ORIGINALLY OPEN TO UFZ, ULFZ, AND LLFZ

Acetone, DCE and MeCl have also been detected, but are not as prevalent as TCE and TCA. Physical and chemical data for these constituents are given in Figure 11 (RFI Figure 70).

In addition to solvents, elevated concentrations of barium, chromium, lead, and manganese have been identified. Historically, chromium has the highest frequency of occurrence of elevated concentration. The elevated chromium detections are exclusively within the boundaries of the TCE plume and restricted to the upper and upper lower flow zones.

The New Mexico Groundwater Standard Maximum Allowable Concentration and the U.S. EPA groundwater protection Maximum Concentration Limit of 0.05 milligrams per liter (mg/l) have been used as the Level of Significance for chromium. A comparison of results from thirty-nine wells included in the RFI Report indicated that, out of thirteen chromium detections, eight samples exhibited concentrations above 0.05 mg/l. However, the RFI Report noted that the detection data was from total (both suspended and dissolved) chromium analysis obtained from unfiltered groundwater samples. In addition, the samples were obtained from wells with stainless steel well screens which could impact the accuracy of metal analyses if any steel was present in samples, all of which were preserved with nitric acid ( $\text{pH} < 2$ ). Accordingly, comparison of these total metals results to groundwater protection standards, which are expressed as dissolved metals concentrations is inappropriate.

FIGURE 11

## CONSTITUENT PHYSICAL AND CHEMICAL DATA

NAME	CAS #	MOLECULAR WEIGHT (g/mole)	WATER SOLUBILITY (mg/l)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT (atm-m <sup>3</sup> /mole)	K <sub>oc</sub> (ml/g)	SPECIFIC GRAVITY @ 20°	VAPOR DENSITY (air = 1.0)	BOILING POINT (°C)
Acetone (2-Propanone)	67-64-1	58	1.00E+06	2.70E+02	2.06E-05	2.2	0.7880	2.00	56.5
Benzene	71-43-2	78	1.75E+03	9.52E+01	5.59E-03	83	0.8787	2.80	80.1
1,1-Dichloroethylene (Vinylidene Chloride)	75-35-4	97	2.25E+03	600E+02	3.40E-02	65	1.2129	3.40	31.70
Dichloromethane (Methylene Chloride)	75-09-2	85	2.00E+04	3.62E+02	2.03E-03	8.8	1.3255	2.90	39.75
Ethylbenzene	100-41-4	106	1.52E+02	7.00E+00	6.43E-03	1100	0.8660	3.90	136.25
1,1,2,2-Tetrachloroethane (Tetrachloroethane)	79-34-5	168	2.90E+03	5.00E+00	3.81E-04	118	1.5866	5.80	146.5
Tetrachloroethylene (Perchloroethylene)	127-18-4	166	1.50E+02	1.78E+01	2.59E-02	364	1.6230	5.80	121.0
Toluene	108-88-3	92	5.35E+02	2.81E+01	6.37E-03	300	0.8660	3.90	110.6
1,1,1-Trichloroethane (Methyl Chloroform)	71-55-6	133	1.50E+03	1.23E+02	1.44E-02	152	1.3376	4.60	113-114
Trichloroethylene	79-01-6	131	1.10E+03	5.79E+01	9.10E-03	126	1.4649	4.53	86.7
Vinyl Chloride (Chloroethylene)	75-01-4	63	2.67E+03	2.66E+03	8.19E-02	57	0.9106	2.20	-13.4
Xylene (mixed)	1330-20-7	106	1.98E+02	1.00E+01	7.04E-03	240	0.86-0.88	3.66	137-144

Subsequent to the RFI, additional sampling and analyses for both total chromium and hexavalent chromium have been conducted. A summary of results is included in Appendix 1.

The 1996 chromium detection results have no apparent correlation with TCE concentration or TCE plume location. Moreover, none of the samples were filtered and analyzed for dissolved chromium. The January 1996 total chromium detection data indicate a log-normal distribution with an average detection concentration of 0.093 mg/L which is below the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL) of 0.1 mg/L. Assuming a concentration of 0.009 mg/L for all non-detect results, an average total chromium concentration of 0.026 mg/L is conservatively obtained which is below the New Mexico MAC of 0.05 mg/L for dissolved chromium (New Mexico WQCC Regulations § 3103).

b. Horizontal Extent of Contamination

As indicated under site-specific hydrogeology in previous Section III A.2.c. of this report, only a single groundwater unit has been investigated beneath the site. Previous reports and correspondence subdivided this groundwater unit into flow zones--the upper, the upper lower, the lower lower, and the third flow zones. Due to the saturated

thickness of the groundwater unit, this subdivision has been retained to simplify three dimensional description and to maintain continuity in reporting. Use of these zone subdivisions is a convenient method to provide horizontal planes of reference at different depths within the groundwater unit.

(1) Upper Flow Zone

TCE concentration data collected from twenty-two upper flow zone wells were contoured to illustrate the general configuration of the contaminant plume (Figure 12) (RFI Figure 55). TCE concentrations were obtained from sampling and analysis conducted during June 1991. Comparison of the June 1991 data with data obtained in 1989 and 1990 indicated a decrease in TCE concentration. The less than 5 µg/l isopleth or contour represents the detection limit of the perimeter of the plume. Based on this boundary, the length along the longitudinal axis of the plume was approximately 2100 feet northwest from the facility's western property line. The longitudinal axis of the plume closely paralleled the implied direction of groundwater flow given on Figure 9A (RFI Figure 25). Transverse width of the plume was approximately 1400 feet.

Figure 12A was prepared using January 1996 data included in Appendix 1. The position of the northwest edge of the plume was estimated using historical plume information including movement rate, concentration gradients, potentiometric information, and geologic data. Plume dimensions have increased to 2,600 feet (off-site longitudinal) and approximately 1,500 feet (transverse). Down-gradient non-detections are still occurring in UFZ wells MW-50, MW-52, MW-57, and PZ-1.



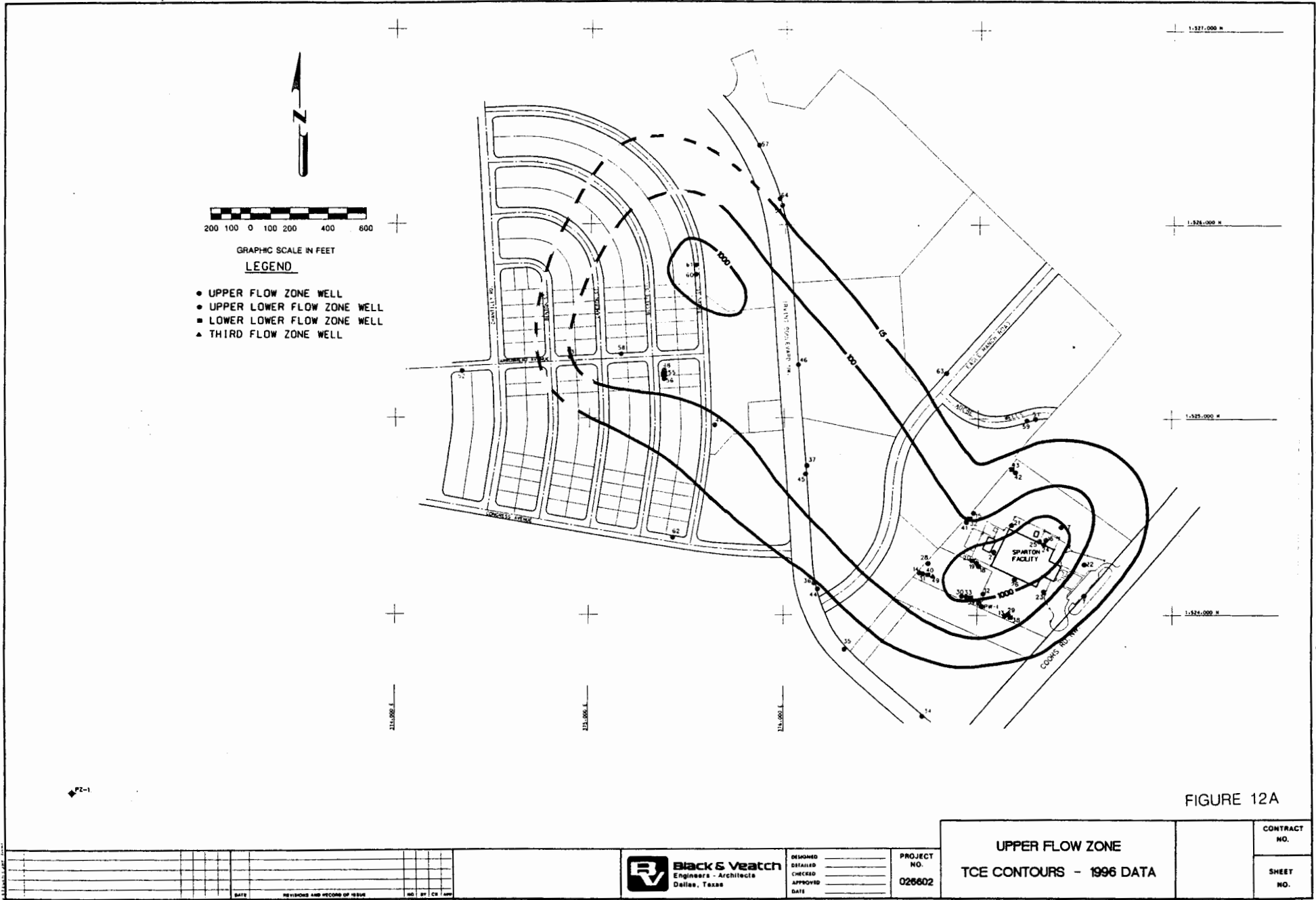


FIGURE 12A

			<p><b>Black &amp; Veatch</b> Engineers - Architects Dallas, Texas</p>	<p>DESIGNED _____</p> <p>DRAWN _____</p> <p>CHECKED _____</p> <p>APPROVED _____</p> <p>DATE _____</p>	<p>PROJECT NO. 026602</p>	<p>UPPER FLOW ZONE TCE CONTOURS - 1996 DATA</p>		<p>CONTRACT NO.</p> <p>SHEET NO.</p>
--	--	--	-------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------	-------------------------------	-----------------------------------------------------	--	--------------------------------------

Comparison of the January 1996 data to the RFI Report information indicates that the areal extent of the UFZ TCE plume has increased approximately fifteen percent; however, average TCE concentration dropped almost fifty percent. Of the twenty-two UFZ wells sampled in January 1996, fourteen wells (all eight on-site and six off-site) show decreasing TCE trends. Three off-site wells near the leading edge of the plume show an increase in TCE concentration, and five off-site wells continue to show no detection.

In the RFI Report, the TCA plume had a similar alignment to the TCE plume with a slight increase in width. However, off site concentrations of TCA were generally over an order of magnitude less than the TCE plume. Analytical results obtained since the RFI Report indicate a steady decrease in TCA concentration (up to 5X) in all eight on-site wells. As of January 1996, maximum TCA concentration on-site was less than 2,000 µg/l. Three off-site wells (MW 37, MW 61, MW 62) show an increase with levels still below action thresholds; however, these wells are randomly located with respect to eleven off-site wells continuing to show no detection of TCA. Based on results through January 1996, TCA average concentration and areal extent in the UFZ has significantly decreased.

With the exception of the movement of the leading edge of the plume, the RFI conclusions relative to decreasing concentration are still valid and the horizontal limits of the plume are still defined by down-gradient non-detection wells. The UFZ plume is adequately defined and characterized for CMS purposes.

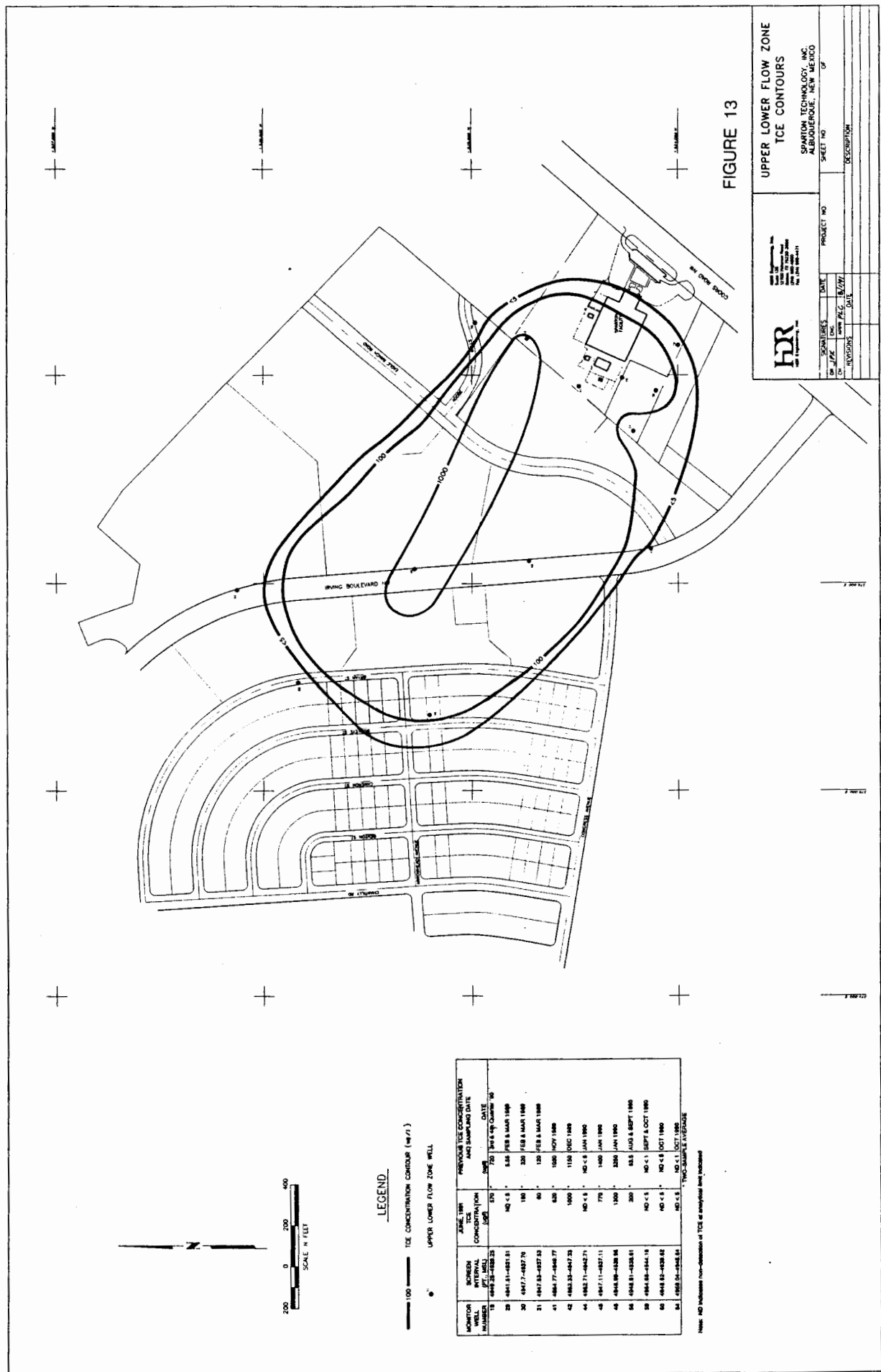


## (2) Upper Lower Flow Zone

Figure 13 (RFI Figure 57) presents the general configuration of the TCE plume based on analytical results from thirteen wells screened in the upper lower flow zone. The isopleth contours are based on June 1991 data. Comparison of the 1991 data with previous 1989 and 1990 data indicated a significant decrease in TCE concentration. The length of the plume along the longitudinal axis is approximately 1900 feet northwest from the west side of the facility. The longitudinal axis of the plume parallels the implied direction of groundwater flow. Width of the plume is approximately 1400 feet. Overall, the areal coverage is similar to the upper flow zone plume.

Recontouring of the TCE plume using analytical data obtained through January 1996 (Appendix 1) indicates changing shape, but little increase in areal extent; however, average TCE concentration has dropped approximately twenty percent. Of 13 wells sampled through January 1996, seven wells are showing a decrease in TCE concentration and three wells on the west edge of the plume are showing an increase in TCE concentration. Figure 13A was contoured using January 1996 data, historical trends, and comparison to the UFZ configuration. The longitudinal axis of the plume currently extends 2,200 feet off-site with a maximum transverse width of 1,500 feet.

In the RFI Report, the general configuration of the TCA plume was similar to the TCE plume; however, TCA concentrations were, on the average, over an order of magnitude less. Analytic results obtained through January 1996 show a significant decrease in TCA concentration. Only a single well (MW 46) is showing concentrations above action levels



**HR**  
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Tel: (310) 275-1111

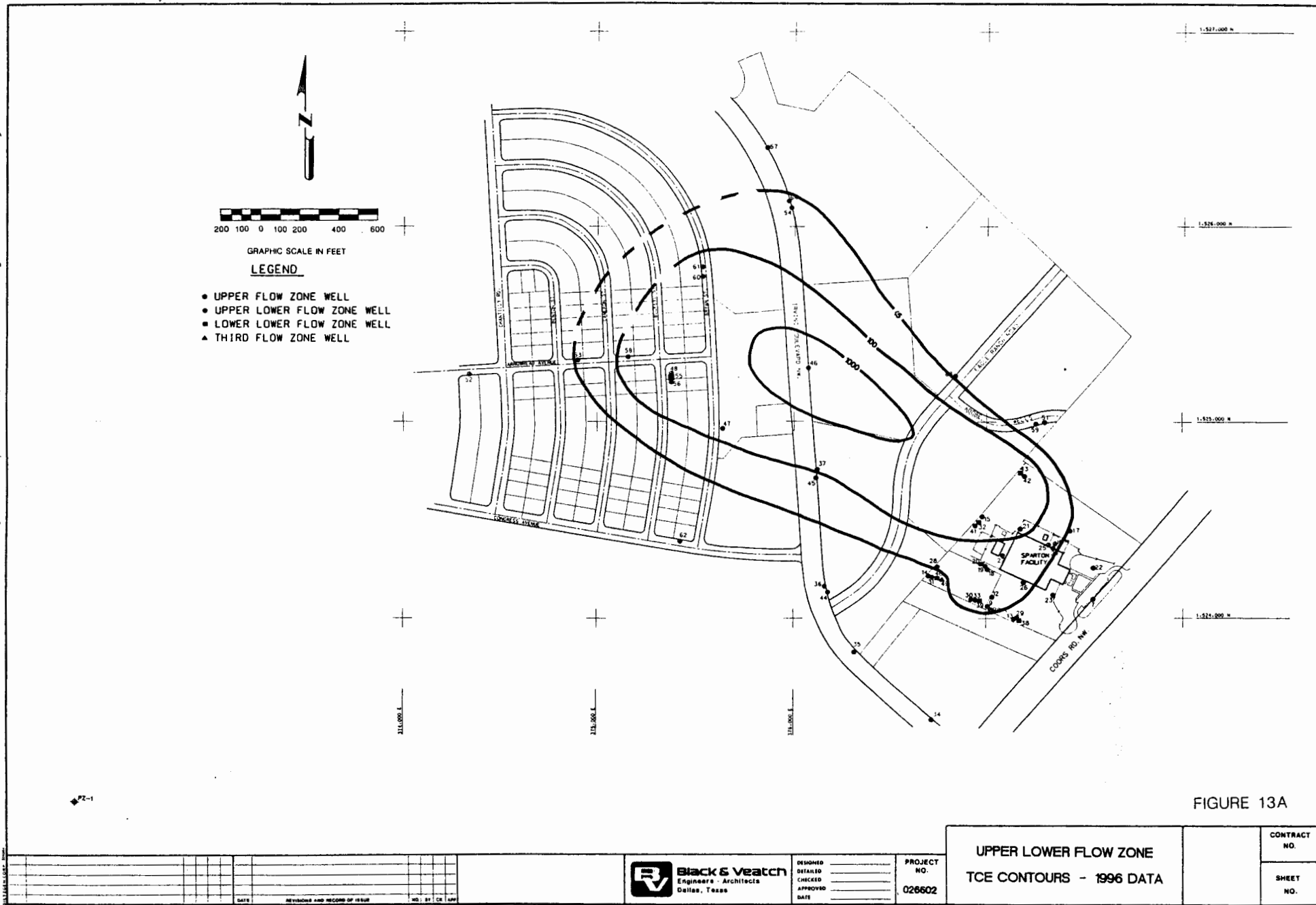
**UPPER LOWER FLOW ZONE  
TCE CONTOURS**

SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO

DATE: 5/1/96  
BY: JFE  
CHECKED: JFE  
APPROVED: JFE

PROJECT NO: 96-001  
SHEET NO: 01

DESCRIPTION:



and only two other wells have detectable concentration (on-site wells MW-41 and MW-42).

The remaining ten wells are below detection levels.

With the exception of the movement of the leading edge of the plume, ULFZ characterization presented in the RFI Report is still valid. Down-gradient non-detection at the time of the RFI Report no longer exists. However, observations in the most down-gradient well on the plume axis indicates a slow rate of plume movement and concentration is increasing at a much lower rate than in the UFZ well immediately above. Considering the historic relationship of the ULFZ plume footprint to the UFZ plume footprint and their relative proximity (~30 feet vertically), and the documented vertical anisotropy, the ULFZ plume is adequately defined for CMS purposes.

### (3) Lower Lower Flow Zone

The TCE plume for the lower flow zone included in the RFI Report is shown on Figure 14 (RFI Figure 59). The TCE plume configuration was based on June 1991 concentration data obtained from 6 wells and November 1991 data for well MW-32 screened in the lower flow zone. Comparison of the June 1991 data with data from 1989 and 1990 indicated over an order of magnitude decrease in TCE concentration with no measurable change in areal extent or plume location. The plume alignment paralleled the implied groundwater flow direction for the lower flow zone. Off-site length was 1800 feet and width was approximately 700 feet.

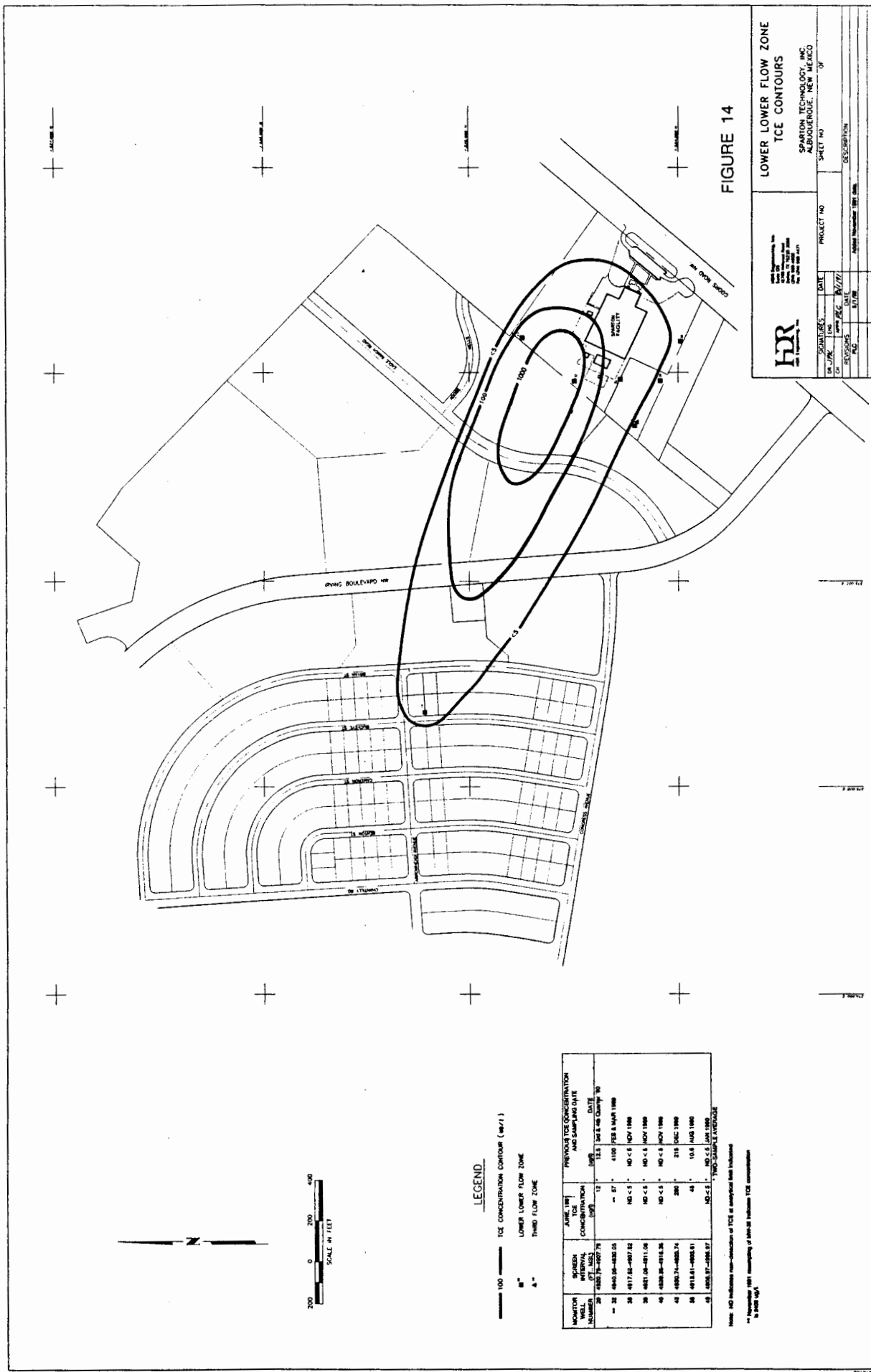


FIGURE 14

**HR**

SPARTON TECHNOLOGY, INC.  
ANN ARBOR, MI 48106

**LOWER LOWER FLOW ZONE  
TCE CONTOURS**

PROJECT NO. \_\_\_\_\_

SHEET NO. \_\_\_\_\_

DATE: \_\_\_\_\_

BY: \_\_\_\_\_

CHECKED: \_\_\_\_\_

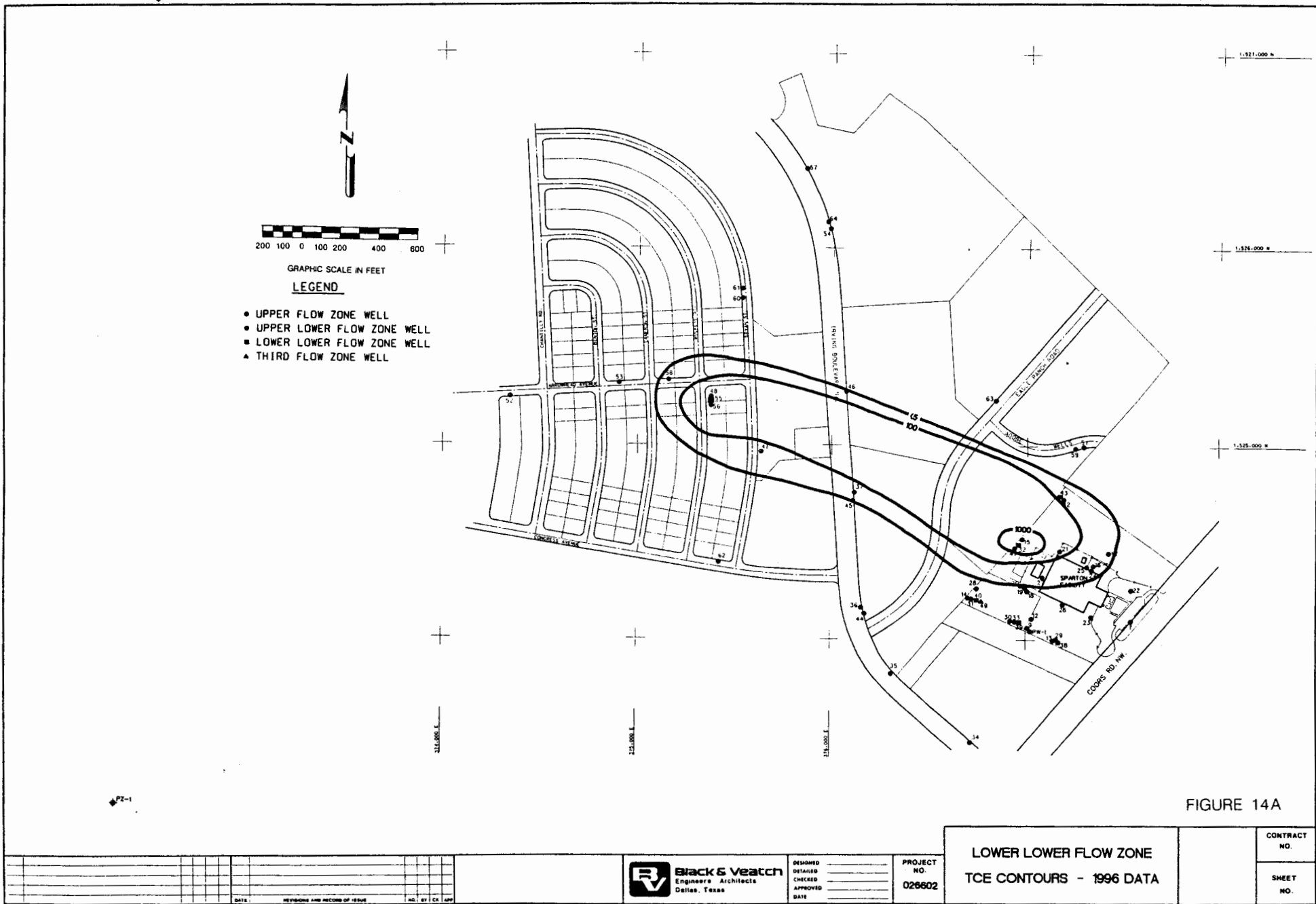
APPROVED: \_\_\_\_\_

Using analytical data obtained through January 1996, the LLFZ TCE plume was recontoured as shown in Figure 14A. The plume areal extent decreased slightly. In the seven LLFZ wells sampled through January 1996, only a single well (MW 55) is showing an increase in TCE concentrations. Three wells are showing steady decrease and three wells continue to show no detection.

The TCA plume given in the RFI Report had the same basic configuration and alignment as the TCE plume; however, it was much shorter and narrower than the TCE plume. The TCA concentrations were also lower. Comparison of June 1991 data with previous data indicated no significant change in either areal extent of the plume or TCA concentration.

Analytical data from seven LLFZ wells sampled through January 1996 indicates TCA detection in only two on-site wells (MW 32 and MW 43). Five wells continue to show non-detect. There are no LLFZ wells showing increases in TCA concentration.

With the exception of increasing concentration in a single well at the leading edge of the plume (MW-55), conclusions in the RFI Report are still valid. Down-gradient non-detection was not available for the RFI. However, comparison of the LLFZ plume with the UFZ and LLFZ footprints and trends, (and recognition of the significant vertical anisotropy and vertical proximity), indicates that the LLFZ plume is adequately characterized for CMS purposes.



#### (4) Third Flow Zone

Only a single well has been constructed in the third flow zone (Well No. 49). June 1991 analyses from this well did not detect volatile organic constituents. Previous analyses in January 1990 detected trichlorofluoromethane at concentrations slightly above detection limits of 5 µg/l. The well was sampled again in December 1993 and January 1996. Both TCE and TCA were below detection limits of 1 µg/l. Characterization of the TFZ contained in the RFI remains unchanged.

#### c. Vertical Extent of Contamination

Vertical extent of contamination has been demonstrated using groundwater analytical results from ten well clusters. The location of the ten well clusters (five on-site and five off-site) is shown on Figure 7 (RFI Figure 11). Analytical data used to evaluate the vertical extent of contamination was obtained from the RFI Report and subsequent results through January 1996 summarized in Appendix 1. Figure 15 (RFI Figure 63) is a key for identifying the wells, screen elevations, and flow zones monitored at each of the ten well clusters.

Time-history plots of TCE concentration through January 1996 for each well cluster are included in Appendix 1. Based on these cluster plots, several conclusions on vertical extent of contamination can be made. Consistent with the heterogenous, anisotropic nature of the subsurface materials, vertical migration of TCE has been significantly impeded relative to horizontal movement. Of the ten well clusters, eight well clusters show



**FIGURE 15**

**WELL CLUSTER SUMMARY**

<b>Well Cluster No.</b>	<b>Well No.</b>	<b>Screened Interval Elevation, Ft (MSL)</b>	<b>Flow Zone</b>
1	13	4983.35 - 4978.35	UFZ
	29	4941.57 - 4931.57	ULFZ
	38	4917.85 - 4907.85	LLFZ
2	33	4981.36 - 4971.36	UFZ
	30	4947.70 - 4937.70	ULFZ
	39	4921.07 - 4911.07	LLFZ
3	14	4980.94 - 4970.94	UFZ
	31	4947.57 - 4937.57	ULFZ
	40	4926.46 - 4916.26	LLFZ
	49	4905.88 - 4895.88	TFZ
4	15	4987.51 - 4977.51	UFZ
	41	4954.79 - 4949.79	ULFZ
	32	4940.08 - 4930.08	LLFZ
5	42	4952.28 - 4942.28	ULFZ
	43	4930.69 - 4920.69	LLFZ
6	36	4977.0 - 4967.0	UFZ
	44	4954.68 - 4944.68	ULFZ
7	37	4976.66 - 4966.66	UFZ
	45	4949.35 - 4939.35	ULFZ
8	51	4983.86 - 4973.86	UFZ
	59	4954.68 - 4944.18	ULFZ
9	48	4976.31 - 4961.31	UFZ
	56	4948.61 - 4938.61	ULFZ
	55	4913.61 - 4903.61	LLFZ
10	61	4975.98 - 4960.98	UFZ
	60	4948.62 - 4938.62	ULFZ

**Note:**

UFZ	=	UPPER FLOW ZONE
ULFZ	=	UPPER LOWER FLOW ZONE
LLFZ	=	LOWER LOWER FLOW ZONE
TFZ	=	THIRD FLOW ZONE

a decrease in TCE concentration with depth and five clusters have shown no detection ( $< 0.3 \mu\text{g/l}$ ) of TCE in the lowest well of the cluster.

Two clusters (No. 4 on-site and No. 9 on the west plume edge off-site) show increasing TCE concentration with depth. The anomalous trends in these two clusters may be related to subsurface differences and/or to well completion.

Eight of the cluster wells also show a cluster decrease in TCE concentration over time. Only two clusters (No. 9 and No. 10) show increasing TCE concentration.

With respect to TCA, eight well clusters have non-detect bottom wells. Only clusters No. 4 and No. 5 on-site have detectable TCA concentrations in the bottom wells. Three off-site clusters (No. 6, No. 8, No. 9) around the outer edge of the plume were non-detect ( $< 1.0 \mu\text{g/l}$ ). Only a single well in a single cluster (UFZ MW-61 in well cluster No. 10) shows increasing concentration of TCA.

With the exception of two well clusters (Nos. 9 and 10) near the leading edge of the plume, the remaining eight clusters continue to show the same trends described in the RFI Report. Considering the maximum vertical interval of some 60 feet in cluster No. 9 and some 25 feet in cluster No. 10, the historic relationship of the UFZ, ULFZ, and LLFZ plumes, and the significant vertical anisotropy, vertical extent of contamination is adequately defined for CMS purposes.

d. Plume Movement

(1) Horizontal Movement

As pointed out in the RFI Report and as confirmed by the latest USGS modeling of the Albuquerque Basin (USGS, 1995), hydraulic parameters in the upper aquifer are relatively constant. The RFI established a horizontal hydraulic conductivity,  $K$  of 21.4 to 32.1 ft/day whereas the USGS used a  $K$  value of 15 ft/day for the upper 580 feet of the aquifer. The RFI indicated a porosity of 0.25 to 0.40 and the USGS used a porosity of 0.15. Using either set of parameters and the equation for groundwater velocity,  $V_a = Ki/n$  where  $V_a$  is the actual particle velocity (L/T)

$K$  is the hydraulic conductivity (L/T)

$i$  is the hydraulic gradient (L/L)

$n$  is the effective porosity

groundwater velocity can be expressed in terms of the hydraulic gradient as:

$$V_a = 36,500 i \text{ (feet/year - USGS)}$$

$$V_a = 19,528 i \text{ to } 45,552 \text{ (feet/year - RFI Report)}$$

Clearly, water velocity (and potentially plume movement) is dependent on hydraulic gradient. The RFI Data and subsequent water level data included in Appendix 1 indicate off-site gradients in the 0.001 to 0.003 range with flow direction indicated generally to the west. The USGS also shows an average gradient of 0.002; however, the implied flow direction is to the southeast for steady state conditions. Simulation to 1994 conditions

showed flow in Layer 5, some eighty feet into the aquifer, to the southwest with an average gradient of 0.0016 (USGS, 1995).

Using an average gradient of 0.002 for off-site conditions, groundwater velocity would range from 39 to 91 feet/year. Considering the length of the plume given in the RFI Report (when the downgradient edge was defined by non-detections at multiple locations) average plume movement would have been less than 100 feet per year; however, considering the increased UFZ on-site gradients from adjacent irrigation, early plume movement would probably have been faster with slower movement in later years as the plume moved off-site. Current plume movement appears to be less than 100 feet/year.

The RFI Report pointed out that there were no stratigraphic or potentiometric bases for use of flow zone divisions off-site. Water level data obtained through January 1996 confirms this conclusion. Further, the RFI Report (consistent with published works of others) pointed out that only a single groundwater unit is present. However, the RFI Report indicated that use of flow zone identifications was useful for vertical location purposes and for assisting in three-dimensional description of the contaminant plume. It should be noted that the multiple flow zone identification was used to describe the upper 60 to 75 feet of the aquifer in significant detail.

It is apparent from various comments and correspondence that flow zone descriptions have been misinterpreted as separate groundwater/stratigraphic units and as

representing a much greater vertical interval. This misinterpretation is unfortunate and creates a false impression that monitoring is inadequate. It should be noted that use of three 10-foot screens in a 60- to 75-foot vertical interval (three-well cluster) or two 10-foot screens in a 30- to 40-foot vertical interval is significant coverage.

It should also be noted that movement is almost exclusively in the horizontal direction. Vertical migration is only a small fraction of the longitudinal and transverse horizontal movement observed to date. This is not unusual, and only confirms the significant vertical anisotropy described in the RFI Report and verified by the USGS study (USGS, 1995) and others.

Some disagreement has recently developed over the form of contaminant transport responsible for plume movement. This is surprising in light of the physical evidence obtained to date and the characterization and conclusions contained in the EPA-approved RFI Report. The disagreement/confusion appears to be the result of semantics and the use of narrow definitions outside their intended purpose. Further, there are significant differences between the definition of certain transport terms and the way those terms are used in describing contaminant transport. For example, EPA and others have offered calculations of molecular diffusion as proof that diffusion is not an important process in plume movement/shape. Molecular diffusion calculations are fine but they miss the normal context or usage of the term diffusion as used to describe contaminant transport.



In the classic use of the terms, advection refers to the coincident transport of water and contaminant within the pore space. Diffusion refers to Brownian or molecular movement of contaminant resulting from concentration differences. Dispersion refers to contaminant movement resulting from variation in the pore-water velocity. However, as typically used in the Advection-Dispersion approach to contaminant transport, there is significant blurring of the definition of dispersion. To model the real world, dispersion is given two components -- one related to diffusion or concentration and one related to pore-water velocity. However, when velocities are low, dispersion is correlated to concentration and transport is described as "diffusion-dominant". It should be noted that description of transport as diffusion-dominant does not preclude advective processes or vice versa. Most references agree that the difference between diffusion-dominated transport and advection-dominant transport can be expressed through the use of the dimensionless Peclet Number,  $Pe$ , or the ratio of advection processes to diffusion processes.

The Peclet Number,  $Pe$ , is generally defined as:

$$Pe = V/D$$

where  $V$  is a characteristic velocity (L/T)

$l$  is a characteristic linear dimension (L)

$D$  is a diffusion coefficient (L<sup>2</sup>/T)

Individual references use varying definitions for each of the latter two parameters; however, all use water velocity for  $V$ . In Transport and Fate of Contaminants in the Subsurface (U.S. EPA, 1989), the Peclet number is defined in terms of the water velocity, the average

grain diameter, and the molecular diffusion coefficient. From the average hydraulic conductivity given in the RFI Report, an average grain size of 0.425 mm can be obtained by averaging the results of numerous reported correlations of grain size to hydraulic conductivity. Molecular diffusion coefficient was averaged from the  $1 \times 10^{-9}$  to  $2 \times 10^{-9}$  range reported in the literature.

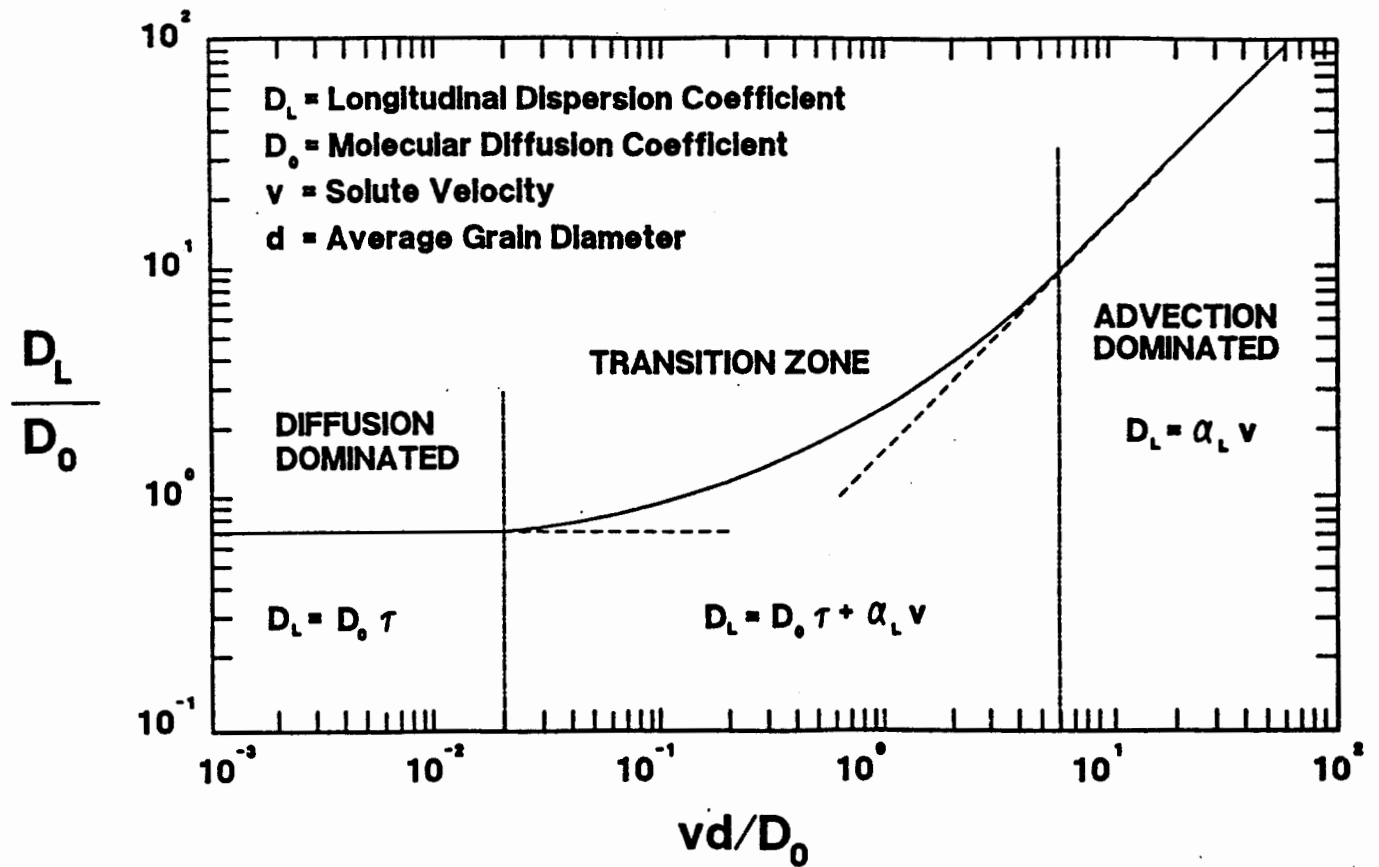
Using the above parameter values, an average Peclet Number of 0.162 is calculated. With reference to the relationship reproduced in Figure 16 (U.S. EPA, 1989), the calculated Peclet Number is in the low end of the transition zone and diffusion-dominated plume characteristics would be expected. Peclet Number calculations using other reference methods (EPRI, 1984, and Freeze and Cherry, 1979) result in Peclet Numbers ranging from  $1.24 \times 10^{-3}$  (EPRI) to  $4.86 \times 10^{-1}$  (Freeze and Cherry). All of these are clearly below the advection-dominant threshold of 6 as shown in Figure 16.

A review of the plume geometry also confirms that concentration-related mechanics exerted larger influence than velocity related mechanics. This is readily apparent in the plume length-to-width ratios of 2:1 (UFZ and ULFZ) and 3.5:1 (LLFZ) and the upgradient spreading of the plume.

Because of the relatively flat gradients and the consistent degree of hydrogeologic heterogeneity and anisotropy, plume movement should continue at rates less than or equal to those observed to date. Since the source has been removed, diffusion and/or dispersion will continue to play an even greater role in plume movement. Extrapolations of plume movement are discussed in Section III.D.2 relative to the down-gradient New Mexico Utilities well serving the Paradise Hills area.

Figure 16

Diffusion-Dominated vs Advection-Dominated Transport



Reference : USEPA Seminar Publication - September 1989  
 Transport and Fate of Contaminants in the Subsurface  
 Document : EPA/625/4-89/019



## (2) Vertical Movement

The RFI Characterization noted the layered heterogeneous, anisotropic subsurface conditions ranging from gravelly sands to silts and clays. The USGS modelling also recognized the significant vertical anisotropy (USGS, 1995). Because of the significant vertical anisotropy and the absence of any significant vertical hydraulic gradients, vertical movement of the plume has been severely restricted and proceeds at a very slow rate. Even in the presence of vertical hydraulic gradients, recent evaluation at the Intel site in Rio Rancho showed almost no impact on shallow wells from heavy pumping from deeper zones of the aquifer.

The plume geometry further illustrates the lack of significant vertical movement. The current horizontal plume limits are some 3,400 feet (longitudinal) by 1,500 feet (transverse) whereas vertical movement is less than 100 feet. As noted in previous Section III.B.4.c., eight well clusters (out of ten) show decreasing TCE concentration with depth and five clusters show no detection in the bottom well of the cluster.

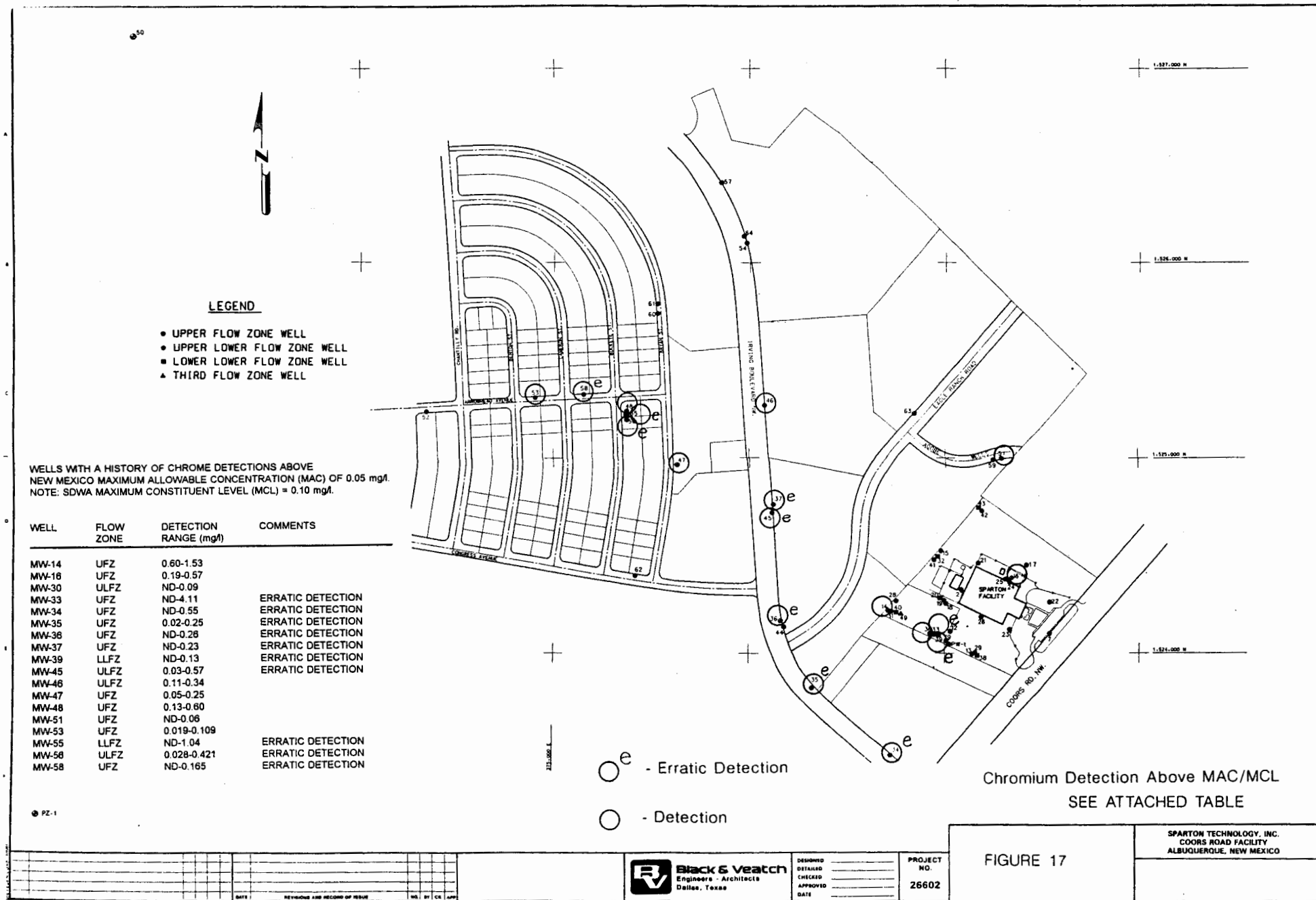
### e. Presence of Appendix IX Constituents

The predominant Appendix IX constituents found consistently throughout the study area are TCE and TCA. DCE and MeCl were detected on a less frequent or consistent basis, but still with some regularity. Chromium has been detected in various wells. But a review of the historic data base for chromium shows that ten wells have erratic chromium detection histories (over an order of magnitude variation) and only nine wells

have reasonable detection histories. Further, there appears to be no correlation to location or other constituents. Historic total chromium detections are shown on Figure 17.

Chromium detection results appear to be log-normally distributed. Using a log normal distribution for all sampling points and assuming a concentration of 0.009 mg/L for all non-detect results, an average total chromium concentration of 0.026 mg/L is conservatively obtained which is below the New Mexico MAC of 0.05 mg/L for dissolved chromium. Using a log-normal distribution for all detected concentrations yields an average total chromium concentration of 0.093 mg/L which is below the SDWA MCL of 0.1 mg/L. Because of the random, erratic nature of chromium detection, the use of average values may be appropriate for CMS purposes to represent chromium concentration in water produced from an extraction well(s) covering a significant portion of the plume.

Previous analysis in March 1989 and re-analysis of MW-32 (lower lower flow zone) in November 1991 indicted low levels of benzene, toluene, ethylbenzene, and xylene (BTEX). The presence of BTEX seems anomalous and isolated to this well; however, in early sampling (1983-1984) of upper flow zone wells MW-9, MW-14, and MW-16, BTEX constituents were also encountered. Occurrences of other Appendix IX constituents were random and inconsistent. A complete listing of all analytical results through 1991 is



provided in Attachments 3, 9, and 11 of the RFI Report. ~~Subsequent results through January 1996 are summarized in Appendix 1.~~

Due to elevated levels of TCE in many of the samples, dilution of the samples prior to analysis was necessary to lower the TCE concentration to within the limits of the analytical instrument. Because of this dilution, the detection limits for other VOC compounds included in the analytical suite were raised to levels which in most cases, exceeded either federal or state standards. All such instances occurred in wells which are inside the plume boundaries and which are therefore considered to be contaminated.

#### C. Previous and Continuing Corrective Action

##### 1. Closure of Solid Waste Management Units

The facility operation produced two waste streams--an aqueous metal plating waste stream and a spent solvent waste stream. The aqueous plating wastes were stored on site in one of two adjacent lined ponds approximately nineteen feet by twenty-eight feet in surface dimension and approximately five to six feet deep. The spent solvent waste was stored in a sump approximately five feet by five feet and two feet deep. The ponds and sump were periodically emptied by vacuum truck for off-site disposal at a permitted facility.

The solvent sump was removed from service in October 1980 and the solvent waste stream diverted to drums ~~accumulated~~ in a "less-than-ninety-day" on-site storage area. All residues in the sump were removed and the sump was then backfilled to prevent water accumulation and/or continued use.

The metal plating waste ponds were removed from service in 1983 and all waste residues were removed. The metal plating waste stream was diverted to a "less-than-ninety-day" on-site drum storage area.

## 2. Final Closure of Solid Waste Management Units

Final pond and sump closure was completed in December 1986 under a state-approved closure plan. Sparton had worked closely with the New Mexico Environmental Improvement Division (NMEID) since 1983 to investigate possible releases from the Solid Waste Management Units (SWMU's) and to develop a final closure plan for the SWMU's. The State-approved closure plan included removing the ponds and sump and capping the entire pond/sump area with an asphaltic concrete cap approximately seventy feet by ninety feet in areal extent to eliminate surface infiltration.

## 3. Interim Measure

In 1987, Sparton determined that contaminants had migrated beyond the facility boundary and commenced negotiations with U.S. EPA Region VI to develop an Administrative Order on Consent. This Consent Order was signed and became effective on October 1, 1988. Less than three months later, in December 1988, a groundwater recovery well network was installed in the upper flow zone as an Interim Measure (IM). The purpose of the IM was to mitigate the spread of the shallow contaminant plume off-site. In order to maximize contaminant removal, the recovery well network utilized eight

on-site wells located in the higher constituent concentration portions of the contaminant plume. The recovery network was designed and constructed according to the provisions of the Interim Measure Work plan approved by EPA on March 1, 1989.

The pumping network consists of eight wells installed in the upper flow zone at the site. Compressed-air-operated pumps remove groundwater from the wells. Groundwater extracted simultaneously at each well location is piped to an air stripper system for treatment and ultimate use in the Sparton facility.

Operation of the IM continues through the present date. Operation of the IM continues to reduce the source of contamination to the groundwater. Specific details and documentation of performance are contained in the draft IM Effectiveness Report (HDR, 1992). Over 3.56 million gallons of groundwater have been recovered, treated and used beneficially in the Sparton Facility to the present date. The IM treatment has reduced effluent constituent concentrations to less than one microgram per liter ( $\mu\text{g/l}$ ) from an incoming influent concentration exceeding 1000  $\mu\text{g/l}$ .

#### D. Potential Receptors/Exposure Pathways

##### 1. General

The Sparton Facility and most of the surrounding area are now in the City of Albuquerque. Development of the area around the facility is evolving as a mixture of commercial business along Coors Road and residential development in the upland areas to the west. Although current receptors/exposure pathways are very limited, U.S. EPA has

suggested human exposure to contaminated groundwater be evaluated (USEPA 1996). EPA's request is apparently based on the incorrect belief that the impacted groundwater is either currently used for human consumption or has some potential for future development. In fact, the currently impacted groundwater is not presently used for human consumption nor is there a reasonable likelihood of such use in the future.

## 2. Groundwater

The nearest downgradient municipal well (New Mexico Utilities) is approximately 2.1 miles from the leading edge of the plume. There are currently no specific plans by the City of Albuquerque or New Mexico Utilities ("NMU"), the only two entities that might be interested in installing a public water supply well in the general plume area, to do so. Although the Sparton Site and the general plume area are located in the City of Albuquerque, they are also in the "service area," for NMU. Under current conditions, the City cannot provide water in New Mexico Utilities' (NMU) service area. N.M. Stat. Ann. 1978§§ 62-9-1, 62-9-1.1; Morningstar Water Users Association v. New Mexico Public Utility Commission, 904 P.2d 28, 120 N.M. 579 (1995). Additionally, it is highly unlikely that the City could receive permission to install a well in the general plume area, e.g., NMU's service area, in order to pump water to customers outside of NMU's service area. To drill such a well, the City would have to satisfy the New Mexico State Engineer's ("SEO") requirements and PUC regulations. The SEO requires that any city well in NMU's service area not impair existing wells and that the well not be contrary to conservation nor detrimental to the public welfare.

For the City to receive such a finding, it will have to file a request with the SEO's office that can be protested by anyone, including Sparton and NMU. Sparton could challenge the request to the extent that water quality issues are triggered, for instance, if the City's proposed well location would tend to pull in surrounding groundwater contamination. NMU could, and undoubtedly would, protest the City's action as a potential impairment to water in its service area. In short, even in the unlikely event that the City chose to construct a well inside NMU's service area, there is no realistic expectation that the SEO or the PUC would grant such a request.

Apart from the institutional constraints, there are numerous hydrogeologic reasons that no public water supply well will be drilled in the vicinity of the Sparton plume. Until quite recently, it was believed that over time water in the Rio Grande served to recharge most removal from the regional aquifer. (City of Albuquerque Public Works Department, Water Resources 1996). It is now accepted by the City that such recharge is much more limited than previously thought, and that the regional aquifer is much less productive on the west side of the Rio Grande. It is now estimated that city pumping, by itself, is depleting the aquifer at a current rate of 41,000 acre feet per year. This depletion has several negative impacts in addition to causing a loss of water, namely subsidence and increasing the concentration of various metals, such as arsenic, in the recovered groundwater, in some cases in excess of drinking water standards. In response to this new understanding of the relationship between the river and the aquifer, the State Engineer has effectively imposed a ban on the drilling of new wells on most of the west side of the river, and has indicated



that all well applications on the west side will be heavily scrutinized. Additionally, the City is currently moving toward a policy of replacing the use of groundwater on the west side of the river with surface water, or possibly pumping groundwater across the river. It is not surprising then that the City's capital budget to the year 2004 does not include the development of any wells within several miles of the Sparton facility. (City of Albuquerque capital Improvements Program March 1995).

All of the hydrogeologic concerns of the City also apply to NMU, but on a much smaller scale. That utility is projected to have only 32,000 meters at full build out, which is estimated to occur in approximately the year 2036. The current thinking of NMU is to install any new wells it needs to meet demand as far from the river as practicable, because NMU has only limited rights to river water. (Communication with Robert Swartout March 1996). Even under the most recent models of the relationship between the river and the aquifer, pumping of the aquifer does result in some loss of water from the river. The general plume area is close enough to the river that any entity putting in a public water supply well at or near that location would be required to have water rights in the river that equal what the SEO finds is depletion of the river associated with removal of water from the aquifer. NMU has a very limited consumptive use right with respect to the river that will probably be exceeded soon. Although NMU has a return flow credit, which it has yet to invoke, that right is also limited. Therefore, future NMU wells will probably be drilled at least eight miles from the river, and that area does not include the general plume area.

Even in the unlikely event that NMU were to install a well in the plume area, wellhead treatment to ensure potable water quality could be effectively provided.

A 1982 master plan by the City does identify the possibility of numerous public water supply wells being installed in the vicinity of the general plume area. The City has recognized that study is no longer valid, as evidenced by new and contrary planning documents. But even if it were, not all of the proposed wells would ever be built, and those that were installed would not be impacted by the Sparton plume.

The 1982 master plan must be read in conjunction with the most recent USGS reports about the relationship between the river and the aquifer, as well as the 1995 CH2MHill Water Management Study, conducted for the City. The essence of the 1995 CH2MHill Water Management Study is that the manner in which the City has been using ground water, and the way it previously planned to use groundwater, is no longer a viable option. Obviously, this conclusion directly impacts prior thinking about the placement and number of wells. The 1982 master plan is an update of the City's original master plan developed in 1963. That 1982 plan was to aid the City in "logically and efficiently developing the system to meet future demands of the system." Accordingly, the 1982 update was only for the purpose of determining how the City could best utilize existing infrastructure to provide water to its service area. By definition then, it could not and did not address the NMU Service area, where the Sparton facility and impacted groundwater associated with that operation are located. The 1982 plan does not, and could not, take into account the

myriad factors and new information which have come to light since 1963 -- information which necessarily affects the very underpinnings of the 1982 study.

Additionally, even a cursory review of the proposed well placements in the 1982 master plan, indicates that not all of those wells could be installed without interfering with one another. Moreover, the depth of those wells would be expected to be approximately 2,000 feet below the surface. At that depth, as is demonstrated in recent work by Shomaker involving Intel's monitoring of drawdown effects, contaminated shallow groundwater such as that associated with Sparton's operations, would not impact the water recovered from deeper wells. Finally, many of the wells in the 1982 study are located outside of the horizontal extent of the plume, either to the side or down-gradient, and again could not be impacted by the contaminants found in the shallow groundwater affected by Sparton's operations.

In short, the 1982 study cannot be used to predict where the City may install future wells on the west side. Even if it still was a competent planning tool, the wells it identified would not be affected by the shallow groundwater impacted by Sparton's operations.

Another reason public water supply wells would not be installed in the general plume area is the absence of necessary infrastructure for either the City or NMU. New demands for water in the vicinity of the Sparton operation will be to the west, which is uphill. Both the City and NMU should want to avoid, as far as possible, the cost of pumping water uphill. Therefore, new wells would be most likely located to the west of the Sparton facility and outside of the general plume area.

No relevant documents show the City has pipelines, easements, or well sites in the general plume area. The nearest city distribution line ends 0.75 miles from the site. There is also no pumping station or reservoir capacity in the water planning area of the City that includes the Sparton facility. Underscoring the conclusion that the area in the vicinity of the Sparton operation is not being considered to supply any future water need for the City is the fact that the 1995 CH2MHill Water Management Study does not discuss the planning area in which the Sparton facility is located, even though all other planning areas are reviewed in detail. This omission manifests the City's intent to limit its service area to its current boundaries, or at the very least, to forego development of infrastructure in the general area of the Sparton facility.

Likewise, NMU has no infrastructure for a public water supply well in the general plume area. The absence of that infrastructure is consistent with NMU's current thinking about locating future public water supply wells at least 8 miles from the river, and generally "uphill" of the Sparton site.

In short, none of the water supply infrastructure for the City and NMU is consistent with the construction of a public water supply well within the general plume area or even a few miles from the outside edges of that plume.

The absence of any city infrastructure is not surprising, given that the general plume area is not in its service area, and that the City apparently has current and planned capacity, without entering the general plume area, to recover enough water from the aquifer to meet demand on the west side through approximately the year 2020. Given the City's

current movement away from reliance on groundwater, the most likely method of meeting additional demand after the year 2020 would be the use of surface water or recycling water.

As the foregoing demonstrates, the City's public statements and all of its actions (outside of the context of the development of a remedy at Sparton), lead to the conclusion that it does not intend to install a public water supply well in the general plume vicinity. Even if it did, such wells would not be impacted by the shallow groundwater affected by Sparton's operations.

There are no identified private wells in the plume area and the nature of current development over the plume area, institutional controls (such as the common practice of requiring residential development to include deed restrictions preventing the completion of groundwater wells as a condition to subdivision approval), and the presence and ready availability of public supplies should preclude their existence.

Because of the absence of wells within the immediate plume area and for an extended distance downgradient, groundwater is not currently an exposure pathway, nor is it expected to be in the foreseeable future. Nonetheless, in an attempt to quantify potential exposure, from a pathway that does not realistically exist, a simplistic groundwater model was constructed to evaluate possible impacts to the nearest receptor (the New Mexico Utilities well some 2.1 miles west of the plume). For a worst case basis, a number of intentionally unrealistic assumptions were used. These included:

- The shallow aquifer is homogeneous and isotropic although the aquifer is actually heterogeneous and anisotropic.
- A continuous source of 10,000 µg/l, although no current analytical results are that high.
- A continuous, constant gradient of 0.002 to the west toward and past the New Mexico Utilities well site, although recent published models indicate flow to the south and southwest.
- New Mexico Utilities well is assumed to be in the shallow, uppermost portion of the aquifer, although it is actually screened at a depth of 350 to 800 feet below ground surface.
- No retardation or degradation effects, although both of these exist.

The model was calibrated to the 1991 TCE plume as defined in the RFI Report. A detailed summary of the model results is included in Appendix 3. Based on the worst case model results, TCE concentrations above the current MAC of 0.05 mg/L will only extend out 9,500 feet from the source or approximately one mile short of the well, and TCE concentrations above the MAC would never reach the well. If correct, realistic assumptions

were used, TCE concentrations above the MAC would not extend out 9500 feet, but some shorter distance

### 3. Surface Water

Surface water in the area includes the Rio Grande and its associated canals and drains to the east of Sparton and the ephemeral Las Calabacillas Arroyo to the northwest of Sparton. These surface water bodies are a source of recharge to the groundwater. The 1995 CH2MHill Water Management study identified two options for enhancing this recharge. One involves dual injection/extraction wells that would be used to place surface water into the aquifer during times of availability and then recover it at some later time. The second option involves enhancing the natural recharge that may be provided by an arroyo by channeling surface water to this area, and then constructing appropriate controls so that such water moves toward the aquifer instead of being released to the river.

There is no particular reason that the use of injection/extraction wells would have to be conducted at or near an arroyo. Nor is there any suggestion that in fact this option has been identified as most likely to be implemented near any arroyos in general or at the Calabacillas Arroyo in particular. The second option obviously could involve the Calabacillas Arroyo. Again, there is no suggestion that there is any specific plan to use that arroyo in conjunction with such a recharge scheme.

The injection/extraction well recharge approach is unlikely to be implemented because: (1) it would require a facility to divert and treat surface water which does not currently exist;



(2) although there are similar sites elsewhere in the country, the necessary technology is still in the development stage, and (3) a recent study sponsored by the City and Intel suggest that this approach may be too costly to be implemented.

The use of the Calabacillas Arroyo for recharge purposes also appears to be unlikely. The 1995 CH2MHill Water Management Study concedes that there are a whole host of technical obstacles that make the use of this approach unlikely.

Nevertheless, if either option was implemented at the Calabacillas Arroyo, the impacts to shallow groundwater associated with Sparton's operation would not interfere with surface water because the observed contamination is horizontally distant and below (down-gradient of) the Arroyo and the Rio Grande and its canals. Stated more simply, there is separation between the contamination and the arroyo, and even greater separation between the contamination and the Rio Grande. Finally, at the current time, the plume is moving in a direction that cannot threaten the Rio Grande. Based on available characterization, surface water does not represent an exposure pathway.

#### 4. Residential

-- Residential development is occurring west of the Sparton Facility as shown on Figure 18. Approximately 15 residences already built and/or under construction are located over the west end of the plume. Due to the topographic rise west of the facility, these residences are -- at least 200 feet above the groundwater surface. In the absence of



private well installation which is unrealistic, there is no immediate threat posed to these residences since all are served by municipal water supplies. Surface soil gas surveys did not detect any VOC in or near the residential area at a method detection limit (MDL) of 0.001 µg/l (0.00022 ppmv). Recent deep soil gas investigation further did not detect any significant VOC off-site in the unsaturated zone (1 ppmv to non-detect TCE and TCA). Residential development is therefore not considered a potential receptor.



**NOTES:**

GROUNDWATER PLUME DEFINED BY METHOD OF DETECTION LIMIT OF 5 ug/l FOR TRICHLOROETHYLENE

← INFERRED GROUNDWATER FLOW DIRECTION

200 100 0 100 200 400

GRAPHIC SCALE IN FEET

**Black & Veatch**  
Engineers Architects  
Dallas Texas

DESIGNED: \_\_\_\_\_  
CHECKED: \_\_\_\_\_  
APPROVED: \_\_\_\_\_  
DATE: \_\_\_\_\_

PROJECT NO.  
**C26602**

**LIMITS OF TCE PLUME**  
1991 AND 1996 DATA

Draft Final CMS-Sparton  
May 6, 1996

**III-74**

CONTRACT NO.  
SHEET NO.

Figure 18  
Revised Aerial Photograph

## 5. Commercial/Industrial

The Sparton Facility is located within an area zoned for manufacturing. Adjacent land to the north along Coors Road is also zoned for manufacturing. To the west and south of the facility, zoning is for commercial development. Land to the east is zoned for agriculture. Continuation of current zoning is expected under future land planning. As shown in Figure 18, both limited commercial/industrial and residential development has occurred over the plume area. Existing facilities are on public water supply. In addition, surface soil gas studies indicate VOC concentrations well below permissible National Institute for Occupational Safety and Health (NIOSH) exposure limits in off-site areas.

In the most recent (1991) survey, highest surface soil gas concentration measured off-site was 8 µg/l (1.8 ppmv) TCE next to the facility; however, over most of the plume area, surface soil gas concentrations were less than 0.001 µg/l (0.00022 ppmv) for all constituents. Permissible exposure limits are all in the hundred ppm range, c.f. TCE is 100 ppm. Current conditions indicate the absence of potential for any exposure that would result in threat or risk.

## E. Groundwater Protection Standards

### 1. Maximum Concentration Limits

Maximum concentration limits for groundwater protection have been established by EPA in 40 CFR 264.94 relative to releases from solid waste management units. These limits are shown in Figure 19 (RFI Figure 82).

### 2. Maximum Contaminant Levels (MCL's)

Maximum contaminant levels (MCL's) for drinking water are promulgated under the Safe Drinking Water Act (SDWA) and can be found in 40 CFR 141.61 and 141.62. MCL's may be considered as appropriate standards for groundwater protection if the groundwater is, or could be potentially, used for drinking consumption. Current MCL's (July 1, 1995) are given in Figure 20.

### 3. New Mexico Groundwater Standards

The New Mexico Water Quality Control Commission (WQCC) Human Health Standards for groundwater quality, as defined in Subpart III, § 3103 of the December 1, 1995, WQCC regulations, are shown in Figure 21 (Revised RFI Figure 84).

### 4. Other Standards

For constituents not covered by regulatory protection standards, alternate concentration limits (ACL's) or action levels can be developed using constituent data

**FIGURE 19**

<b>MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION</b>	
<b>Constituent</b>	<b>Maximum Concentration mg/l</b>
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP Silvex	0.01

Source: 40 CFR 264.94

**FIGURE 20**

**SAFE DRINKING WATER ACT - MAXIMUM CONTAMINANT LEVELS**

Type of Contaminant	Name of Contaminant	Maximum Contaminant Level (MCL) (mg/l, unless noted otherwise)
<b>Inorganic Chemicals</b>	Antimony	0.006
	Asbestos	7 MFL (million fibers per liter longer than 10 microns)
	Arsenic	0.05
	Barium	2
	Beryllium	0.004
	Cadmium	0.005
	Chromium	0.1
	Cyanide	0.2
	Fluoride	4 (secondary MCL of 2 triggers public notice)
	Mercury	0.002
	Nickel	0.1
	Nitrate (as N)	10
	Nitrite (as N)	1
	Total Nitrate/Nitrite	10
	Selenium	0.05
	Sulfate	500
	Thallium	0.002
	Lead, Copper	See comments
<b>Organic Chemicals</b>	<b>Pesticides</b>	
	Alachlor	0.002
	Aldicarb	0.003
	Aldicarb sulfoxide	0.004
	Aldicarb sulfone	0.002
	Atrazine	0.003
	Carbofuran	0.04
	Chlorodane	0.002
	Dalapon	0.02
	Dibromochloropropane (DBCP)	0.0002
	Dinoseb	0.007
	Diquat	0.02
	Endothall	0.1
	Endrin	0.002
	Ethylene dibromide (EDB)	0.00005
	Glyphosate	0.7
	Heptachlor	0.0004
	Heptachlor epoxide	0.0002
	Lindane	0.0002
	Methoxychlor	0.04
	Oxamyl (Vydate)	0.2
	Pentachlorophenol	0.001
	Picloram	0.5
	Simazine	0.004
	Toxaphene	0.003
	2, 4, 5 - TP (Silvex)	0.05
	2, 4 - D	0.07



**FIGURE 20**

**SAFE DRINKING WATER ACT - MAXIMUM CONTAMINANT LEVELS**

**Continued**

Type of Contaminant	Name of Contaminant	Maximum Contaminant Level (MCL) (mg/l, unless noted otherwise)
<b>Organic Chemicals</b>	<b>Volatile Organic Chemicals</b> Benzene Carbon tetrachloride para-Dichlorobenzene ortho-Dichlorobenzene 1, 2 - Dichloroethane 1, 1 - Dichloroethylene cis - 1, 2 - Dichloroethylene trans - 1, 2 - Dichloroethylene Dichloromethane 1, 2 - Dichloropropane Ethylbenzene Monochlorobenzene Styrene Tetrachloroethylene (PCE) Toluene 1, 2, 4 - Trichlorobenzene 1, 1, 1 - Trichloroethane 1, 1, 2 - Trichloroethane Trichloroethylene (TCE) Vinyl chloride Xylenes	0.005 0.005 0.075 0.6 0.005 0.007 0.07 0.1 0.005 0.005 0.7 0.1 0.1 0.005 1 0.07 0.20 0.005 0.005 0.002 10
	<b>Synthetic Organic Chemicals</b> Benzo (a) pyrene Di (2 - ethylhexyl) adipate Di (2 - ethylhexyl) phthalate Hexachlorobenzene Hexachlorocyclopentadiene (HEX) PCBs 2, 3, 7, 8 Tetrachlorodibenzo - p - dioxin	0.002 0.5 0.006 0.001 0.05 0.0005 $3 \times 10^{-8}$
<b>Proposed Regulations/Expected Date/Comments</b>		
<p>EPA promulgated the Lead and Copper Rule on June 7, 1991. Major points in the regulation are:</p> <ol style="list-style-type: none"> <li>1. Action levels (ALs) measured at the tap have been set instead of MCLs. Action levels are: lead <math>\leq 0.015</math> mg/L and copper <math>\leq 1.3</math> mg/L. Both must be met in at least 90% of samples taken during either sampling period.</li> <li>2. Two initial sampling periods, each six months long and to be consecutive. Sampling periods must begin by: January 1, 1992 for systems &gt; 50,000; July 1, 1992 for systems 3,301 to 50,000; and July 1, 1993 for systems <math>\leq 3,300</math>.</li> <li>3. Systems &gt; 50,000 must optimize corrosion control.</li> <li>4. Systems &lt; 50,000 not meeting action levels must provide corrosion control treatment and public education.</li> <li>5. Systems not meeting action levels that are providing corrosion control treatment must initiate lead service line replacement.</li> <li>6. Systems consistently meeting action levels can reduce monitoring to annually, and then to every 3 years.</li> </ol>		

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May 6, 1996

**FIGURE 21**

<b>NEW MEXICO GROUNDWATER STANDARDS</b>	
<b>Parameter</b>	<b>Maximum Allowable Concentration</b>
Arsenic	100 µg/l
Barium	1000 µg/l
Cadmium	10 µg/l
Chromium	50 µg/l
Cyanide	200 µg/l
Fluoride	1600 µg/l
Lead	50 µg/l
Total Mercury	2 µg/l
Nitrate as N	10000 µg/l
Selenium	50 µg/l
Silver	50 µg/l
Uranium	5000 µg/l
Radioactivity: Combined Radium-226 and Radium-228	30.0 pCi/l
Benzene	10 µg/l
Polychlorinated Biphenyls	1 µg/l
Toluene	750 µg/l
Carbon Tetrachloride	10 µg/l
1,2-Dichloroethane	10 µg/l
1,1-Dichloroethylene	5 µg/l
1,1,2,2-Tetrachloroethylene	20 µg/l
1,1,2-Trichloroethylene	100 µg/l
Ethylbenzene	750 µg/l



**FIGURE 21 (Continued)**

<b>NEW MEXICO GROUNDWATER STANDARDS</b>	
<b>Parameter</b>	<b>Maximum Allowable Concentration</b>
Total Xylenes	620 µg/l
Methylene Chloride	100 µg/l
Chloroform	100 µg/l
1,1-Dichloroethane	25 µg/l
Ethylene Dibromide	0.1 µg/l
1,1,1-Trichloroethane	60 µg/l
1,1,2-Trichloroethane	10 µg/l
1,1,2,2-Tetrachloroethane	10 µg/l
Vinyl Chloride	1 µg/l
PAHS: total naphthalene plus monomethylnaphthalenes	30 µg/l
Benzo-a-pyrene	0.7 µg/l
<b>Secondary Standards</b>	
Chloride (Cl)	250 mg/l
Copper (Cu)	1000 µg/l
Iron (Fe)	1000 µg/l
Manganese (Mn)	200 µg/l
Phenols	5 µg/l
Sulfate (SO <sub>4</sub> )	600 mg/l
Total Dissolved Solids (TDS)	1000 mg/l
Zinc (Zn)	10 mg/l
Ph	between 6 and 9

**FIGURE 21 (Continued)**

<b>NEW MEXICO GROUNDWATER STANDARDS</b>	
<b>Parameter</b>	<b>Maximum Allowable Concentration</b>
<b>Irrigation Standards</b>	
Aluminum (Al)	5000 µg/l
Boron (B)	750 µg/l
Cobalt (Co)	50 µg/l
Molybdenum (Mo)	1000 µg/l
Nickel (Ni)	200 µg/l

Source: New Mexico Water Quality Control Commission Regulations,  
Subpart III, §3103, December 1, 1995.

obtained from the Integrated Risk Information System (IRIS) updated on a continuous basis by U. S. EPA's Office of Health and Environmental Assessment. Using the constituent data and standardized human intake assumptions, ACL's can be calculated. Constituent data is given as carcinogen slope factors (CSF's) for carcinogenic effects and as reference doses (RfD's) for systemic toxicants. For those constituents identified at this site, CSF and RfD data is included in Figure 22 (RFI Figure 85).

F. Purpose for Response

The contamination characterized in the RFI posed minimal threat or risk to human health and the environment. Continuing investigation since the RFI indicates that significant exposure pathways or potential receptors do not exist under current conditions. Further, the Interim Measure installed in December 1988 is accomplishing its goal of mitigating further off-site migration of contaminants in the Upper Flow Zone.

**FIGURE 22**

CONSTITUENT DATA FOR HEALTH RISK ASSESSMENT			
CONSTITUENT NAME	CLASS	ORAL REFERENCE DOSE (mg/kg/day)	ORAL CARCINOGEN SLOPE FACTOR (mg/kg/day) <sup>-1</sup>
Acetone	D	1.0E-01	NA
1,1-Dichloroethylene	C	9.0E-03	6.0E-01
Methylene Chloride	B	6.0E-02	7.5E-03
1,1,2,2-Tetrachloroethane	C	NA	2.0E-01
Tetrachloroethylene	B2	1.0E-02	5.1E-02
1,1,1-Trichloroethane	D	9.0E-02	NA
Trichloroethylene	B2	NA	1.1E-02
Chromium (VI)	A	5.0E-03	4.1E+01*
Benzene	A	NA	2.9E-02
Ethylbenzene	D	1.0E-01	NA
Toluene	D	3.0E-01	NA
Xylenes	D	2.0E+00	NA

\* Inhalation slope factor

#### **IV ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES**

The objectives of a Corrective Action Program (CAP) are: to evaluate the nature and extent of a release of hazardous constituents to the environment; to evaluate the site characteristics of the facility and surrounding area; and to identify, develop, and implement the appropriate corrective measure(s) necessary to protect human health and the environment. (Order, Task VII.B, 40 CFR 264.100)

The RCRA Facility Investigation (RFI) identified the sources of the releases and characterized the nature and extent of contamination resulting from the releases. Further, the RFI identified potential receptors and assessed short- and long-term threat to these receptors. An updated review of potential receptors and exposure pathways was given in previous Section III.D. As part of the CAP, various corrective measures have already been undertaken at this facility since 1983. These measures included closure of the Solid Waste Management Units (SWMU's) responsible for the releases; capping of the closure area; and source removal through operation of an Interim Measure (IM) consisting of groundwater recovery and treatment implemented in 1988. Details of these corrective measures are given in previous Section III.C. Continuing analyses of soil gas and groundwater samples since implementation of these corrective measures indicate that, with the exception of a few wells at the leading edge of the plume, contaminant concentrations have decreased significantly in most of the wells showing historical detections. Analytical data through 1996 included in Appendix 1 shows that:

- Fourteen UFZ wells show a decline in concentration, three UFZ wells show an increase, and five UFZ wells continue non-detect.
- Seven ULFZ wells show a decline in concentration, three UFZ wells show an increase, one shows little change, and two ULFZ wells show continuous non-detect.
- Three LLFZ wells show a decline in concentration, one well shows an increase, and three continue to show non-detect.

Further, the leading edge of the plume is over two miles from the nearest down gradient reception point (New Mexico Utilities Paradise Hills well).

In identifying, developing, and implementing the appropriate corrective measure necessary to protect public health and the environment, the potential injury to receptors and the possible impact on use of that portion of the environment that is affected must be considered. In other words, the measure "necessary" to protect human health, is a function of the risk presented. If no risk exists, no corrective measure is necessary. If some risk exists, then the "necessary" action is that required to reduce that risk to acceptable levels. Similarly, protection of the environment must be considered in the context of the possible use of the resource affected. If an impact does not affect use, then no corrective measure is necessary. If the use of a portion of the impacted environment is affected, then the "necessary" corrective measure is the one that alleviates such an impact, and allows use of the resource.

This study has already discussed risk to human health and impacts on the use of the environment affected by Sparton's operations.

From a purely technical standpoint, responding to the plume involves five options: doing nothing, removing source material, containing the plume, containing the plume and removing source material, and removing all contaminants to specified levels. Technologies will be identified that theoretically could achieve each one of these goals. There will be a further evaluation of whether in fact a technology can achieve one or more of the five options. If a technology can achieve one of the options, then it is necessary to determine if an option must be implemented to achieve the objective -- protection of public health and the environment.

EPA has suggested that there be three corrective action objectives: "(1) prevent further migration of the contaminant plume; (2) restore the contaminated aquifer to the more stringent of federal or state standards; and (3) reduce the quantity of source material in the soil and groundwater to the extent practicable to minimize further releases of contaminants to the surrounding groundwater and ensure that no further contaminant migrates to the groundwater above the existing cleanup goals established for groundwater." (U.S. EPA 1996). EPA confuses objectives with what may be technically possible. The fact that it may be technically possible to prevent further migration of the contaminant plume, does not mean that goal is necessarily an objective at this site, unless such action is necessary to protect public health and the environment.

This study will address the technical practicability of what EPA has identified as "objectives," which should in reality be referred to as technical possibilities, but will then go a step further and compare what is technically practicable, to the objective of this study as recognized in both the Administrative Order on Consent and EPA's regulations -- to implement those actions "necessary to protect public health and the environment."



## V SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES

Corrective measure technologies (CMTs) are defined as specific processes, systems or actions that may be utilized to remediate or mitigate chemical problems. CMTs may be used singly or combined ~~in a treatment train~~ to form Corrective Measure Alternatives.

A screening of known corrective measure technologies applicable to groundwater, soil and soil gas remediation is summarized in Figure 23. General categories of corrective measure technologies include no further action, containment, disposal, in situ treatment and ex situ treatment.

The CMTs in this figure were screened according to three general criteria. The first criterion is the ability of the process option to be effective for the affected medium (site characteristics). Technologies inappropriate for groundwater have been eliminated. The second criterion is the ability of the CMT to be effective for the waste type. The third criterion is the stage of development of the CMT (i.e, whether the CMT is past bench-scale, pilot-scale, or full-scale development for the particular medium and type of chemical). CMTs can be eliminated if they are not past bench-scale development, if they have failed at pilot- or full-scale development, or if they cannot be implemented without extensive technology transfer or development.

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER	NO FURTHER ACTION	Not Applicable	Sites without and/or limited potential receptors. Exposure is limited	Effective where receptors and exposure pathways are limited. Applicable to slow-moving plumes where groundwater can be monitored. Can be impacted by change in demographics/land use.	Implementable due to moderate size of plume.  No waste management issues	Not Applicable	Retained. VOC concentrations are decreasing. No significant potential threat or risk.
	CONTAINMENT	Slurry Walls	Sites with relatively level grade, and shallow impermeable zones (i.e. bedrock)	Varies with chemicals and concentrations.  The limitation is the deep bedrock and areal extent of plume.	Difficult to implement in areas of deep bedrock and access constraints.  Contaminated slurry must be removed or treated on-site.	Conventional: readily available	Eliminated: due to deep bedrock and areal extent of plume.
		Subsurface Drains	Intercept shallow contamination in areas with low hydraulic conductivity.	Varies/applicable to depths less than 40 feet.	Easy to implement contaminated soil and water must be removed or treated on-site.	Conventional: widely accepted.	Eliminated due to depth limitations and areal extent of plume
		Extraction Wells	Flat hydraulic gradient, moderate conductivities, immiscible contamination.	Varies, depending on the intergranular hydraulic conductivity of the aquifer/steep gradients, high conductivity, miscible contamination, limited to high concentration areas, requires disposal of produced water.	Easy to implement contaminated water must be removed or treated on-site.	Conventional: commonly used; However, will not get contamination levels to MCL.	Retained for potential use with treatment option. Site hydraulic gradients and conductivities are within those required to achieve adequate effectiveness.
		Infiltration gallery	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from the State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Conventional: not widely used.	Retained per consent order.

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	CONTAINMENT cont'd	Injection wells	Applicable to organic and inorganic wastes after treatment	Effective in high hydraulic conductivity aquifers/groundwater cannot be pumped back into the aquifer at the same rate it was extracted.	Implementation requires sufficient access. Permit from the State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Rarely used due to regional prohibitions	Retained per consent order.
	DISPOSAL	Discharge to publicly owned treatment works (POTW).	Applicable to organic and inorganic wastes after treatment and in areas where extraction wells or other methods of removing GW can be used.	Effective for low concentrations in conventional WWT process. Limitations are distance to POTW and concentrations of chemicals POTW can accept. Capacity of POTW.	Normally easy to implement; however, must meet EPA effluent criteria POTWs may restrict the amount that can be accepted.	Conventional: widely accepted	Eliminated: POTW unavailable because of capacity overloads.
		Discharge to surface water.	Applicable to organic and inorganic wastes after treatment.	Effective if NPDES discharge standards are met/requires constant monitoring.	Implementable due to close proximity of the Rio Grande. Must obtain NPDES permit and meet New Mexico Water Quality Standards.	Conventional: widely accepted	Retained for potential use with treatment option.
		Infiltration gallery	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Conventional: yet not widely used.	Retained per consent order.

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	DISPOSAL cont'd	Infiltration bed	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from State required. Minimal additional treatment needed. Permit difficult to obtain	Conventional; yet not widely used.	Retained for potential use.
		Injection wells	Applicable to organic and inorganic wastes after treatment	Effective in high hydraulic conductivity aquifers/groundwater cannot be pumped back into the aquifer at the same rate it was extracted.	Implementation requires sufficient access. Permit from State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Rarely used due to regional prohibitions	Retained per consent order.
		Calabacillas Arroyo Recharge	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Conceptual stage.	Retained per EPA, 1996.
		Evaporation Ponds	Applicable to organic and inorganic wastes after treatment	Effective if area is large and climate suitable. Limited during certain times of the year.	Implementable. Must obtain NPDES permit for storm release and possibly air emissions permit.	Conventional, proven technology.	Eliminated: insufficient area for use, excessive water quantity for application.
	IN SITU TREATMENT	Vapor Extraction	VOC contaminated groundwater	Effective on shallow water in permeable soils.	Implemented by conventional means, off gas air emissions must be collected and treated.	Commercially available	Retained for potential use with other treatment options.
		In situ air stripping (air sparging)	Applicable to volatile organic compounds (VOCs)	95-97% removal in sandy soil less effective in clay soil/maximum depth of groundwater 140 feet.	Implementable, requires VES	Innovative technology	Retained for potential use with other treatment options.

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	IN SITU TREATMENT cont'd	Bioremediation	VOC contaminants	97% reduction in contaminant concentration/will not treat metals, pesticides, and chlorinated hydrocarbons.	Difficult to implement in low permeability soils or deep aquifers/biological clogging of aquifers and/or wells may occur.	Technology is commercially available	Retained for potential use with other treatment options.
		Lining of Corrales Main Canal	Potential reduction of recharge to groundwater/elimination of seasonal fluctuation.	Minimal effectiveness since large irrigated fields are adjacent to canal.	Implementable.	N/A	Retained per EPA 1996 large irrigated fields render ineffective/seasonal fluctuation beneficial to existing IM.
	EX SITU TREATMENT	Aerobic biological treatment	Applicable to non-halogenated organics and certain halogenated organics	98% removal/cannot be used with high concentrations of metals.	Easy to implement/remaining biosludge requires disposal.	Conventional, broadly used technology	Retained for potential use with other treatment options
		Activated sludge	Applicable to dilute non-halogenated organics	99% removal/subject to breakdowns from varying influent.	Requires major design and construction/output sludge requires further treatment.	Conventional, proven technology	Eliminated: lacks flexibility to treat varying influent. Extensive design and construction time.
		Anaerobic digestion	Aqueous wastes with low to moderate level of VOCS	Effective widely used at POTWS/will not treat inorganics and subject to breakdowns from varying influent.	Requires major design and construction/no mobile units available/sludges require further treatment.	Conventional, proven technology	Eliminated: lacks flexibility to treat varying influent. Extensive design and construction time.
		White rot fungus	Aqueous organic wastes	97% reduction on laboratory scale/will not treat inorganics	Laboratory scale only	Bench scale	Eliminated: technology is not commercially available and not proven in field applications.
		Chemical oxidation/reduction	Aqueous wastes containing Cr, Hg, Pb	Effective for inorganics/cannot be used for organics	Conventional process/waste composition and reactions must be well known to prevent inadvertent production of a more hazardous end product	Commercially available, full scale	Eliminated: influent stream contains organics.

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	EX SITU TREATMENT cont'd	Ultraviolet oxidation	Low level aqueous organics	79% reduction in contaminant concentration/will not treat inorganics	Requires clear aqueous solutions/no further treatment of residues is required	Commerically available	Retained for potential use with other treatment options.
		Chemical precipitation	Aqueous wastes containing metals	Effective for removal of metals.	Difficult to implement for more than one metal if pH's required to precipitate are different/sludges may be hazardous	Commercially available	Retained as part of treatment train for metals (chromium).
		Advanced oxidation (Ozonation)	Aqueous organics	Effective on waste streams which contain less than 1.0% oxidizable compounds/will not be effective on sludges and solids	Easy to implement mobil units are available/no residues or sludges are generated	Commercially available	Retained for potential use with other treatment options.
		Carbon adsorption (GAC)	Low concentration aqueous organics	99% reduction in contaminant concentration/cannot be used if concentrations are greater than 10,000 ppm, suspended solids >50 ppm alcohols, ketones.	Easy to implement mobil units are available/carbon must be replaced or regenerated periodically	Commercially available	Retained for potential use with other treatment options.  Best Demonstrated Available Technology (BDAT)
		Filtration	Suspended solids	Can reduce suspended solids to between 1 and 10 mg/l will not affect dissolved contaminants	Easy to implement/residues may be hazardous - no reduction of toxicity disposal required	Commercially available	Retained for part of treatment train.
		Steam stripping	Aqueous wastes contaminated with VOC's boiling point at 150°C	Effective for VOCs/cannot be used on VOC with BP >150°C	May be difficult to implement depending on availability of steam/air emissions	Commercially available	Eliminated: insufficient steam available. Not appropriate for current conditions.
		Ion Exchange	Aqueous wastes containing metals	Effective for removal of metals	Easy to implement/residues may be hazardous	Commercially available	Retained as part of treatment train for metals (chromium).

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	EX SITU TREATMENT cont'd	Air stripping (Packed Tower Aeration)	Aqueous VOC contaminated wastes	99.99% reduction in contaminant concentration/cannot treat metals or semi-volatiles	Conventional equipment and mobile units air emissions must be monitored	Commercially available	Retained for potential use with other treatment options BDAT
		Catalytic oxidation	Aqueous organic wastes	99.99% reduction in contaminant concentration/inorganics	May be difficult to implement due to permitting/no residues	Commercially available	Eliminated. Other BDAT's available. High costs.
		Wet air oxidation	Aqueous organic wastes	93% to 99% reduction in contaminant concentration/inorganics	Implementation is not difficult but may be costly/no residues	Commercially available	Eliminated. Other BDAT's available. High costs.
		Thermal destruction	VOC contaminated groundwater	99.99% reduction in contaminant dependent on VOC concentrations and volumes of water to be treated.	Conventional equipment and mobile units, air emissions must be monitored.	Commercially available. May be difficult to implement due to permitting/no residues.	Eliminated. High costs. Other BDAT's suitable for site.
SOIL	NO FURTHER ACTION	Not applicable	Sites without and/or limited potential receptors. Exposure is limited.	Effective where receptors and exposure pathways are limited.	Implementable. No waste management issues.	Not applicable	Retained. Soil concentrations confined to site. No immediate threat to any potential receptors.
	IN SITU TREATMENT	Bioremediation	Organics	Effectiveness varies with chemical contaminant, concentration, and soil type. Will not treat metals.	Implemented by conventional means/biological clogging may occur	Commercially available	Retained for potential use with other treatment options.
		Vapor extraction	VOC contaminated soils	99.9% reduction in contaminant concentration/cannot be used on sludges, liquids, and in dense clays.	Implemented by conventional means/off gas air emissions must be collected	Commercially available	Retained for potential use with other treatment options BDAT
		Air injection	VOC contaminated soils	99.9% reduction in contaminant concentration/not effective in soils containing clay layers. Must be used with VES.	Implemented by conventional means/off gas air emissions must be collected	Commercially available	Retained for potential use with other treatment options

FIGURE 23

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
SOIL cont'd	IN SITU TREATMENT cont'd	Soil flushing	Organic and inorganic contaminated soils	79% to 99% reduction in contaminant concentration/will not be effective in heavy clays.	Implemented by conventional means/effluent must be treated	Pilot scale/emerging field scale	Retained for potential use.
SOIL GAS	NO FURTHER ACTION	Not applicable	Sites without and/or limited potential receptors. Exposure is limited.	Effective where receptors and exposure pathways are limited.	Implementable. No waste management issues.	Not applicable	Retained. Soil gas concentrations low and areal extent limited to on site.
	IN SITU TREATMENT	Soil flushing	Organic and inorganic contaminated soils	79% to 99% reduction in contaminant concentration/will not be effective in heavy clays	Implemented by conventional means/effluent must be treated	Pilot scale/emerging field scale	Retained for potential use.
		Vapor Extraction	VOC contaminated soil gas	99.99% reduction in contaminant. Concentration will not be as effective in heavy clay	Implemented by conventional means/effluent must be treated.	Commercially available	Retained for potential use



## **VI IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES**

### **A. General**

Each corrective measure technology is identified by its applicability to the containment or remediation of three phases of the contaminants, which include the (i) dissolved groundwater phase (saturated zone), (ii) soil sorbed or residual NAPL phase (saturated and unsaturated zone), and (iii) soil gas vapor phase (unsaturated zone). TCE and TCA in the free product or non-aqueous phase in the saturated zone (if any) or the soil pore water dissolved phase (unsaturated zone) can be remediated as part of the three phases described above. A combination of several methods, or treatment train, should be evaluated to address the successful remediation of the specified contaminants.

Further information on technology/methodology discussed in this Section can be found in references listed under that specific heading in the Report's Bibliography. As a general reference of available technologies, the publication Remediation Technologies Screening Matrix and Reference Guide (EPA/USAF, 1993) has been appended to this Report. (Appendix 4).

References to certain technologies being the "best available" or BAT or as "best demonstrated available technology" or BDAT are based on determinations made by EPA under the Safe Drinking Water ACT (EPA 1985, 1987, 1988, 1990).

Other information in this chapter is based on institutional knowledge, developed from other projects of the authors and their professional experience.

## B. Retained Alternatives

Based upon the results of the screening, the alternatives for this site are summarized below. Each of these retained alternatives is discussed in greater detail in Section VII.

### Groundwater Phase (Saturated Zone)

- No Further Action.
- Continuation of Interim Measure Corrective Action
- Expansion of Interim Measure
- Infiltration gallery or injection wells to contain plume (per consent order).
- Large-scale groundwater extraction combined with either air stripping, granular activated carbon, advanced oxidation, or aerobic bioreactors to treat the groundwater organic contamination and chemical precipitation/ion exchange to remove inorganics (pump and treat system).
- Vapor extraction to remove soil gas and eventually VOC from groundwater through phase equilibrium.
- In situ bioremediation to treat the groundwater in place.

### Soil Sorbed Phase (Unsaturated Zone)

- No Further Action.
- Soil flushing to remove contaminants adhered to soil particles.

- In situ bioremediation to treat the soil in place.
- Vapor extraction to remove soil gas and eventually VOC from soil through phase equilibrium.

#### Soil Gas Vapor Phase (Unsaturated Zone)

- No Further Action.
- Vapor extraction to remove soil gas for treatment.

### C. Non-Retained Alternatives

The alternatives that were judged as not being suitable for the Sparton facility are described in the following paragraphs:

#### 1. Slurry Wall

This alternative was not retained because the excessive depth to water at the leading edge of the plume makes it technically impracticable. Furthermore, the lack of an impervious strata to tie a slurry wall into, the overall extent of the contaminant plume off the Sparton site, and the possible creation of contaminated slurry wall material render this option non-feasible.

## 2. Subsurface Drains

This alternative was not retained because (...) groundwater and bedrock are too deep for economic installation and the areal extent of the plume is too large. (...)

## 3. Discharge to POTW

This alternative is not appropriate because the quantity and rate at which groundwater would be removed is too large for the capacity of the publicly owned treatment works (POTWs) in the vicinity. Adding POTW capacity is very expensive and time consuming relative to the remediation of groundwater from the Sparton site.

## 4. Activated Sludge

This technology is used to dilute non-halogenated organics and make them inert. This technology requires extensive design and construction time that will increase costs substantially, making it less cost effective than other best demonstrated available technologies (BDAT). Furthermore, this process creates another medium to have to treat or dispose which further increases costs. This alternative was not retained because it is not appropriate methodology for treatment of halogenated VOC, such as TCE and TCA, present at this site.

#### 5. Anaerobic Digestion

This technology utilizes anaerobic microorganisms to reduce halogenated compounds into compounds that are generally less toxic and less likely to bioaccumulate. The reducing process consists of removing halogen from the halogenated compound through electron exchanges between the halogenated compound and the microorganisms. Once the reduction process is completed, the compound can undergo further reductions and transformations by aerobic microorganisms.

This alternative was not retained because it involves extensive design and portable units are not available to make this a feasible methodology. In addition, this process may break down the constituents and form vinyl chloride (VC) which is a toxic compound. Additional treatment of VC will be required which would increase costs.

#### 6. White Rot Fungus

This alternative was not retained because it has only been used in laboratory testing and has not been proven in field applications. There is uncertainty in the reliability of this technology on a large scale.

#### 7. Chemical Oxidation/Reduction

This technology involves changing the chemical form of a hazardous material in order to create a less toxic compound for handling or disposal purposes. The oxidation process involves the transformation of organics to various compounds such as carbon

dioxide and water. The function of chemical oxidation is to change the chemical form of the molecular structure for the purposes of detoxification. Chemical reduction essentially converts inorganics to less toxic forms so additional treatment processes can be applied.

This alternative was not retained because this technology will not work on organic waste streams that contain VOC such as TCE and TCA. In addition, chemical reactions may be explosive and must be monitored carefully to avoid creating a more hazardous by-product.

(...)

(...)

#### 8. Steam Stripping

This technology involves the injection of steam into the selected medium for the purpose of volatilizing VOC and various non-soluble constituents. For soil, the steam is injected directly into the subsurface soils through selective well locations and then the volatilized constituents are removed from the subsurface by vacuum extraction wells. For aqueous waste streams the process is similar; however, the application of the steam is conducted in a controlled environment (i.e., pressure chamber). The volatilized constituents are then thermally destroyed or vaporized.

This alternative was not retained because a steam source is not readily available at the site and there are better BDATs for the Sparton Facility. This technology is also not effective on VOC with boiling points greater than 150°C. TCA and TCE both have boiling points greater than 150°C.

## 9. Catalytic Oxidation

This technology involves destruction of contaminants by oxidizing the constituents in the presence of a catalyst in order to detoxify the compound. The process involves removing electrons from the constituent (oxidizing) to alter the molecular structure of the constituent.

Catalytic oxidation was considered for three purposes -- as a primary treatment for organic-contaminated aqueous waste streams, as part of a treatment train to "polish" gas effluent from an air stripper or as the primary treatment for a gas effluent produced from a soil vapor extraction system. It should be noted that treatment of halogenated hydrocarbon constituents will progressively deactivate the catalyst and reduce the destructive efficiency. Frequent catalyst replacement would be required.

This alternative was not retained for the following reasons: with respect to aqueous waste streams, recognized BDATs would be more appropriate and cost effective. For vapor-phase waste streams, other treatments offer better reliability and cost effectiveness. In addition, long term performance for halogenated hydrocarbon treatment is not well documented.

## 10. Wet Air Oxidation

This technology involves generally the same principals as catalytic oxidation except the process uses air with high moisture content to effectively oxidize the contaminants into less toxic compounds.

This alternative was not retained because costs can be excessive and this technology has not been used widely enough to evaluate its effectiveness.

#### 11. Thermal Destruction

This technology essentially destroys contaminants by direct application of intense heat. Thermal destruction is an oxidative process which is used for detoxification and sterilization, volume reduction, energy recovery, and by-product chemical recovery. The thermal destruction process can be used to destroy organics in liquids, solids/sludges, soils and gases. For liquids, several types of thermal destruction methods such as liquid injection furnaces, plasma arc units, and rotary kilns can be used to effectively treat liquids containing organic compounds. For solids, methods such as rotary kiln, fluidized bed, circulating bed, and infrared are typically used for treatment.

This alternative was not retained because residuals are produced such as ash and solids that will require additional treatment before disposal. Furthermore, this process generates off-gas emissions which would require treatment before releasing them to the atmosphere. This technology is very costly because of energy requirements. Because halogenated constituents are present, thermal destruction systems are RCRA-regulated as a hazardous waste incinerator.



## **VII EVALUATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES**

### **A. General**

As specified under Task VIII of Exhibit I, Corrective Action Plan (CAP), of the Order, each corrective measure alternative passing through the Initial Screening identified under Task VII has been evaluated using specific criteria. The evaluation of each alternative considered for potential implementation has been evaluated based on 1) technical, 2) environmental, 3) human health, and 4) institutional concerns. In addition, cost estimates for each corrective measure alternative have been prepared. Specific evaluation procedures are discussed in the following paragraphs.

Further information on technology/methodology discussed in this Section can be found in references listed under that specific heading in the Report's Bibliography. As a general reference of available technologies, the publication Remediation Technologies Screening Matrix and Reference Guide (EPA/USAF, 1993) has been appended to this Report (Appendix 4).

References to certain technologies being the "best available" or BAT or as "best demonstrated available technology" or BDAT are based on determinations made by EPA under the Safe Drinking Water ACT (EPA 1985, 1987, 1988, 1990).

Other information in this chapter is based on institutional knowledge, developed from other projects of the authors and their professional experience.

## 1. Technical Evaluation Criteria

Each retained technology or corrective measure technology has been evaluated relative to a set of technical criteria. Technical evaluation criteria included: effectiveness, useful life, reliability and implementability. Application of these criteria to the evaluation process is outlined in this section.

- Effectiveness has been evaluated with respect to accomplishing ~~containment~~, source control and/or restoration of groundwater quality and with respect to specific application to conditions characterized at the Sparton facility. Any specific waste or site characteristics which could reduce effectiveness of a given technology have also been considered.
- Useful life has been evaluated with respect to the ability of a given technology to be successfully operated for a sufficient length of time necessary to achieve ~~containment, source control, and/or restoration of groundwater quality~~.
- Evaluation of reliability has been based on previous demonstrated performance under similar conditions to those found at the Sparton facility. Particular emphasis has been placed on operation and maintenance costs as evidence of reliability. Evaluation of the retained alternatives and appropriate treatment trains has determined if failure of any one technology has an immediate effect on potential receptors and whether the technology has the flexibility to deal with uncontrollable changes at the site.

- Implementability has been evaluated relative to the ease with which a given technology can be installed and operated. This evaluation included how well a given alternative matches site characteristics, existing facility operation, institutional requirements, and time requirements. Time requirements included both time for implementation and time required to achieve beneficial results.

In addition to evaluating individual technologies or alternatives under these criteria, combinations of technologies or treatment trains have also been evaluated. The synergism resulting from combining technologies into a treatment train may result in higher evaluation relative to these technical criteria.

## 2. Environmental Evaluation Criteria

Each retained technology or alternative has been evaluated in terms of environmental risk and/or threat resulting from construction and operation. This includes short- and long-term beneficial and adverse effects on the environment from application of the technology. The potential of a given technology to transfer or create additional problems, such as creating a residual waste, have also been examined. The evaluation has also considered whether any adverse effects created by the technology can be successfully mitigated.

### 3. Human Health Criteria

Each retained corrective measure alternative has been evaluated relative to minimizing potential adverse effects on human health, both short- and long-term, and to mitigating potential exposure. Potential exposure pathways and level of exposure resulting from construction and operation of a given technology have also been evaluated.

### 4. Institutional Criteria

Each retained technology has been evaluated with respect to institutional concerns including: esthetics; community acceptance; and compliance with city, county, state, and federal requirements. Included in this evaluation criteria is the number and types of permits required for implementation of a given technology and the time and difficulty associated with obtaining the necessary permits.

## B. Containment of the Dissolved Groundwater Phase (Saturated Zone)

### 1. No Further Action

Under ~~what EPA labels and requires as part of an evaluation of alternatives --~~ No Further Action (NFA) ~~-- the IM~~ would be discontinued and no additional treatment technology would be implemented at the site. The NFA alternative has been retained because the RFI ~~and subsequent investigation have~~ identified no significant risk or threat to human health or the environment ~~as noted in Section III.D.~~ Existing land use and probable future development of this area minimize both potential receptors and exposure

pathways with respect to the contamination characterization for the Sparton Facility. As noted in Section III, some 43 groundwater wells have extensive time-histories. Of the 32 wells that have detection histories, 24 wells (75%) exhibit decreasing concentration with time and 7 wells (22%) show increasing concentration. These trends are consistent in the UFZ, ULFZ, and LLFZ with decreasing/increasing percentages of 82/18, 64/27 and 75/25 respectively. The plume has continued to expand at the extreme western (down-gradient) end; however, there are currently two non-detect downgradient monitoring wells in the probable path of the plume--UFZ wells MW-50 and MW-52 and one down-gradient well, MW-57, to the north of the leading edge of the plume.

Under the NFA alternative, quarterly monitoring of selected wells would continue. However, EPA has suggested that new groundwater monitoring wells would confirm the plume limits and the rate of movement. Confirmation of horizontal plume limits could be accomplished by adding LLFZ wells to the existing UFZ well locations MW-52 and MW-57 and by adding a new UFZ/LLFZ well cluster on Chantilly Road near Buckeye to define the horizontal down-gradient plume limits. Confirming vertical plume limits in the vicinity of well cluster No. 9 (MW-48, MW-55, MW-56) could be accomplished by installing a fourth well in the Third Flow Zone (TFZ). It should be noted that well cluster #9 is the only off-site cluster showing an increase in TCE concentration with depth. These new wells would also be monitored on a quarterly basis.

The results of the continued groundwater monitoring and changes in land use/development would be monitored by requesting notices of proposed subdivision

approvals and zoning changes within two miles of the Sparton facility be provided to Sparton. An annual evaluation would be conducted to determine the need, if any, for other corrective measures, based on changes in land use.

Applications for permits to drill and complete private or public drinking water wells in groundwater impacted by Sparton's operations will be monitored on at least an annual basis. Notice will be given to the State Engineer's Office of the area impacted by Sparton's operations and that Sparton should be notified in the event that any applications are received for the drilling and completion of wells within that area. Sparton will on an annual basis update its description of the impacted area to take into consideration any expansion or contraction of the impacted groundwater as shown by the quarterly monitoring and other data. Sparton will participate in any permit proceedings, and to the extent a permit is granted that will allow a well to be drilled in the impacted area, Sparton will undertake an additional corrective measure study to determine what response is appropriate in order to address any threat that may be presented.

Capital costs for installing the four additional monitoring wells downgradient of the plume would be in the range of \$70,000 to \$80,000. Capital cost for the deep well in cluster No. 9 would be in the range of \$40,000 to \$50,000 because of the existing contamination.

Costs on an annual basis for quarterly monitoring of approximately twenty wells and providing an annual report is as follows:

Sampling	\$22,500
VOC Analyses	40,000
Evaluation, Annual Report	<u>15,000</u>
	\$77,500 annually

## 2. Infiltration Gallery/Injection Wells

This alternative has been retained for consideration as required under provisions of the Consent Order (Exhibit I, CAP Scope of Work, Task VII.D.).

In many instances, the function of injection wells and infiltration galleries during a groundwater remedial program are as follows:

- Dispose of groundwater after treatment.
- Utilize (---) as injection devices for nutrients to operate a bioremediation system.
- Force a contaminant plume toward a recovery point to facilitate groundwater restoration.

However, in most cases the primary function or purpose of injection wells and infiltration galleries is to provide containment for a contaminant groundwater plume while other processes are used to provide groundwater restoration. The proper use of injection wells and infiltration galleries is to install them just beyond the downgradient edge of a plume.

Under the current set of geologic/hydrogeologic conditions at the Sparton facility, infiltration galleries and injection wells are not considered appropriate corrective measure alternatives to accomplish the corrective action objectives. However, in order to comply with the Consent Order, infiltration galleries and injection wells have been retained from the screening process to select the appropriate corrective measure alternatives. Under an objective screening process, neither infiltration galleries and/or injection wells would have

been retained due to site-specific application, technology constraints, and institutional issues. Specific reasons why these technologies would not have been retained are as follows:

- Infiltration galleries are usually constructed under shallow groundwater conditions (generally less than forty feet in depth). Infiltration galleries are generally constructed to just above the receiving body of water. Groundwater at the Sparton facility ranges from sixty-five to seventy-five feet below ground surface to over 200 feet off site toward the northwest and downgradient edge of the contaminant plume. Under these sets of hydrogeologic conditions, an infiltration gallery could not be constructed using conventional equipment/technology because of the depth to groundwater and the instability of the soil during construction.
- Because of the areal extent of the downgradient edge of the contaminant plume, numerous injection wells or a significant length of infiltration gallery would need to be installed to provide a reasonable possibility of dealing with the plume. Because of the areal extent of the plume and the depth to groundwater along the downgradient edge of the plume, capital costs for injection well installation could easily exceed several million dollars. Infiltration galleries, assuming that equipment/technology could be developed to meet site requirements, would be prohibitively expensive. Note that these costs do not take into account the operation and maintenance costs to



service such a system. Given the magnitude of such a program and the objective of the corrective measure, this type of corrective measure alternative would not be cost effective and would not adequately deal with the problem.

- Injection wells and infiltration galleries may create a mounding of the water table and cause the groundwater contaminant plume to disperse and spread over a larger area.
- Because the contaminant plume extends off site, most of the construction for injection wells and infiltration galleries would have to take place on private property. Gaining access to private property for construction could be difficult. In addition, numerous political and technical issues would need to be addressed.
- Installation of infiltration galleries and injection wells requires a permit from the State of New Mexico. Obtaining required permits is a long process. In addition, the State of New Mexico has a no degradation policy for groundwater protection. Consequently, the issuance of a permit may require a change in the level of treatment above that required for remediation.
- As discussed earlier, infiltration galleries and injection wells are viewed primarily as a containment technology to inhibit or slow the advancement of a groundwater contaminant plume. However, the groundwater gradient off-site near the leading edge of the plume is relatively flat. Alteration of the

groundwater gradient by injection in the vicinity of the downgradient edge may cause the plume to disperse over a larger area and spread the contamination.

- Infiltration galleries and injection wells are used primarily for small groundwater plumes. The areal extent of the plume makes the use of these alternatives infeasible. Furthermore, these alternatives require a steady flow of water to be effective. Under typical groundwater extraction plans, wells are pumped in a pulse format, i.e., a several week pumping period followed by a similar recovery period. This type of pumping scheme will not supply either sufficient quantities, or a continuous supply, of water to the injection wells or infiltration galleries for them to be effective.

### 3. Extraction Wells for Containment

EPA has directed that groundwater extraction wells be evaluated for containment of the contaminant plume (US EPA, 1996). Based on understanding of the current plume, containment could be provided by a single extraction well located in the western end of the plume. The partially penetrating well would be screened into approximately the upper thirty to thirty-five of the saturated zone. (Upper and Upper Lower Flow Zones). Deeper penetrations are undesirable due to the potential for contaminant migration to the Lower Lower Flow Zone. Using aquifer properties given in the RFI Report and confirmed by the USGS, a pumping rate of 50 to 100 gpm would give a capture zone width (at the well) of approximately 1,500 to 2,000 feet which would adequately cover the width of the

plume. Alternatively, capture zone width could be based on the 600-foot-plus radius of influence demonstrated in pumping tests reported in the RFI. The pumping rate would give a drawdown in the range of six to ten feet. The pumping rate should be adjusted to provide sufficient drawdown for containment but not so much drawdown to pull shallow contamination deeper into the aquifer.

Extracted water would either be treated near the wellhead or conveyed through a buried pipeline installed in the public right-of-way to the Sparton facility for treatment. It should be noted that bringing contaminated water to the surface in off-site areas poses some risk to the general public, off-site landowners and the environment.

Costs for a single well extraction system are given in Figure 24.

#### C. Restoration of the Dissolved Groundwater Phase (Saturated Zone)

Groundwater remediation alternatives for this project would include no further action, groundwater extraction and treatment system, vapor extraction system, in situ air stripping, and in situ bioremediation. Treatment of the water effluent pumped from the ground may utilize air stripping, granular activated carbon (GAC), advanced oxidation, aerobic bioreactors, or a combination of all the above to treat volatile organics. The treatment train may include ion exchange and chemical precipitation for metal treatment. Vapor obtained from vapor extraction and/or in situ air stripping may be treated with granular activated carbon (GAC) or thermally destructed. Bioremediation provides total treatment in place.

**FIGURE 24**

<b>CONTAINMENT EXTRACTION WELL COSTS</b>	
<b>CAPITAL COSTS</b>	
<b>Item</b>	<b>Cost</b>
Well Installation	\$ 40,000
Submersible pump	5,000
Controls	5,000
Electric Service	20,000
Well head protection	5,000
Double contained piping to Sparton Facility	60,000
Contingency (25%)	33,750
Total Capital Cost	\$168,750
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>	
<b>Item</b>	<b>Cost</b>
Electricity	\$ 3,500
Maintenance, Depreciation	16,875
Effluent Monitoring	3,000
Annual O&M	\$ 23,375

1. No Further Action

Under what EPA labels and requires as part of an evaluation of alternatives -- No Further Action -- the IM would be discontinued and no additional treatment technology would be implemented at the site. The NFA alternative has been retained because the RFI and subsequent investigation have identified no significant risk or threat to human health or the environment as noted in Section III. D. Existing land use and probable future development of this area minimize both potential receptors and exposure pathways with respect to the contamination characterization for the Sparton Facility. As noted in Section III, some 43 groundwater wells have extensive time-histories. Of the 32 wells that have detection histories, 24 wells (75%) exhibit decreasing concentration with time and 7 wells (22%) show increasing concentration. These trends are consistent in the UFZ, ULFZ, and LLFZ with decreasing/increasing percentages of 82/18, 64/27 and 75/25 respectively. The plume has continued to expand at the extreme western (downgradient) end; however, there are currently two non-detect downgradient monitoring wells in the probable path of the plume--UFZ wells MW-50 and MW-52 and one down-gradient well, MW-57, to the north of the leading edge of the plume.

Under the NFA alternative, quarterly monitoring of selected wells would continue. However, EPA has suggested that new groundwater monitoring wells would confirm the plume limits and the rate of movement. Confirmation of horizontal plume limits could be accomplished by adding LLFZ wells to the existing UFZ well locations MW-52 and MW-57 and by adding a new UFZ/LLFZ well cluster on Chantilly Road near Buckeye to define the

horizontal down-gradient plume limits. Confirming vertical plume limits in the vicinity of well cluster No. 9 (MW-48, MW-55, MW-56) could be accomplished by installing a fourth well in the Third Flow Zone (TFZ). It should be noted that well cluster No. 9 is the only off-site cluster showing an increase in TCE concentration with depth. These new wells would also be monitored on a quarterly basis.

The results of the continued groundwater monitoring and changes in land use/development would be monitored by requesting notices of proposed subdivision approvals and zoning changes within two miles of the Sparton facility be provided to Sparton. An annual evaluation would be conducted to determine the need, if any, for other corrective measures, based on changes in land use.

Applications for permits to drill and complete private or public drinking water wells in groundwater impacted by Sparton's operations will be monitored on at least an annual basis. Notice will be given to the State Engineer's Office of the area impacted by Sparton's operations and that Sparton should be notified in the event that any applications are received for the drilling and completion of wells within that area. Sparton will on an annual basis update its description of the impacted area to take into consideration any expansion or contraction of the impacted groundwater as shown by the quarterly monitoring and other data. Sparton will participate in any permit proceedings, and to the extent a permit is granted that will allow a well to be drilled in the impacted area, Sparton will undertake an additional corrective measure study to determine what response is appropriate in order to address any threat that may be presented.

Capital costs for installing the four additional monitoring wells down-gradient of the plume would be in the range of \$70,000 to \$80,000. Capital cost for the deep well in cluster No. 9 would be in the range of \$40,000 to \$50,000 because of the existing contamination.

Costs on an annual basis for quarterly monitoring of approximately twenty wells and providing an annual report is as follows:

Sampling	\$22,500
VOC Analyses	40,000
Evaluation, Annual Report	<u>15,000</u>
	\$77,500 annually

## 2. Continuation of Interim Measure Corrective Action

Continuation of the Interim Measure (IM) groundwater recovery and treatment system has been retained as a corrective measure alternative at the Sparton Facility. The IM consists of eight groundwater extraction wells located on-site. The recovery wells were installed in the upper flow zone. Compressed-air-operated pumps are installed in each well. Produced water is routed through double-walled piping to the treatment building. The water is treated in a packed tower aeration (PTA) unit to remove VOC. After treatment the produced water is used in the Sparton plant as cooling and flushing water and then discharged into the sanitary sewer system. The total system capacity is twenty gallons per minute (gpm). Since start-up in December 1988, the IM system has successfully treated

over 3.56 million gallons of recovered groundwater with a treatment efficiency of over ninety-nine percent. The IM has achieved a reduction in VOC concentration in groundwater and has limited, if not prevented, further migration from on-site. However, even after over seven years of pumping, VOC concentrations are still orders of magnitude above MAC/MCL.

Under this alternative, the IM would continue to be operated to obtain the maximum practical limitation of off-site migration and removal and reduction of VOC on-site in areas most heavily impacted. Reliability has been demonstrated by almost seven and one-half years of successful operation. Use of this alternative poses little risk to human population or the environment. All operating equipment is located on-site and treatment facilities are located in a secure, fenced area. Performance will be monitored by quarterly sampling and analysis of selected wells.

There are no additional capital costs for continuing operation of the IM system. However, design and capital costs of approximately \$200,000 were incurred in 1988. Current annual operation and maintenance (O&M) costs for the system are approximately \$25,000. Capital costs for additional monitoring wells as discussed in VII.C.1 would be \$75,000 to \$90,000. Quarterly sampling and analysis would bring the total O&M costs for this alternative to \$102,500 annually.

Based on comments received at the February 1, 1996, Public Meeting, EPA has directed that lining of the Corrales Main Canal east of the Sparton facility be evaluated in the context of increasing the effectiveness of the IM (U.S. EPA, 1996). As noted in



Figure 23 Screening of Corrective Measure Technologies, this technology, if previously considered, would have been eliminated for several reasons. First, lining of the canal would be relatively ineffective since the majority of the recharge is coming from the irrigated fields supplied by the canal. The canal represents only a small fraction of the recharge area and lining would have little impact. Secondly, seasonal fluctuation of the groundwater levels in the UFZ onsite probably enhances both the performance of the IM and in situ bioremediation by alternatively saturating and then exposing and aerating a portion of the UFZ.

### 3. Expansion of Interim Measure

This alternative is similar to the previous discussion in Item 2 with the exception of adding a single groundwater recovery well to the existing IM system. On-site lower flow zone well 32 would be added to the IM to address the anomalously high concentrations of VOC in this well. The current IM system has sufficient remaining capacity to accommodate the inclusion of well 32. Capital costs would be approximately \$10,000. Operation and maintenance costs would be unchanged from Item 2.

### 4. Large-Scale Groundwater Extraction and Treatment System

Extracting groundwater with pumped wells on a large scale and treating it at the surface has been retained as a corrective measure alternative at the Sparton site for groundwater remediation. Use for containment was previously discussed in VII.B.3. This technology is more suitable in high permeability materials such as the subsurface gravelly sands and less effective in the clays and silts at the Sparton site. It should be noted that groundwater extraction and treatment is limited in its ability to reduce groundwater

contamination to low levels approaching groundwater protection standards. In the extensive review of pump and treat system performance given in Evaluation of Groundwater Extraction Remedies: Phase II (US EPA 1992), the EPA reported that groundwater extraction could produce approximately an order of magnitude decrease in contaminant concentration. However, after several years of pumping, contaminant concentrations "tail" off or reach a "plateau" concentration well above MCL. The plateau concentration is typically an order of magnitude less than the initial concentration. Further pumping does not decrease containment levels to any significant degree. A second study (National Research Council, 1994) also found that pump and treat was ineffective in restoring aquifers to health-based standards within a reasonable time. The study found restoration could take hundreds if not thousands of years at sites with heterogeneous, anisotropic conditions and adsorbed chlorinated solvents such as at the Sparton facility. This technology is therefore most appropriate for reducing high concentrations of contaminants in an expedient manner and not for achieving health-based standards. Achievement of low contaminant concentration in groundwater may be inordinately difficult, if not impossible. EPA Directive 9234.2-25 Guidance for Evaluating the Technical Impracticability of Groundwater Restoration (U.S. EPA 1993) discusses a number of factors that impact groundwater restoration and may render it technically impracticable. These factors applied to the Sparton facility are summarized in Figure 25. Due to the Sparton site-specific conditions, restoration to drinking water standards using a pump and treat system is technically impracticable. A more realistic and achievable alternative concentration limit (ACL) based on prevailing experience could provide attainable goals in an efficient and timely manner.

**FIGURE 25****SITE-SPECIFIC FACTORS AFFECTING GROUNDWATER REMEDIATION**

Contaminant/ Hydrogeologic Factors	Basis/Description	Remediation Difficulty
Nature of release	Long duration	High
Biotic/abiotic decay potential	Moderate to low potential	Moderate to High
Volatility	Moderate	Moderate
Retardation (sorption) potential	High (Residual DNAPL)	High
Contaminant phase	Aqueous, gaseous, sorbed (Residual DNAPL)	Moderate to High
Volume of contaminated media	Relatively large	High
Contamination depth	Relatively deep	High
Stratigraphy	Complex geology, interbedded and discontinuous	High
Texture of deposits	Ranges from gravelly sand to silts and clays	Moderate to High
Degree of Heterogeneity	Heterogeneous, anisotropic, interbedded and discontinuous	High
Hydraulic conductivity	Range from high ( $\approx 10^{-3}$ cm/sec) in gravelly sand to low ( $< 10^{-5}$ cm/sec) in clays/ silts.	Low to High
Temporal variation	Slight change in water elevation/gradient	Low to Moderate
Vertical flow	Little to None	Low

The ability of pump and treat technology to reduce high contaminant concentrations under the Sparton facility has been demonstrated by the successful performance of the Interim Measure (IM) pump and treat system over the past 7-1/2 years. However, as expected, contaminant concentrations have "tailed off" at levels well above groundwater protection standards.

As directed by EPA (U.S. EPA 1996), the use of surfactants to enhance pump and treat performance was evaluated. The use of surfactants looks promising in the laboratory - particularly with oily DNAPLS such as petroleum hydrocarbons, polynuclear aromatic hydrocarbons, and polychlorinated biphenyls. A general discussion of the use of surfactants can be found in Chemical Enhancements to Pump-and-Treat Remediation (U.S. EPA, 1992). However, information on the use of surfactants to enhance remediation of chlorinated solvents such as TCE and TCA was not located in literature searches. In the absence of any meaningful evaluation derived from pilot-scale or full-scale implementation of surfactant use, this technology was not reviewed further. It should be noted that State regulations may also prohibit or restrict the use of surfactants as another form of contamination.

For maximum efficiency in contaminant removal from the groundwater, intermittent or pulse pumping would be required. Continuous pumping removes a constant volume of water which can result in an initial rapid decrease in contaminant concentration. Continuous pumping, however, often cannot decrease the contamination level below a certain minimum concentration level, also called "tailing phenomenon", because the rapid

pore velocities do not provide sufficient time for contaminant levels to build back up to equilibrium levels. Pulse or intermittent pumping provides greater efficiency in contaminant removal by allowing sufficient time for dissolved contaminants to diffuse out of less permeable zones and sorbed contaminants to reach equilibrium concentrations with groundwater prior to removal for surface treatment. Using pulse pumping, several years of operation would be required to obtain a maximum reduction in contaminant concentration, but would still not achieve health-based standards.

On-site pump testing has established aquifer parameters. These parameters include a 600-foot radius of influence and a specific capacity of 7.5 to 9 gallons per minute per foot of drawdown. Capture Zone calculations indicate widths of several thousand feet for pumping rates in excess of 50 gpm. Based on the present groundwater plume characterization, this alternative could involve anywhere from one to three groundwater extraction wells. A single on-site well would effectively cover the high contaminant concentration area of the plume. For purposes of reducing the VOC concentration, a total of three wells would be required to cover the entire area of the plume. Off-site wells, if any, would be located in public rights-of-way to minimize off-site access problems. It should be noted that off-site wells pose some risk to the general public and off-site landowners. This risk is the result of bringing contaminated water to the surface and then conveying it through a buried pipeline to the Sparton facility for treatment. Both the well head and buried pipeline are subject to possible malfunction, inadvertent destruction and possible vandalism.

Wells should not be screened more than thirty to thirty-five feet into the aquifer to prevent the migration of higher concentrations of constituents into lower portions of the aquifer. Based on drawdown limitations posed by this screen depth, ~~maximum~~ pumping rates in the order of 180 to 200 gallons per minute (gpm) would be utilized. This pumping rate would require eight- to ten-inch wells with pump size ranging from ten to twenty horsepower depending on depth to groundwater. Costs for extraction wells have been estimated in Figure ~~26~~. Costs for both a single on-site groundwater extraction well and a three well system (one on-site well and two off-site wells) are given for comparison purposes.

The groundwater extraction and treatment alternative is conventional in concept. Operation will be similar to the current Interim Measure pump and treat system. Because this alternative is self-explanatory, preliminary process flow diagrams have not been included in this report.

Time required for implementation of this alternative will be a function of season, chosen treatment option, required permits, and whether groundwater wells are located on-site or off-site. Assuming a single on-site well, this alternative could be fully operational in approximately one year. Once operation in a pulsed mode is begun, it is estimated that two to three years of operation will be required to produce a significant reduction in VOC concentration in groundwater. The useful life of the equipment is much longer (in excess of ten years.) ~~This pumping duration should produce a "plateau" concentration~~

**FIGURE 26**

<b>GROUNDWATER EXTRACTION WELL COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>One On-Site Well (200 gpm)</b>	<b>Three Wells Total (600 gpm)</b>
Well Installation	\$40,000	\$120,000
Submersible Pump	5,000	20,000
Controls	5,000	15,000
Electric Service	1,000	20,000
Wellhead Protection	N/A	10,000
Double Contained Piping To Sparton Facility	N/A	60,000
Contingency (25%)	12,750	61,250
<b>Total Capital Cost</b>	<b>\$63,750</b>	<b>\$306,250</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>One On-Site Well (200 gpm)</b>	<b>Three Wells Total (600 gpm)</b>
Electricity (4380 hr)	\$3,285	\$14,785
Maintenance, Depreciation	6,375	30,625
Effluent Monitoring	3,000	9,000
<b>Annual O &amp; M</b>	<b>\$12,660</b>	<b>\$54,410</b>

approximately on order of magnitude less than initial concentrations, however, it is believed that attainment of MCL is not achievable. As previously discussed in this section, site-specific conditions at the Sparton site document that restoration of ground water to protection standards is technically impracticable. An alternative concentration limit will be needed for successful implementation.

a. Disposal Alternatives for Produced Water

For any extraction system to be viable, an alternative for disposal or use of the produced water must be developed as part of the system. Available options are: to pump treated water to the Rio Grande, to place treated water back into the aquifer, or, to beneficially reuse treated water. As discussed in a previous section, discharge to a POTW is not an option. Available options will be discussed in detail in the following sections.

(1) Discharge to the Rio Grande

This disposal alternative is demonstrated to be an effective and reliable method for disposing of large quantities of water for an extended period of time. The discharge could be used to obtain river recharge credits.

After treatment, effluent could be routed along public right-of-way to Las Calabacillas Arroyo and then along the Arroyo to the Rio Grande. Discharge would require a National Pollutant Discharge Elimination System (NPDES) permit. (---)



Estimated costs for disposal of extracted groundwater are given in Figure 27. Costs for handling discharge from both a single well system and a three well system have been estimated to show the effect of disposal quantity.

## (2) Injection Wells

The primary advantages of injection wells are that the requirements for water rights are minimized, a NPDES permit is not required (groundwater discharge permit is required), disposal of water can occur in the same general area as extraction, and minimal amounts of land/access are required. However, injection wells are much more likely to fail than are typical water wells. Clogging of screens is a serious problem in injection well operation. Recharge through injection wells usually requires stringent water quality considerations, and recharge operations are generally less successful than in spreading basins because suspended sediment in the recharge water clogs the formation near the well. Once the formation is clogged, it is difficult to remove enough sediment to completely rejuvenate the well. The problem can be avoided only if clear water is used for recharge.

**FIGURE 27**

<b>COSTS FOR DISPOSAL TO RIO GRANDE</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>One On-Site Well (200 gpm)</b>	<b>Three Wells Total (600 gpm)</b>
Transfer Pump and Surge Tank	\$5,000	\$10,000
Controls	4,500	4,500
Pipeline	50,000	50,000
Coors Road Crossing	10,000	10,000
Discharge Structure	5,000	5,000
Contingency (25%)	18,600	20,000
<b>Total Capital Cost</b>	<b>93,000</b>	<b>99,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>One On-Site Well (200 gpm)</b>	<b>Three Wells Total (600 gpm)</b>
Electricity (4380 hr)	\$3,285	\$8,212
Maintenance, Depreciation	9,300	9,950
Effluent Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$15,585</b>	<b>\$21,162</b>

The principal causes of clogging mentioned in reports concerning recharge through wells are:

- Suspended particles in the recharge water. In an injection well, fine sediment contained in the injection water will continuously collect in the formation or filter pack outside the well screen. Over time, the formation slowly becomes clogged, reducing the capacity of the aquifer to receive water. Sand, even in concentrations of one part per million, can be sufficient to clog injection wells in a relatively short time.
- Bacterial contamination of the aquifer by the recharge water and subsequent clogging by bacterial growths. Bacterial growth can be promoted by the change in temperature caused by injection, especially when warmer water is added to a cool aquifer.
- Chemical reactions between the groundwater and recharge water of different quality causing precipitation of insoluble products.
- Mechanical jamming of the aquifer, caused by particle rearrangement when the direction of water movement through the aquifer is reversed.
- Swelling of clay colloids in the aquifer.
- Incrustation created by injection water which is high in mineral content.
- Ion exchange reactions that could result in clay-particle dispersal.
- Precipitation of iron in the recharge water as a result of aeration.

- Injection tubing corrosion. Differential oxygen cell corrosion occurs in carbon steel injection tubing. For stainless steel, stress cracking is a problem. For fiberglass plastics, softening by sorption of fluids can occur.
- Biochemical changes in the recharge water and groundwater involving iron reducing bacteria or sulfate-splitting organisms.
- Gas binding or air entrainment in the aquifer. When air is entrained with injection water, serious interference with permeability and transmissivity can be expected because air molecules can effectively block the passage of water by plugging pore space within the aquifer.
- Water temperature and viscosity due to temperature difference between injected water and groundwater.

Injection wells have been used at several sites in the South Valley area. However, these installations have experienced severe clogging and/or plugging problems due to calcium carbonate buildup and biologic growth. Encrustation and biofouling have quickly reduced the ability of these systems to inject treated water into the surface. With additional treatment, including extended storage, injection wells have performed better; however, some of the additional treatment such as chlorine disinfection has produced trihalomethanes and other chlorinated compounds. Further, treatment to remove encrusting chemicals may result in a hazardous sludge byproduct. This is particularly significant in the Sparton facility area where naturally occurring arsenic is present in the groundwater. Arsenic, for instance, is generally not a concern in the South Valley area.

For cost estimation of this alternative, 200-gpm injection wells capable of continuous operation have been assumed. A nominal eight-inch well some 400 feet deep with 200 feet of screen would be required. It is estimated (based on local experience) that redevelopment of the well would be required six times per year and replacement would be needed every two years. Injection back into the aquifer would also require additional treatment beyond that necessary to remove contaminants from the extracted water. At a minimum, this additional water treatment would include:

- Filtration to remove suspended solids.
- Adjustment (lowering) of pH to prevent precipitation of salts.
- Air removal to prevent gas binding of the aquifer and biologic stimulation.
- Chlorination to prevent bacterial clogging.

Note that the anticipated level of water treatment further assumed that reverse osmosis (RO) treatment would not be needed to match the total dissolved solids (TDS) content of the injected water to the receiving groundwater.

Costs for injection well disposal and additional water treatment required for injection disposal are given in Figure 28.

**FIGURE 28**

<b>INJECTION WELL DISPOSAL COSTS</b>		
<b>CAPITAL COSTS*</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Well Installation	\$120,000	\$360,000
Additional Water Treatment*	200,000	600,000
Plumbing, Electrical	10,000	30,000
Contingency (25%)	82,500	247,500
<b>Total Capital Cost</b>	<b>\$412,500</b>	<b>\$1,237,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS*</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Water Treatment*	\$ 60,000	\$180,000
Redevelopment of Wells	30,000	90,000
Well Replacement, Abandonment	80,000	240,000
<b>Annual O &amp; M</b>	<b>\$170,000</b>	<b>\$510,000</b>

\*Does not include cost for reverse osmosis treatment to remove dissolved solids.

### (3) Infiltration galleries

Infiltration galleries have most of the same advantages and disadvantages as the injection wells discussed in the previous section. Based on local experience, injection galleries have a longer life than injection wells but require much larger land area for implementation. Assuming an available infiltration rate of 100 ft/yr, a 200-gpm infiltration gallery would require 46,500 linear feet of 3-foot wide trench. At a trench spacing of 6 feet, the required land area would be 9.7 acres. Costs for infiltration galleries as a disposal option are given in Figure 29.

### (4) Infiltration beds

Infiltration beds are shallow ponds (6 inches to 12 inches deep) which allow recharge through the bottoms of the ponds. The main advantage of infiltration beds is that the clogging layer which develops in any injection/infiltration system can be easily removed and, as a result, additional water treatment to minimize clogging is not required.

Soil clogging is the principal problem associated with infiltration beds or water spreading. Accumulation of suspended solids in water occurs on the bottom and banks of the infiltration facility as they settle or are strained out on the soil surface. The suspended solids may be inorganic (clays, silts, fine sands) or organic (algae, bacteria flocks, sludge particles). Also biofilms may grow on the bottom. Consequently, clogging layers may consist of a mixture of organic and inorganic products. As a clogging layer



**FIGURE 29**

<b>INFILTRATION GALLERY DISPOSAL COST</b>		
<b>CAPITAL COSTS*</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Trench Construction	\$186,000	\$ 558,000
Trench Materials	387,500	1,162,500
Sitework, Fencing	30,000	90,000
Additional Water Treatment	150,000	450,000
Contingency (25%)	188,375	565,125
Total Capital Cost*	\$941,875	\$2,825,625
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Water Treatment	\$ 45,000	\$135,000
Trench Replacement	150,000	450,000
Annual O & M	\$195,000	\$585,000

\*Does not include land cost.



continues to develop, infiltration rates become so low that the clogging layer must ultimately be dried and removed, causing temporary shut down (2 weeks) of the system. Other disadvantages cited for infiltration beds or water spreading are loss of water by evaporation, insect or algae breeding, and safety considerations of the water body.

Assuming an available infiltration rate of 200 ft/yr for the infiltration beds, a 200-gpm infiltration bed capacity would require 1.75 acres of pond. The beds would have to be dried and the clogging layer removed approximately twice a year. Costs for infiltration beds are given in Figure 30.

#### (5) Beneficial reuse

Beneficial reuse of the produced water is also a potential alternative for disposal. Recent discussions with both New Mexico Utilities and the City of Albuquerque have indicated that suitable receivers/users may be available. The most promising site would be the Paradise Hills Country Club golf course. The golf course is currently irrigated using potable water purchased from New Mexico Utilities. The golf course is approximately 4,500 feet west of the leading edge of the plume (7,200 feet from the original source area on site).

Pumping water to the golf course for irrigation should not require any additional treatment beyond that needed to remove contaminants from the produced water. Cost for pumping to the golf course from extraction wells (containment) near the leading edge of the plume would be similar in cost to that for discharge to the Rio Grande as discussed in

**FIGURE 30**

<b>INFILTRATION BED DISPOSAL COSTS</b>		
<b>CAPITAL COSTS*</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Pond Construction	\$ 25,000	\$ 75,000
Sitework, Fencing	25,000	75,000
Contingency (25%)	12,500	37,500
<b>Total Capital Cost*</b>	<b>\$62,500</b>	<b>\$187,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200 gpm System</b>	<b>600 gpm System</b>
Remove clogging layer (two times per year)	\$ 5,000	\$ 15,000
Landfill disposal of clogging layer (two times per year)**	132,000	396,000
<b>Annual O &amp; M</b>	<b>\$137,000</b>	<b>\$411,000</b>

\* Does not include land cost.

\*\*Non-hazardous disposal.

Section VII.C.4.a (1). Costs for pumping to the golf course from extraction wells on the Spanton facility (source control) would be approximately doubled due to the increased distance and increased elevation difference.

Other options are currently being explored with both the City of Albuquerque and New Mexico Utilities. Beneficial reuse requires some suitable site that can accept and use the water year round. In the absence of a potential user year round, the extraction system would either require seasonal suspension or alternative disposal.

#### (6) Calabacillas Arroyo Recharge

EPA also directed that surficial recharge in the Calabacillas Arroyo be considered (U.S. EPA, 1996). A "Calabacillas Recharge Window" was described by Mr. Steve Hansen of the USDOl Bureau of Reclamation (BuRec) during the public meeting on February 1, 1996, and in a subsequent memorandum furnished to EPA. The memorandum provided little meaningful or area-specific information on hydrogeological features to allow evaluation of this alternative. The memorandum further referenced several reports published through 1996 (by author and date); however, review of these referenced reports did not provide any specific information. In lieu of any specific hydrogeological data, this alternative is speculative at best and probably is comparable to injection wells and infiltration galleries.

#### (7) Summary

Legal issues related to injection wells and beneficial reuse include potential liability for the creation of toxic conditions not present not from use of the

recovered water; extensive, contested permitting processes; and the need to obtain easements.

Due to the combination of legal and technical difficulties associated with injection wells and reuse, direct discharge is still the most viable option. Discharge to the Rio Grande with a NPDES permit is much more straightforward and is the most practicable and lowest risk option for disposal of treated water. Moreover, discharge is not a loss of the water, but makes supply available for a non-local use.

Treatment options for extracted groundwater pumped to the surface at the Sparton site would include a number of technologies which may be used individually or in combination with one another. These options are discussed in detail in subsequent sections.

**b. Air Stripping**

Air stripping is a mass transfer process in which volatile contaminants in water or soil are transferred to gas. Generally, organic chemicals such as TCE and TCA with Henry's law constants greater than 0.003 can be effectively removed by air stripping. Air stripping is considered one of several best demonstrated available technologies (BDATS) for removal of volatile contaminants such as those present at the Sparton site. Air stripping is frequently accomplished in a packed tower aerator (PTA) equipped with an air blower.

In packed tower aeration, loosely packed material is placed within a vertical cylindrical tower. Water cascading through the packing breaks into small droplets providing

a large surface area to enhance mass transfer. Air forced upward through the packing from the tower base promotes the transfer of VOC from the water to the air.

Air stripping is suitable for this site because of its high effectiveness in removing VOC and its moderate cost. Capital cost for a packed tower aeration treatment unit is a function of treatment capacity. Estimated costs corresponding to the range of flows anticipated from the groundwater extraction system are given in Figure 31. For the 200-gpm capacity, a 36- to 42-inch diameter packed column will be required. For 600 gpm, a 72-inch packed column will be used. Operation and maintenance (O & M) costs will be in the range of \$0.15 to \$0.22 per 1000 gallons.

Air stripping technology has been used on site at the Sparton Facility for over seven years as an Interim Measure (IM). The effectiveness of this method has been demonstrated by pumping and treating over 3,559,400 gallons of water through March 1, 1996, with a contaminant removal efficiency of ninety-nine per cent. Assuming an average initial influent concentration of 2 mg/l VOC (1.5 mg/l TCE and 0.5 mg/l TCA), the air stripping will produce five to fifteen pounds of VOC in the air effluent for the 200 to 600-gpm treatment range. It is understood that city of Albuquerque air quality regulations may require treatment or "polishing" of the air effluent to remove VOC. Polishing of the air effluent can be most efficiently achieved by the use of granular activated carbon (GAC) treatment. GAC treatment costs are estimated in Figure 32. Operation and maintenance costs would be in the range of \$0.34 to \$0.43 per 1000 gallons.

**FIGURE 31**

<b>PACKED TOWER AERATION COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Packed Tower	\$30,000	\$70,000
Control Building	5,000	5,000
Miscellaneous Electric and Plumbing	2,500	2,500
Controls	5,000	5,000
Tower Foundation	2,500	2,500
Contingency (25%)	11,250	21,250
<b>Total Capital Cost</b>	<b>\$56,250</b>	<b>\$106,250</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Electricity (4380 hr)	\$3,450	\$9,850
Maintenance, Depreciation	5,000	10,000
Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$11,450</b>	<b>\$22,850</b>

**FIGURE 32**

<b>GAC AIR POLISHING COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200-gpm Air Stripper</b>	<b>600-gpm Air Stripper</b>
GAC Unit With Heater	\$30,000	\$50,000
Miscellaneous Electric and Plumbing	5,000	5,000
Shelter Unit	5,000	5,000
Contingency (25%)	10,000	15,000
<b>Total Capital Cost</b>	<b>\$50,000</b>	<b>\$75,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200-gpm Air Stripper</b>	<b>600-gpm Air Stripper</b>
Electricity (4380 hr)	\$4,380	\$13,140
Maintenance, Depreciation	5,000	7,500
Carbon Replacement	10,000	30,000
Effluent Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$22,380</b>	<b>\$53,640</b>

Thermal destruction of the contaminants in off gas is also feasible using mobile incineration units. A catalytic operation, which costs less than thermal destruction, may be considered using lower temperatures. Thermal destruction has been successfully used in the Albuquerque area at petroleum hydrocarbon remediation sites.

C. Granular Activated Carbon (GAC) Treatment

This process consists of passing the water through packed beds of granular activated carbon. Contaminants are absorbed in the internal pores of the carbon granules. The activated carbon is an effective method for removing volatile organic constituents (VOC) and it is not sensitive to flow rate changes, concentration changes, or toxic materials. It is sensitive to suspended solids and oil and grease concentrations. This method is also considered a best demonstrated available technology (BDAT) for treatment of VOC and is widely used in the treatment of hazardous waste streams.

The primary limitation of GAC treatment is the high cost of carbon disposal and/or regeneration. Because of the relatively low concentrations of VOC in extracted groundwater produced at the site, carbon exhaustion is estimated at 250 to 750 pounds of carbon per day. This rate of exhaustion can be economically handled by either off-site



disposal or off-site regeneration. On-site regeneration is not cost effective until carbon exhaustion exceeds 1500 to 2000 pounds of carbon per day. Estimated costs for GAC treatment of the produced groundwater are given in Figure 33.

#### d. Advanced Oxidation

This technology involves the complete destruction of organic compounds such as TCE and TCA by using ozone and the generation of hydroxyl radicals (OH). By combining hydrogen peroxide ( $H_2O_2$ ) and  $O_3$  to the ozone stream, decomposition of  $O_3$  occurs, which in turn helps the formation of OH radicals. The process involves the exchange of electrons. Advanced oxidation essentially destroys the organic compound by oxidation and the compounds become mineralized. The advanced oxidation process can be accelerated by combining ultraviolet (UV) light with  $H_2O_2$  and  $O_3$ . The absorption of UV energy results in a molecule's cleavage, which increases the ease of subsequent oxidation of the molecule. Varying doses of  $H_2O_2$  and  $O_3$  with UV in the reaction process controls the effectiveness of the treatment. The dosage ratios of  $H_2O_2$  and  $O_3$  is dependant upon the contaminant concentrations. In addition, contact time of the waste stream in the reactor is critical to assure complete mineralization of the compound.

Advanced oxidation has been demonstrated to be an effective treatment process for groundwater contaminated with VOC such as TCE and TCA. The process has been found to be more effective in low alkalinity waters that are softened before treatment and by applying UV light to the waste stream.

**FIGURE 33**

<b>GAC TREATMENT COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Parallel Treatment Unit	\$125,000	\$250,000
Carbon	25,000	50,000
Shelter Unit	10,000	15,000
Miscellaneous Plumbing	5,000	5,000
Contingency (25%)	41,000	80,000
<b>Total Capital Cost</b>	<b>\$206,000</b>	<b>\$400,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Electricity/Water	\$3,000	\$6,000
Maintenance, Depreciation	20,600	40,000
Carbon Replacement	100,000	200,000
Effluent Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$126,600</b>	<b>\$303,000</b>

Costs for advanced oxidation vary depending on factors such as contaminant concentrations, treatment volume, dosage ratios, treatment levels, contact or residence time in the reactor, and energy consumption. Estimated costs for advanced oxidation are presented in Figure 34. The costs include generating ozone on-site.

#### g. Aerobic Bioreactors

This technology also destroys volatile organics instead of mass transfer to other mediums. This process uses aerobic biodegradation to convert VOC into non-toxic constituents. Pilot scale studies have achieved effective removal of TCE in groundwater. Similar technology has also been used on industrial wastewater streams.

At this site, fixed-film bioreactors would be appropriate. The bioreactor vessel would be covered to prevent any VOC emission to the atmosphere. Bioreaction units would be vented through a GAC polishing unit similar to that used for treatment of air stripper emissions.

Although the low concentration of VOC in the extracted groundwater would result in a minimal biosolids production rate, a sedimentation tank would be included to capture biosolids during sloughing events. Costs for aerobic bioreaction treatment are given on Figure 35. Note that costs for disposal of biosolids has not been included.

**FIGURE 34**

<b>ADVANCED OXIDATION TREATMENT COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Treatment Unit	\$800,000	\$2,000,000
Miscellaneous Plumbing and Electric	5,000	5,000
Shelter Unit	10,000	15,000
Installation/Start-up	16,000	20,000
Contingency	207,750	510,000
<b>Total Capital Cost</b>	<b>\$1,038,750</b>	<b>\$2,550,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Electricity (4380 hr)	\$350,000	\$900,000
Maintenance, Depreciation	103,875	255,000
Hydrogen Peroxide	21,000	63,000
Effluent Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$477,875</b>	<b>\$1,221,000</b>

**FIGURE 35**

<b>AEROBIC BIOREACTOR TREATMENT COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Fixed-Film Treatment Units	\$335,000	\$890,000
Covers	24,000	72,000
Sedimentation	45,000	275,000
Sitework, Piping, Building	191,000	583,000
Nutrient Feed Systems	12,000	15,000
Air Polishing System	50,000	75,000
Contingency (25%)	164,250	477,500
<b>Total Capital Cost</b>	<b>\$821,250</b>	<b>\$2,387,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200-gpm Capacity</b>	<b>600-gpm Capacity</b>
Electricity (4380 hr)	\$7,400	\$22,200
Maintenance, Depreciation	82,125	238,750
Effluent Monitoring	3,000	3,000
<b>Annual O &amp; M</b>	<b>\$92,525</b>	<b>\$263,950</b>

f. Ion Exchange

This technology is a chemical treatment process where water is passed through a media (resin) which removes certain ionic constituents and replaces them with other ions. For removal of metals like chromium a cation exchange process is used.

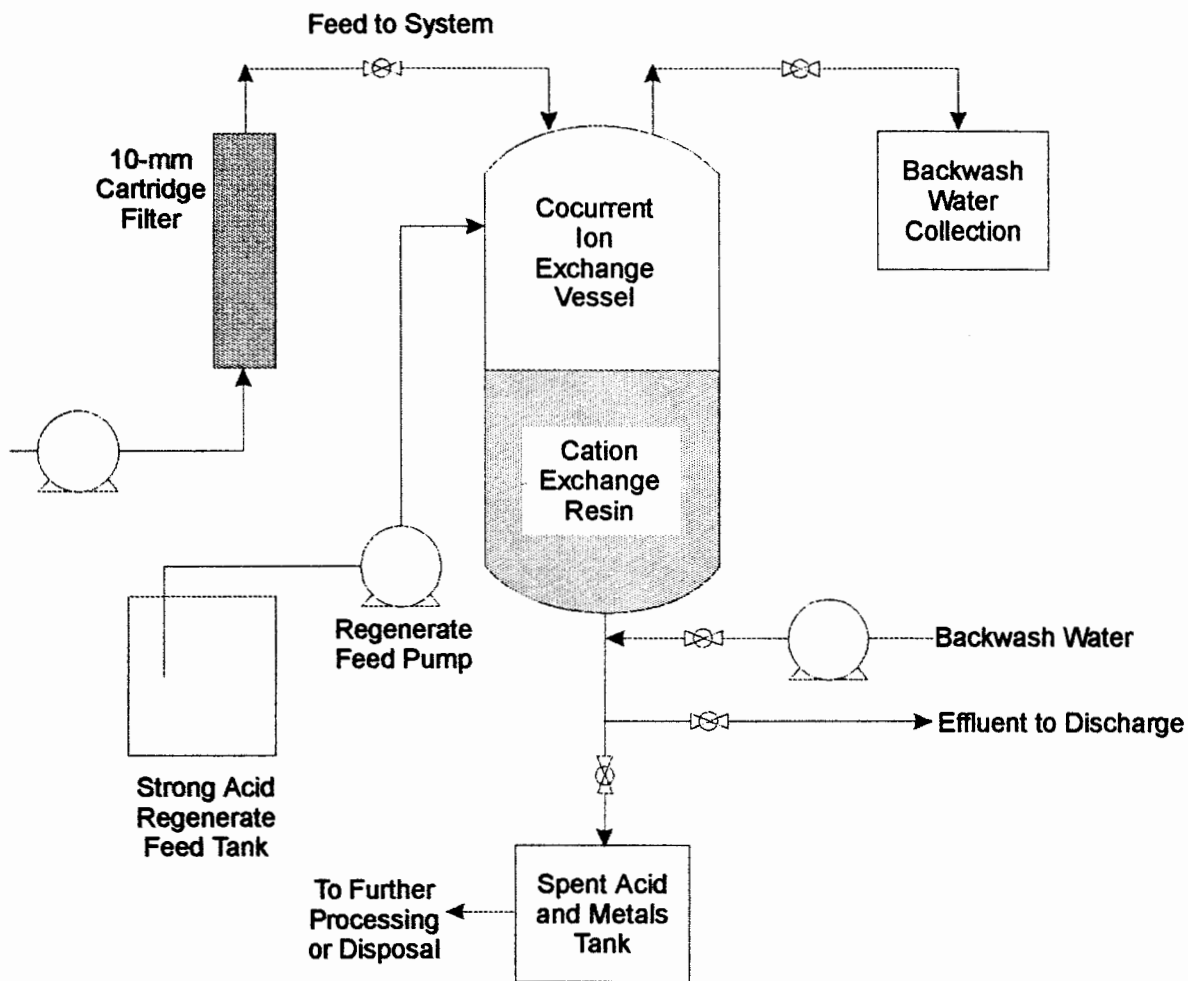
Ion exchange systems consist of pressure vessels containing beds of resin. The most common mode of operation is continuous down flow using a fixed bed. For redundancy purposes and to allow continuous operations, a parallel operation of separate ion exchange systems is typically used.

At the start of the process, the resin media is saturated with  $H^+$  ions from an acid solution. As the process water flows over the media,  $H^+$  ions are released in exchange for those ions for which the media becomes depleted or fouled, it must be backwashed, regenerated, and rinsed. Rinsate, backwash fluids, spent acids, and metal containing sludge are collected for disposal and the treated process water is either further processed or disposed. A typical process diagram is given in Figure 36. (U.S. EPA, 1995).

As detailed in Section III.B.4.e., the average chromium concentration (total) for all wells sampled in January 1996 was 0.026 mg/L which is below the New Mexico MAC of 0.05 mg/L for dissolved chromium. The average January 1996 chromium detection value was 0.093 mg/L which is still below the SDWA MCL of 0.1 mg/L. Maximum historical total chromium detection has been in the low single-digit mg/L range.

Figure 36

# ION EXCHANGE PROCESS DIAGRAM



Reference: USEPA Manual  
Ground-water and Leachate Treatment Systems  
Document: EPA/625/R-94/005

For conditions at this site, capacity will range from 200 gpm to 600 gpm. For worst-case design purposes and assuming treatment is needed, a chromium concentration up to 3 mg/l, pH ranging from 7-7.8, and TDS in the range of 1,000 to 2,000 ppm was used. Since pH is greater than 7, either a strong acid cation resin or weak acid cation resin can be used. The strong acid resin can be used at a higher ratio and therefore can be smaller and cheaper to construct; however, the regeneration of the strong acid resin is inefficient and operating costs are higher. For either system, the 600 gpm capacity will require six to seven foot diameter vessels with a bed depth of approximately 2.5 feet. It is anticipated that ion exchange would be used as part of a treatment train to remove both chromium and VOC.

Costs for ion exchange treatment are given in Figure 37. Note that residual disposal will be a significant cost based on the assumed influent TDS.

g. Chemical Precipitation

Chemical precipitation is a technology of removing metal contaminants from contaminated ground water. In general, metals can be precipitated to insoluble metal hydroxides, sulfides, carbonates, or the salts. The chemical precipitation process involves several principle mechanisms, including formation of the metal precipitate species, and coprecipitation or adsorption. The major process variables that influence precipitation reactions are treatment pH, type of treatment chemical(s) and dosage, types of ligands present, wastewater volume and temperature, the number of treatment stages, and the chemical speciation(s) of the pollutant(s) to be precipitated.



**FIGURE 37**

<b>ION EXCHANGE TREATMENT COST</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200 gpm Capacity</b>	<b>600 gpm Capacity</b>
<b>Ion Exchange Unit</b>	<b>\$ 180,000</b>	<b>\$450,000</b>
<b>Miscellaneous Plumbing &amp; Electric</b>	<b>10,000</b>	<b>10,000</b>
<b>Shelter Unit</b>	<b>10,000</b>	<b>10,000</b>
<b>Contingency (25%)</b>	<b>50,000</b>	<b>117,500</b>
<b>Total Capital Cost</b>	<b>\$250,000</b>	<b>\$587,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200 gpm Capacity</b>	<b>600 gpm Capacity</b>
<b>Actual Operations &amp; Maintenance</b>	<b>\$230,000</b>	<b>\$ 650,000</b>
<b>Depreciation</b>	<b>25,000</b>	<b>60,000</b>
<b>Residual disposal (Hazardous sludge)</b>	<b>675,000</b>	<b>2,000,000</b>
<b>Annual O&amp;M</b>	<b>\$930,000</b>	<b>\$2,710,000</b>

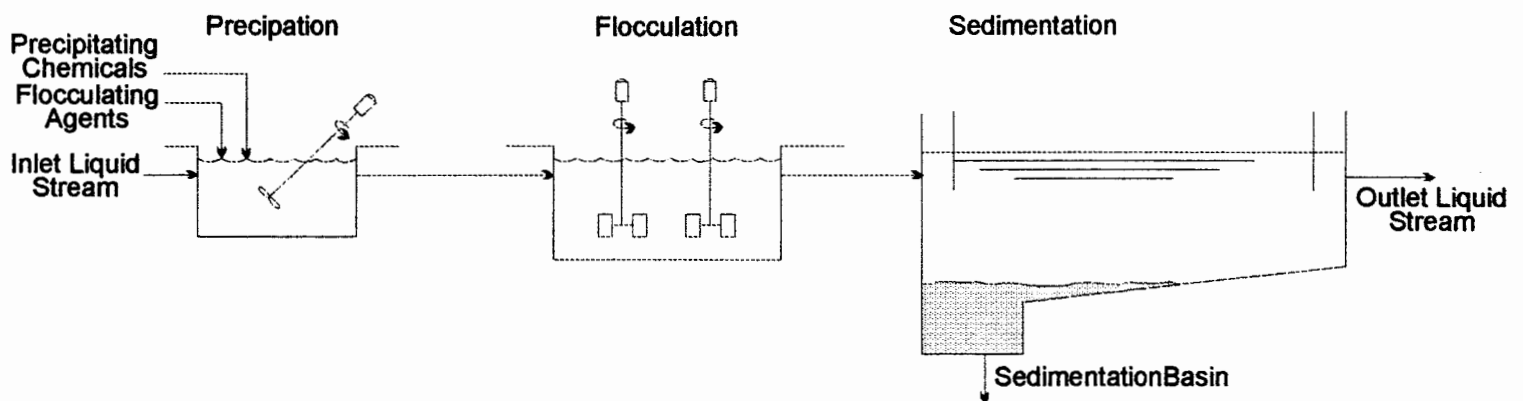
Classically, precipitation for heavy metals treatment is perceived to result through pH adjustment and consequent precipitation of the metal hydroxide. "Precipitation," however, is now recognized to encompass a much broader range of phenomena, including formation of mixed or transient salts and adsorptive coprecipitation. The latter results from adsorption of one metal species onto the highly reactive surface of a solid phase, typically formed in situ. Coprecipitation may be induced, for example, by the addition of an iron or alum coagulant, or incidental due to the precipitation of a secondary species already present within the wastewater. The consequence of this broader range of chemical behavior is that residual metal solubility levels far below the theoretical solubility limits of simple metals salts are commonly achieved.

Treatability studies are often needed to optimize treatment variables, such that effluent limits are achieved cost effectively. Volumes and handling characteristics of precipitation treatment sludges frequently override other economic factors in selection or optimization of precipitation treatment variables.

The physical/chemical system includes the following unit processes: equalization, coarse filtration, chemical oxidation, coprecipitation with lime and ferric chloride, clarification (flocculation and sedimentation), polishing filtration for clarifier supernatant, and sludge dewatering. A typical process flow diagram is given on Figure 38.

**FIGURE 38**

**PROCESS DIAGRAM FOR CHEMICAL PRECIPITATION**



Reference: USEPA Manual  
Ground-water and Leachate Treatment Systems  
Document: EPA/625/R-94/005

Chemical precipitation is often used as part of a treatment train. The effectiveness of chemical precipitation treatment is limited. At low influent heavy metals concentration, ion exchange may be a more cost-effective treatment technique. As detailed in Section III.B.4.e., the average chromium concentration (total) for all wells sampled in January 1996 was 0.026 mg/L which is below the New Mexico MAC of 0.05 mg/L for dissolved chromium. The average January 1996 total chromium detection value was 0.093 mg/L which is still below the SDWA MCL of 0.1 mg/L. Maximum historical total chromium detection has been in the low single-digit mg/L range. For conditions at this site, capacity will range from 200 to 600 gpm. For worst-case design purposes and assuming treatment is needed, a chromium concentration up to 3 mg/L, pH ranging from 7 to 7.8, and TDS in the range of 1,000 to 2,000 ppm was used. Costs for chemical precipitation are given in Figure 39.

##### 5. Vapor Extraction System

Vapor extraction systems (VES), also known as vapor recovery systems (VRS), soil vapor extraction (SVE) systems or forced air venting, remove existing soil gas by placing a partial vacuum on the unsaturated or vadose zone. The partial vacuum is obtained through a series of vapor extraction wells connected to a suction fan. Soil, gas and vapor-phase VOC are removed from the subsurface. The resulting decrease in VOC concentration in the soil gas often results in the desorption or off-gassing from VOC adsorbed into fine-grained soils or dissolved in shallow groundwater. This off-gassing results from phase-equilibrium requirements.

**FIGURE 39**

<b>CHEMICAL PRECIPITATION TREATMENT COST</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>200 gpm Capacity</b>	<b>600 gpm Capacity</b>
Chemical Precipitation Unit	\$ 280,000	\$500,000
Miscellaneous Plumbing & Electric	10,000	10,000
Shelter Unit	20,000	20,000
Contingency (25%)		
<b>Total Capital Cost</b>	<b>\$310,000</b>	<b>\$530,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>200 gpm Capacity</b>	<b>600 gpm Capacity</b>
Actual Operations & Maintenance	\$ 60,000	\$ 100,000
Depreciation	31,000	53,000
Residual disposal (Hazardous sludge)	675,000	2,000,000
<b>Annual O&amp;M</b>	<b>\$766,000</b>	<b>\$2,153,000</b>

For highly porous subsurface conditions with high VOC concentrations observed in the uppermost portion of an aquifer, operation of vapor recovery systems installed immediately above the water table can significantly impact the groundwater dissolved-phase VOC concentrations. Removal of soil gas from above the water table reduces the vapor phase VOC concentrations resulting in off-gassing (dissolution) from the groundwater in accordance with Henry's Law. To be most effective, vapor recovery systems should be operated in a pulsed mode similar to groundwater extraction systems. Vapor extraction is also useful in removing adsorbed phase VOC from soil materials dewatered during groundwater extraction.

Soil gas surveys and groundwater sample analyses indicate highest soil gas (and groundwater) VOC concentrations occur under the facility. In April 1996, soil gas immediately above the saturated zone was sampled from on-site and off-site UFZ wells. Results are discussed in the Section III B.1 c. Deep Soil Gas and included in Appendix 2. This deep soil gas information indicates that elevated soil gas concentrations are found only in the immediate, original source area, significant off-gassing from the groundwater is not occurring since soil gas concentrations are generally below equilibrium conditions, and subsurface gas transmissivity is not as high as expected. In fact, significant negative pressures were required to produce gas flow rates in the order of one standard cubic foot per minute (scfm). Based on the characterization discussed in the RFI, an average radius of influence of approximately 150 feet is also anticipated.

Depending on the overlap between vapor extraction wells, and well-specific radius of influence, between ten and twenty wells will be required to cover the area showing elevated soil gas concentration in the most recent (1991) soil-gas survey. Recent deep soil gas investigation indicates that the area and number of wells will be much less. Combined extraction rate would thus range from 50 standard cubic feet per minute (scfm) to 200 scfm (or 5 to 10 scfm per well). Extracted vapor would be routed to a central vacuum unit. The effluent from the vacuum unit would then be treated using GAC air polishing or thermal destruction as required by applicable regulations to remove VOC. Estimated costs for VES installation and operation are given in Figure 40.

The benefits of using vacuum extraction include:

- Implementation can be conducted in situ and requires relatively little disturbance to existing facilities or operations.
- The process reduces contaminant concentration and mobility at the treated area.
- Implementation can be flexible, allowing for adaptation to changing site conditions or as additional analytical and subsurface data is developed.
- In situ installation and operation requires little handling of contaminated materials, limiting the risk of exposure to workers and the public.
- Vacuum extraction has few secondary impacts.

**FIGURE 40**

<b>VAPOR EXTRACTION SYSTEM COSTS</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>Ten-Well System</b>	<b>Twenty Well System</b>
Well Installation	\$17,500	\$ 35,000
Buried Piping	13,000	25,000
Blower Unit	10,000	20,000
Miscellaneous Electric and Plumbing	5,000	5,000
Controls	5,000	5,000
GAC Air Treatment Unit	7,500	15,000
Shelter Unit	10,000	15,000
Contingency (25%)	17,000	30,000
<b>Total Capital Cost</b>	<b>\$85,000</b>	<b>\$150,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>Ten Well System</b>	<b>Twenty Well System</b>
Electricity (4380 hr)	\$2,465	\$4,928
Maintenance, Depreciation	8,500	15,000
Carbon Replacement	2,500	5,000
Effluent Monitoring	3,000	3,000
<b>Annual O&amp;M</b>	<b>\$16,465</b>	<b>\$27,928</b>



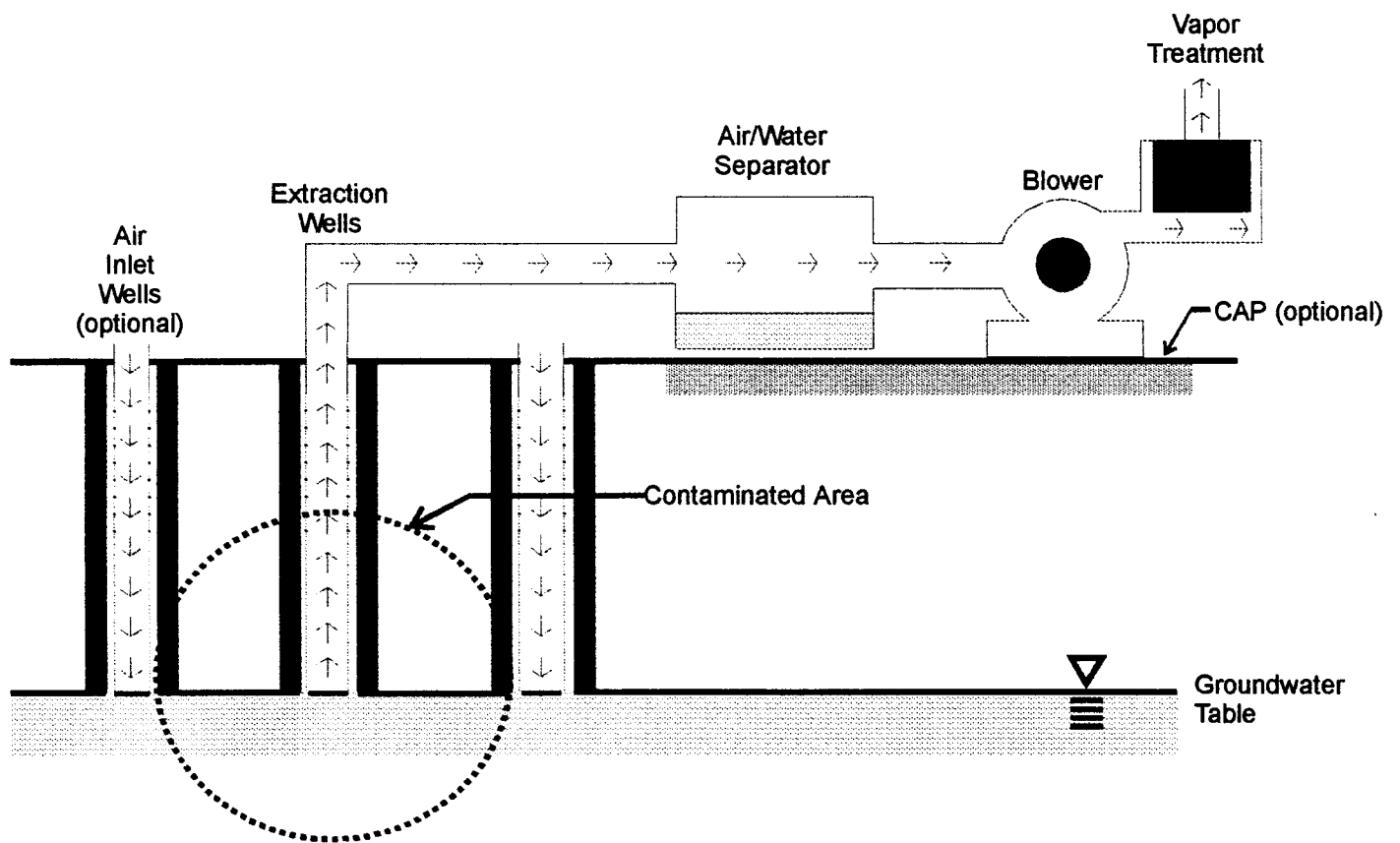
Vacuum extraction is only applicable to VOC. Vacuum extraction will be costly and may require prohibitive operation times to achieve cleanup at sites where soil is heterogeneous with significant clay/silt content and has very low air permeability. In addition, off-gas treatment may produce RCRA-regulated wastes, which may require special handling and disposal practices.

A process diagram for a VES is shown on Figure 41. Individual extraction wells would be manifolded to a common location containing the negative pressure blower and VOC treatment system. Since only on-site installation is anticipated, all piping would be routed within Spartan property. It is estimated that approximately one year will be required to place a VES into full operation. Approximately one to three years of pulsed extraction will be required to improve groundwater quality. VES equipment has a useful life of approximately ten years.

VES can be combined with groundwater extraction. This is useful in removing sorbed phase contaminants from dewatered soils located within the cone of depression of the groundwater extraction well. VES may also be useful in applications with pulse-pumped groundwater extraction systems where the periodic dewatering and/or change in flow direction "flushes" out sorbed constituents. Further, VES may also assist in offgassing and recovering dissolved-phase constituents collected or concentrated by groundwater extraction.

**Figure 4f**

**Process Diagram for VES System**



Reference: USEPA, September 1989  
Document EPA-450/4-89-017

Based on the subsurface characterization detailed in the RFI Report, the observed decrease in surface soil gas concentration and the recent deep soil gas sampling, VES may have limited potential at this site for the following reasons:

- The subsurface is a layered, heterogeneous and anisotropic sequence of gravelly sands, silts, and clays.
- The subsurface is not as gas transmissive as previously thought.
- With the exception of the source area, soil gas results indicate little remaining VOC.
- Significant off-gassing from the groundwater is apparently not occurring.

As discussed in Section VII.C.2., lining of the Corrales Main Canal has no technical basis and, in fact, would defeat the synergy of a VES with a fluctuating water level as described above.

#### 6. In Situ Air Stripping (Air Sparging)

An innovative technology for treatment of volatile organic compounds in groundwater is in situ air stripping or sparging. This technology is an enhanced version of vapor recovery and utilizes air injection wells installed in the aquifer in addition to the vapor extraction system (VES). Dissolved-phase VOC are stripped from the groundwater by the mechanics of the rising air bubbles around the air injection wells. The vapor-phase VOC are then removed by the VES. Typical operation utilizes standard VES operation until a tailing phenomenon is observed in soil-gas VOC concentrations. Air injection is then

begun to increase efficiency of removal. Air injection quantities are on the order of ten percent (10%) of the VES recovery rate. Injection wells should be located in the vicinity of the vapor recovery wells to obtain maximum removal efficiency and to avoid spreading of the soil-gas plume. A typical process diagram is given on Figure 42. Air sparging would be applied in the same area where VES had been implemented. In this case, air sparging would be considered for the on-site areas of the Spartan facility.

Air sparging also increases the dissolved oxygen content which greatly enhances natural biodegradation. Injection of air also causes a "mounding" of the groundwater near the injection well; however, this mound is the result of reduced water density from entrained air bubbles and does not represent a dispersing factor. It should be noted that air sparging wells are often subject to biofouling and periodic treatment with hydrogen peroxide may be required to maintain performance.

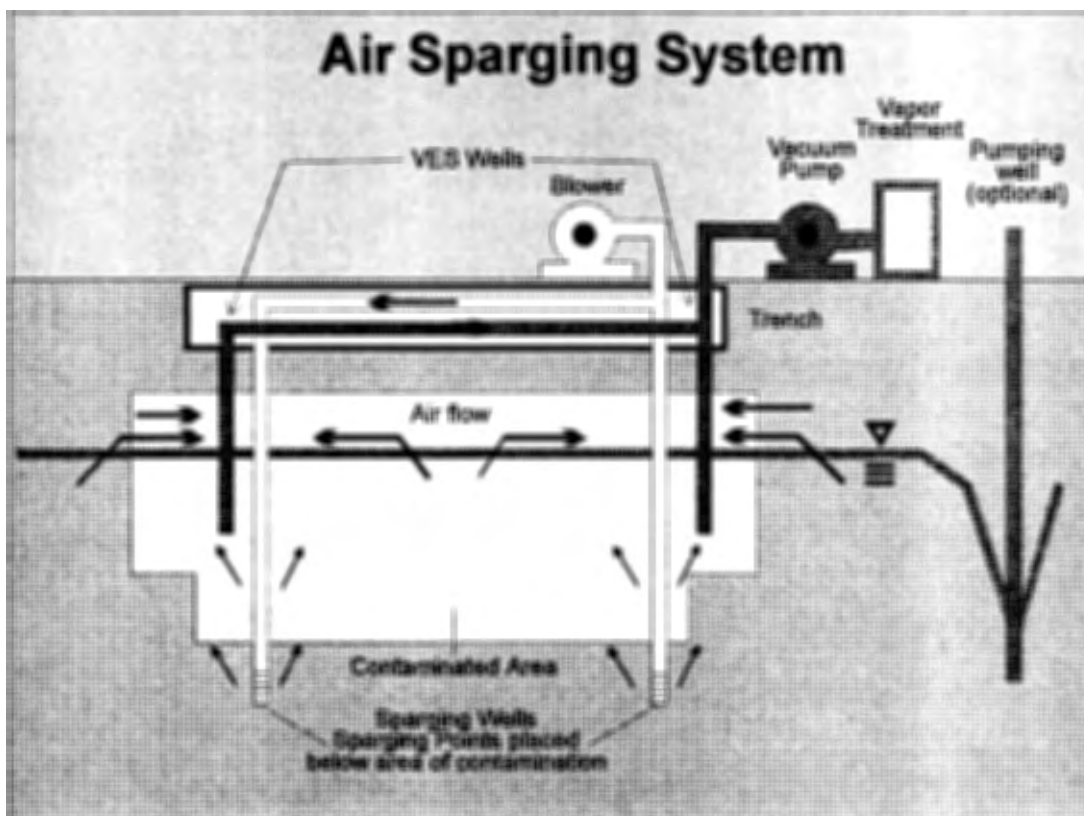
Recent studies have indicated that air sparging enhancement may increase VES performance to a significant degree. Estimated costs for air sparging enhancement are given in Figure 43.

## 7. In Situ Bioremediation

Bioremediation occurs when microorganisms degrade contaminant compounds. Bioremediation occurring in the subsurface is called natural attenuation (intrinsic bioremediation) if no system is used to enhance the natural biologic activity. It is termed enhanced or in situ bioremediation if an engineered system is used to increase biological

**Figure 42**

**Process Diagram for Air Sparging**



**FIGURE 43**

<b>AIR SPARGING COSTS*</b>		
<b>CAPITAL COSTS</b>		
<b>Item</b>	<b>Forty Well System**</b>	<b>Eighty Well System</b>
Well Installation	\$100,000	\$200,000
Buried Piping	36,000	72,000
Blower Unit	5,000	10,000
Miscellaneous Electric and Plumbing, Controls	10,000	20,000
Contingency (25%)	37,750	75,500
<b>Total Capital Cost</b>	<b>\$188,750</b>	<b>\$377,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>		
<b>Item</b>	<b>Forty Well System</b>	<b>Eighty Well System</b>
Electricity (4380 hr)	\$500	\$1,000
Maintenance, Depreciation	18,875	37,750
Bifouling Treatment	40,000	80,000
<b>Annual O&amp;M</b>	<b>\$59,375</b>	<b>\$118,750</b>

\*In addition to VES Capital and O&M Costs

\*\*Approximately four times as many injection wells are needed as vapor extraction wells

activity in the subsurface. Bioremediation of chlorinated solvents has been successfully demonstrated in a variety of laboratory and field experiments and a number of full scale projects are currently being performed. Biodegradation of TCE has been more thoroughly studied than any other chlorinated solvent. Both TCE and TCA can be degraded under a variety of conditions. Biodegradation by methanotropic bacteria is typical of aerobic biomineralization of chlorinated solvents. TCE degradation by methanogenic bacteria is one of the best understood anaerobic processes. Many other microorganisms and processes can degrade these compounds.

There is site-specific information that indicates that natural attenuation is an active process at the Spartan facility. This information would include:

- 1) decrease in groundwater TCE and TCA concentrations observed in most wells.
- 2) the presence of 1, 1-DCE, a typical degradation byproduct.
- 3) the significant decrease in surface soil gas concentrations.

Further, studies of Albuquerque Basin aquifer material by the University of New Mexico, showed that indigenous organisms degraded TCA both aerobically and anaerobically (NMWRRI, 1992). The study also believed that the substantial number of biodegrading organisms was the result of "pre-exposure" from industrial practice in the Albuquerque Basin.

Before implementation of an in situ bioremediation system, the concentration of VOC in the groundwater should be reduced as much as possible using other technologies.

Bioremediation can be utilized as the final part of a treatment train or used as a separate, later technology application.

The benefits of in situ bioremediation include:

- Excavation of contaminated materials is not required.
- It may result in complete degradation of organic contaminants to non-toxic byproducts (carbon dioxide, methane, water, etc.).
- There are minimal mechanical equipment requirements.

The limitations of in situ bioremediation include:

- There is a potential for partial degradation to equally toxic, more highly mobile byproducts - particularly under anaerobic conditions.
- It may be difficult to contain volatile organic compounds emitted during remediation.
- The process is highly sensitive to toxins and environmental conditions.

The advantage of this method is that contaminated materials can remain in place, even outside the Sparton site. The limitations are the ability to achieve adequate contact between microbes and the VOC and the degree of degradation that can be obtained.

Aerobic biodegradation would be the preferred technology due to the complete degradation of the target VOC to non-toxic products. Aerobic bioremediation of groundwater (using either indigenous or introduced microorganisms) will require injection wells to introduce oxygen (usually air) and nutrients. Permitting of these injection wells may be difficult under New Mexico groundwater regulations. In addition, a vapor extraction



system (VES) may be needed to remove carbon dioxide produced by the aerobic degradation.

Additional study would be needed for successful implementation of in situ bioremediation. This study would include laboratory assays on soil and groundwater samples to determine available organisms and preferred environment, testing for chemical and biological parameters, and pilot-scale field tests to verify and optimize system design. The subsurface stratigraphy is highly heterogeneous and anisotropic and plume movement is relatively slow. As a result, it is anticipated that an excessively large number of injection wells would be needed to provide needed nutrients and other amendments over the entire area of the plume. Wells conceivably could require 50 to 100 foot spacing; however, the off-site restrictions on access would probably prevent use of closely-spaced injection wells. Further, state regulations may restrict the injection of nutrients and other amendments into the aquifer.

Assuming that in situ bioremediation is permissible and that a system will be implemented on site, estimated costs have been calculated in Figure 44.

Implementation of in situ bioremediation may require up to one year to install equipment and obtain the necessary permits. Because of the somewhat experimental nature of the alternative, it is believed that up to three years of operation may be required to produce beneficial results.

**FIGURE 44**

<b>IN SITU BIOREMEDIATION COSTS</b>	
<b>CAPITAL COSTS</b>	
<b>Item</b>	<b>Cost</b>
Chemical and biologic testing	\$100,000
Nutrient injection wells (50 wells at 100' c-c)	\$500,000
Nutrient injection equipment	\$100,000
Contingency (25%)	\$175,000
<b>Total Capital Cost</b>	<b>\$875,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>	
<b>Item</b>	<b>Cost</b>
Nutrients, amendments	\$ 75,000
Biofouling treatment	\$ 50,000
Maintenance, depreciation	\$ 87,500
<b>Annual O&amp;M</b>	<b>\$212,500</b>

D. Removal of the Soil-Sorbed Phase (Unsaturated Zone)

Potential technologies for removing the soil-sorbed phase of contamination includes no further action, soil flushing, in situ bioremediation, and vapor extraction systems.

1. No Further Action

Under what EPA labels and requires as part of an evaluation of alternatives -- No Further Action (NFA) -- no additional treatment technology for soil would be implemented at this site. This alternative has been retained because characterization in the RFI identified only scattered random detections of VOC and heavy metals in soils under the sump/pond area. The entire sump/pond area had been capped, thus minimum potential existed for further migration of any soil contamination down to groundwater. Continuing surface soil gas surveys indicated a significant decrease in VOC since closure and remediation of the source area. Subsequent groundwater sampling and analysis through January 1996 (Appendix 1) shows a steady decrease in VOC concentration in all on-site wells. Further deep soil gas analyses conducted in April 1996 (Appendix 2) indicated elevated levels of TCE and TCA only in the source area. Concentrations over the remainder of the plume area were in the low single-digit ppmv range to no detect. The absence of significant deep soil gas concentrations, and the steadily decreasing on-site groundwater concentrations, indicates that migration to the groundwater has essentially ceased and further soil remediation does not appear necessary.

## 2. Soil Flushing

Soil flushing is used for removal of a number of organic and inorganic materials from vadose zone soils. A variation of soil flushing, referred to as chemical extraction, may be used to remove non-water soluble organics from the saturated zone.

Soil flushing involves the addition of a solvent or surfactant to contaminated soil to enhance contaminant mobility. The contaminants are then recovered in the ground water by strategically placed extraction wells and pumped to the surface for treatment. Soil flushing is most applicable when soils must be remediated but other technologies such as vacuum extraction, bioremediation, or physical removal (i.e. excavation) are not feasible. The addition of chemicals to the flushing solution that will increase contaminant mobility are necessary if strongly adsorbed, hydrophobic contaminants are present in the soil. The extraction of strong adsorbed contaminants may not be desirable for a corrective action unless there is an imminent threat to human health and the environment. The more permeable the soil and the more water that can be flushed through the soil, the more practicable is this technology. Soil flushing strategies can be incorporated into pump and treat or containment systems to accelerate the contaminant removal processes. Soil flushing can be accomplished using sprinkling systems or, more aggressively, by flooding the contaminated area. Chemical extraction involves extracting ground water, amending it with solvents and/or other chemicals, and reinjecting it at strategic locations into the aquifer. With any soil flushing system, proper controls must be incorporated to prevent migration of extractant-contaminant mixtures.

The flushing solution to be used at a site depends on the type of contamination present. Flushing solutions may include water, acidic aqueous solutions (i.e., sulfuric, hydrochloric, nitric, phosphoric, and carbonic acids), basic solutions (i.e., sodium hydroxide), surfactants (i.e., alkylbenzene sulfonate), chelating agents, oxidizing agents, or reducing agents. Water can be used to extract water-soluble or water-mobile constituents. Acidic solutions are used for metals and certain organic constituents (including amines, ethers, and anilines) that are soluble in an acidic environment.

The level of treatment that can be achieved will vary depending on the contact of the flushing solution with waste constituents, the appropriateness of the solutions for the wastes, the soil adsorption coefficients of the waste, waste partitioning coefficients, and the unsaturated hydraulic conductivity of the soil. This technology should produce the best treatment results in highly permeable soils with low organic content.

Soil flushing may be used as a pretreatment for, or in combination with, bioremediation. As a pretreatment step, soil flushing may be used to remove inhibitory compounds or reduce contaminant levels, making the soil media more amenable to biological activity. In combination with bioremediation, the flushing solution can be amended with nutrients to enhance biological activity.

The benefits of using soil flushing include:

- Removal of contaminants is permanent.
- Removal of soils is not necessary.
- The technology is easily applied to permeable soils.

The limitations of soil flushing technologies include:

- The State of New Mexico may not permit soil flushing under its no degradation policy.
- The technology introduces potential toxins (the flushing solution) into the soil system. Therefore, containment may be needed.
- Physical/chemical properties of the soil system may be altered because of the introduction of the flushing solution.
- A potential exists for solvents to transport contaminants away from the site into uncontaminated areas. Therefore, containment may be needed.
- A potential exists for incomplete removal of contaminants due to heterogeneity of soil permeability.
- Contaminants are not destroyed. On-site treatment is required to remove contaminants from extracted flushing solvents.
- Flushing agents usually cannot be recycled.
- It may take a long period of time for remediation below cleanup standards to be achieved.

Assuming that the State of New Mexico would even permit a soil flushing alternative, soil flushing would face severe difficulties. Obtaining a uniform distribution of flushing agents (surfactant, alcohol) would be difficult because of the layered heterogeneous, anisotropic subsurface stratigraphy. However, assuming that either the IM

is continued or large-scale groundwater extraction is implemented, and assuming soil flushing is utilized, soil flushing costs for on-site soil treatment are given in Figure 45. Implementation time for this alternative will be approximately one year assuming that permits can be obtained. Beneficial results will require multiple treatments over several years.

This alternative has been retained because characterization in the RFI identified only scattered, random detections of VOC and heavy metals in soils under the sump/pond area. The entire sump/pond area had been capped, thus minimum potential existed for further migration of any soil contamination down to groundwater. Continuing surface soil gas surveys indicated a significant decrease in VOC since closure and remediation of the source area. Subsequent groundwater sampling and analysis through January 1996 (Appendix 1) shows a steady decrease in VOC concentration in all on-site wells. Further deep soil gas analyses conducted in April 1996 (Appendix 2) indicated elevated levels of TCE and TCA only in the source area. Concentrations over the remainder of the plume area were in the low single-digit ppmv range to no detect. The absence of significant deep soil gas concentrations, and the steadily decreasing on-site groundwater concentrations, indicates that migration to the groundwater has essentially ceased and further soil remediation does not appear necessary.

**FIGURE 45**

<b>SOIL FLUSHING COSTS*</b>	
<b>CAPITAL COSTS</b>	
<b>Item</b>	<b>Cost</b>
Injection wells (50 wells at 100' c-c)	\$500,000
Flushing agent injection equipment	\$100,000
Contingency (25%)	\$150,000
<b>Total Capital Cost</b>	<b>\$750,000</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>	
<b>Item</b>	<b>Cost</b>
Flushing agents	\$ 75,000
Maintenance Depreciation	\$ 75,000
Chemical testing	\$ 10,000
<b>Annual O&amp;M</b>	<b>\$160,000</b>

\* Note: Requires groundwater (and flushant) extraction from Upper Flow Zone through continuation of the Interim Measures or large-scale groundwater extraction



### 3. In Situ Bioremediation

In situ bioremediation is the process of using bacteria to biodegrade organic compounds in soils. Under favorable conditions, microorganisms may be capable of completely degrading many organic compounds into carbon dioxide, methane, water and/or organic acids. Both aerobic and anaerobic processes can be used to degrade TCE and TCA and other volatile chlorinated organics. A detailed discussion of in situ bioremediation is given in Section VII.C.7.

In situ bioremediation of soils generally involves the stimulation of naturally occurring, or indigenous, microorganisms to degrade organic contaminants. Transplanted and/or genetically engineered microorganisms can be utilized as well. Aerobic processes will dominate in the shallow, unsaturated zone where oxygen is available and in deeper zones if oxygen can be successfully introduced. Microorganisms are stimulated by the addition of nutrients such as ammonia, methane, nitrate, and/or orthophosphate.

Very often bioremediation is used as part of a treatment train, such as post treatment following soil flushing or vacuum extraction.

The benefits of in situ bioremediation include:

- Excavation of contaminated materials is not required.
- It may result in complete degradation of organic contaminants to non-toxic byproducts (carbon dioxide, methane, water, etc.).
- There are minimal mechanical equipment requirements.

The limitations of in situ bioremediation include:

- There is a slight potential for partial degradation to equally toxic, more highly mobile byproducts--particularly under anaerobic conditions.
- It may be difficult to contain volatile organic compounds emitted during remediation.
- The process is highly sensitive to toxins and environmental conditions.

In situ bioremediation could be appropriate to treat VOC contaminated soils occurring within the general boundaries of the facility. Additional study would be needed for successful implementation of in situ bioremediation. This study would include laboratory assays on soil and groundwater samples to determine available organisms and preferred environment; testing for chemical and biological parameters, and pilot-scale field tests to verify and optimize system design. Assuming that the State of New Mexico will allow the injection of nutrients into the subsurface, the estimated costs for bioremediation of soil on site are given in Figure 46.

The advantage of this method is that contaminated materials can remain in place, even outside the Sparton site. The limitations are the ability to achieve adequate contact between microbes and the sorbed VOC and the degree of degradation that can be obtained.

**FIGURE 46**

<b>IN SITU SOIL BIOREMEDIATION COSTS</b>	
<b>CAPITAL COSTS</b>	
<b>Item</b>	<b>Cost</b>
Chemical and biologic testing	\$100,000
Nutrient injection wells (50 wells at 100' c-c)	\$250,000
Nutrient injection equipment	\$100,000
Contingent (25%)	\$112,500
<b>Total Capital Cost</b>	<b>\$562,500</b>
<b>ANNUAL OPERATION AND MAINTENANCE COSTS</b>	
<b>Item</b>	<b>Cost</b>
Nutrients, amendments	\$ 75,000
Biofouling treatment	\$ 50,000
Maintenance, depreciation	\$ 56,250
<b>Annual O&amp;M</b>	<b>\$181,250</b>

#### 4. Vapor Extraction System

Vapor extraction systems (VES), also known as vapor recovery systems (VRS), soil vapor extraction (SVE) systems and forced air venting, consists of the removal of existing soil gas by placing a partial vacuum on extraction wells installed in the unsaturated zone. Contaminants desorb from the soil and are carried away with the exhausted air. Continued flushing with clean air brought in from outside the contaminated area can result in a significant decrease in the concentration of volatile compounds in soil.

The basic components of a vacuum extraction system are extraction wells and a blower. A process diagram is given in previous Figure 41. In most cases, moisture separation and off-gas treatment will also be required in order to meet air discharge requirements. Recharge wells, an impermeable cover, conditioning of recharge air, flow control and measurement instrumentation, vapor concentration monitoring, and other enhancements are also frequently added in order to improve system performance and flexibility.

The physical basis of the technique rests on the tendency of many volatile organic compounds to diffuse from the soil matrix to the air in pore spaces as result of the concentration difference between the soil and the clean air that is introduced. Once the contaminants have become entrained in the soil gas, they are carried out of the soil through the circulation of fresh air. The effectiveness of vacuum extraction is therefore related to those properties that determine the extent to which contaminants diffuse into the soil atmosphere and the effort required to remove the contaminant-laden air from the soil.

Vacuum extraction is most likely to be successful at sites where highly volatile contaminants are present in homogeneous soils of high permeability and porosity. The benefits of using vacuum extraction include:

- Implementation can be conducted in situ and requires relatively little disturbance to existing facilities or operations.
- Contaminant concentration and mobility is reduced in the treated area.
- Implementation can be flexible, allowing for adaptation to changing site conditions or as additional analytical and subsurface data is developed.
- In situ installation and operation requires little handling of contaminated materials, limiting the risk of exposure to workers and the public.
- Vacuum extraction has few secondary impacts.

Vacuum extraction is only applicable to VOC. Vacuum extraction will be costly and may require prohibitive operation times to achieve cleanup at sites where soil is heterogeneous with significant clay/silt content and has very low air permeability. In addition, off-gas treatment may produce RCRA-regulated wastes, which will require special handling and disposal practices.

- Soils must be permeable and fairly homogeneous for the technique to be efficient; impermeable lenses may adversely affect the results of the process.
- Cleanup to low levels can be difficult and require lengthy remediation time with the potential for greater than anticipated operation and maintenance costs, particularly in heterogeneous soils.

- Verification of complete cleanup effectiveness can be difficult, particularly in heterogeneous soils.

A detailed discussion of VES application to this site has been previously given in Section VII.C.5 with detailed costs given in Figure 40. Based on the subsurface characterization detailed in the RFI Report, the observed decrease in surface soil gas concentration and the recent deep soil gas sampling, VES may have limited potential for the following reasons:

- Subsurface is a heterogeneous, anisotropic layered sequence of gravelly sands, silts, and clays.
- Subsurface is not as gas transmissive as previously thought.
- With the exception of the source area, soil gas results indicate little remaining VOC.

#### E. Removal of Soil Gas Vapor Phase (Unsaturated Zone)

##### 1. No Further Action

Under what EPA labels and requires as part of an evaluation of alternatives -- No Further Action (NFA) -- no additional treatment technology for soil gas would be implemented at this site. This alternative has been retained because characterization in the RFI identified scattered, random detections of VOC in soils under the sump/pond (source area). Soil gas surface surveys conducted in 1984, 1987, and 1991 showed a decreasing trend in VOC concentration with elevated (1 to 10 µg/l or 0.2 to 2.2 ppmv) detections occurring only in the immediate vicinity of the facility (Appendix 2). It should be noted that the highest detected surface soil gas concentrations are 20 times less than

NIOSH permissible exposure limits. In April 1996, deep soil gas was sampled from various on- and off-site UFZ wells. Highest soil gas VOC detections were under the original source area and the adjacent Sparton building (Appendix 2). Remaining detections were in the low single-digit ppmv to no detect. The low VOC detections from soil gas samples immediately above the saturated zone confirm two assumptions:

- Since TCE and TCA vapors are some four times heavier than air, significant migration of TCE and TCE to the groundwater is no longer occurring.
- Observed soil gas concentrations may be the result of offgassing from the aqueous dissolved phase since soil gas concentrations are generally below the equilibrium soil gas concentration corresponding to the groundwater concentration at a given location.

The low soil gas concentrations indicate that remediation of soil gas does not appear necessary.

## 2. Vapor Extraction System

Vapor extraction systems (VES) as previously discussed in Sections VII.C.5. and VII.D.4. are also directly applicable to remediation of soil-gas contamination. VOC existing in the vapor phase in interstitial pore space in the unsaturated zone can be removed by VES. As vapor phase VOC is removed, phase equilibrium mechanisms result in off-gassing from the soil-sorbed phase and the dissolved groundwater phase. Continued operation of the VES results in remediation of all three phases. However, as noted in previous sections, soil gas VOC concentrations are very low.

## VIII JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE

### A. General

(-- Operation of an enhanced Interim Measure (IM) groundwater recovery and treatment system, coupled with the installation of five new monitoring wells and a phased approach to soil vapor extraction, has been selected as the recommended corrective action alternative. This recommendation was based on the following:

- Lack of risk from current conditions considering both current and potential receptors and exposure pathways identified at the site.
- Lack of impact on use of the affected groundwater considering potential use of that resource.
- Inability of available technologies to restore groundwater quality to Maximum Contaminant Levels (MCLs) within any reasonable time period or at a reasonable cost.
- Constituent concentrations in much of the plume area have already dropped below technology application levels.
- Effectiveness of previous corrective actions (i.e., closure and capping of the ponds/sump).
- Effectiveness of the currently operating IM system to prevent migration off-site.
- Cost effectiveness of the IM system relative to other alternatives retained from the Initial Screening.



## B. Description of the Recommended Alternative

Based on the characterization presented in the RFI, and subsequent sampling and analysis to the current time, corrective action in the form of operation of an enhanced IM groundwater recovery and treatment system, coupled with the installation of five new groundwater monitoring wells and a phased approach to soil vapor extraction, is recommended. The installation of five new groundwater monitoring wells is intended to confirm the conclusions in the CMS about plume location and movement, both vertically and horizontally. These wells are described in previous Sections VII.B.1 and VII.C.1. Commentors at the public hearing expressed concerns about whether the plume was moving in the manner identified by Sparton. These new wells should answer these concerns, and provide additional support for the remedy proposed by Sparton.

A phased approach to soil vapor extraction involves the implementation of a testing program, in the source area, to identify soil vapor concentrations between the surface and the groundwater. If, as expected, that testing establishes concentrations in the soil at or below 10 ppmv, no further action will be required. To the extent concentrations above that threshold are identified, an appropriate soil vapor extraction program will be initiated to reduce the concentrations to the target number. Such an approach will complement the operation of an enhanced IM groundwater recovery and treatment system and should insure that contaminants are no longer being introduced off-site.

As part of this recommendation, groundwater monitoring wells at selected locations would be sampled and analyzed on a quarterly basis to confirm plume characteristics. The

results of groundwater monitoring and evaluations of any changes in land use/development would be monitored by requesting notices of proposed subdivision approvals and zoning changes within two miles of the Sparton facility be provided to Sparton. An annual evaluation would be conducted to determine the need, if any, for further corrective measure studies, based on changes in land use.

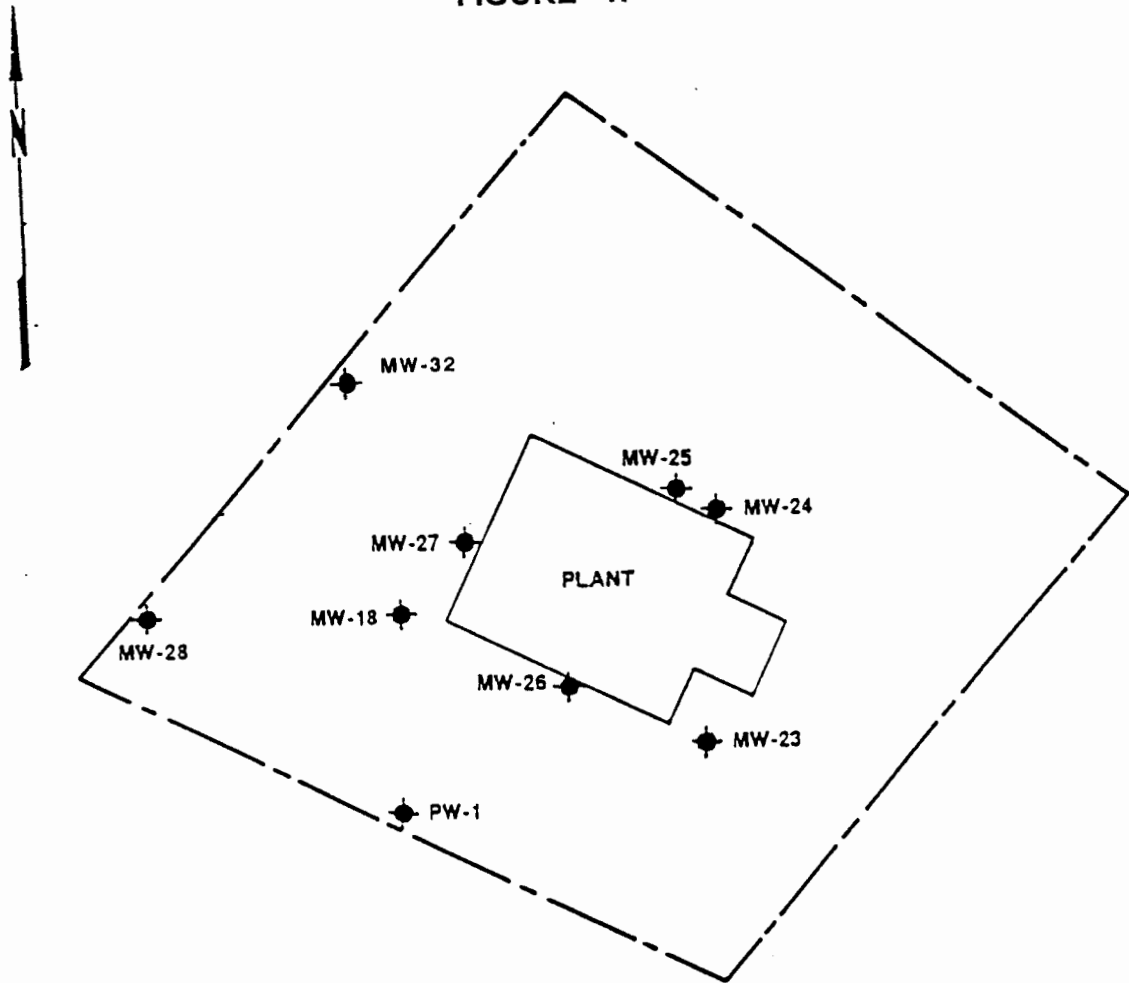
Applications for permits to drill and complete private or public drinking water wells in groundwater impacted by Sparton's operations will be monitored on at least an annual basis. Notice will be given to the State Engineer's Office of the area impacted by Sparton's operations and that Sparton should be notified in the event that any applications are received for the drilling and completion of wells within that area. Sparton will, on an annual basis, update its description of the impacted area to take into consideration any expansion or contraction of the impacted groundwater as shown by the quarterly monitoring and other data. Sparton will participate in any permit proceedings, and to the extent a permit is granted that will allow a well to be drilled in the impacted area, Sparton will undertake an additional corrective measure study to determine what response is appropriate in order to address any threat that may be presented.

The IM consists of groundwater extraction wells and treatment in a packed tower aeration unit. The ~~current~~ IM groundwater recovery network is comprised of eight wells (PW-1, MW-18, MW-23, MW-24, MW-25, MW-26, MW-27, and MW-28) installed in the upper flow zone at the on-site locations shown on Figure ~~47~~ (Figure 5, Effectiveness Report). The wells are set in the upper flow zone (UFZ) with screened interval depths ranging from 60 to 78 feet below the existing ground surface. Figure ~~48~~ (Table 1, Effectiveness Report) lists the pertinent construction details for each of the eight wells.

Compressed-air-operated, positive-displacement pumps were installed at or near the bottom of each well. The compressed air is supplied by an air compressor located in the central control building. Air is pumped through piping to the well pumps and pump controllers. Four controllers are provided to control pump operations. Two pumps are controlled by each controller. Each well pump is equipped with a remote well operator to allow independent adjustment of pumping rates for each well. Each well pump discharges through flexible tubing into a common gravity drain or header. Each discharge line is equipped with a two-way sampling valve for sample collection and flow measurement.

~~The enhanced IM system would include pumping from on-site lower lower flow zone well MW-32. Well MW-32 has historically exhibited anomalously high concentrations of VOC. The current IM system has sufficient excess capacity to accommodate the inclusion of this well. Further, the well is situated close to the IM treatment unit. Well MW-32 is shown on Figure 47 and construction details are given in Figure 48.~~

FIGURE 47



LEGEND

MW-23  
● RECOVERY WELL LOCATION AND NUMBER

0 200 400  
SCALE FEET

**HDR**  
HDR ENGINEERING, INC.  
DALLAS, TEXAS

Recovery Well Location Plan  
Sparton Technology, Inc.  
Coors Road Facility  
Albuquerque, New Mexico

Date *Dec*  
*8/92*

**FIGURE 48**

<b>IM GROUNDWATER RECOVERY NETWORK WELL CONSTRUCTION DETAILS</b>						
Well No.	Well Diameter (inches)	Well Screen Material	Riser Material	Depth of Screened Interval (feet)	Elevation at top of Screen (ft., MSL)	Construction Date
PW-1	10	PVC <sup>(1)</sup>	PVC	60-70	4984.54	9/84
MW-18	4	PVC	PVC	68-78	4977.58	5/86
MW-23	2	SS <sup>(2)</sup>	PVC	72-77	4976.51	8/86
MW-24	2	SS	PVC	68.4-73.4	4980.30	12/86
MW-25	2	SS	PVC	67.7-72.7	4981.30	12/86
MW-26	2	SS	PVC	73-78	4972.71	5/88
MW-27	2	SS	PVC	67-72	4978.50	5/88
MW-28	2	SS	PVC	65-70	4977.69	5/88
<del>MW-32</del>	<del>4</del>	<del>SS</del>	<del>PVC</del>	<del>108-118</del>	<del>4940.05</del>	<del>6/88</del>

(1) Polyvinyl chloride

(2) Stainless Steel

Groundwater extracted simultaneously at each well location is piped to an air stripper system for treatment and ultimate beneficial use in the Sparton Facility. The collection piping system consists of discharge lines encased in secondary piping to provide leak detection and containment. Figure 49 (Table 2, Effectiveness Report) describes the pumping flow rate for each recovery well as of late February 1992.

The produced groundwater is collected in a 550-gallon fiberglass-coated steel tank. The double wall tank has a leak detection system with a visual and audible alarm in the control building. A centrifugal transfer pump, which is controlled by the water level in the collection tank, transports water from the collection tank to the top of the packed tower (air stripper).

The twenty-gallon-per-minute packed tower aeration unit receives untreated water from the transfer pump and discharges to the storage tank. A 400-cfm blower provides a counter-current flow of air through the packed tower to remove volatile organic constituents (VOC) from the water. A recirculation line is provided on the packed tower discharge to allow a portion of the flow to be recirculated to the collection tank. The recirculation shortens the time between pumping cycles of the transfer pump. This procedure maintains the tower packing in a wet condition, thus improving treatment efficiency. The rate of recirculation may be adjusted by setting the butterfly valve on the recirculation line.

Effluent from the packed tower is discharged to a 15,000-gallon fiberglass-coated steel tank for storage. The double-walled tank has a leak detection system with a visual and audible alarm in the control building. Water from the storage tank is used in the main plant building as cooling and flushing water and eventually discharged into the sewer system.

**FIGURE 49**

<b>CURRENT RECOVERY WELL NETWORK FLOW RATES</b>	
<b>Well No.</b>	<b>Flow Rate (gal/hr)</b>
PW-1	3.7
MW-18	10.0
MW-23	21.3
MW-24	1.0
MW-25	1.8
MW-26	2.0
MW-27	13.4
MW-28	2.9
<b>TOTAL</b>	<b>56.1</b>

To date, approximately 3.56 million gallons of water have been treated in the packed tower. The air stripping system has demonstrated an average VOC removal efficiency of 99 percent for the measured indicators, which include 1,1-dichloroethylene (DCE), methylene chloride (MeCl), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE). Total influent concentrations have exceeded 1000 micrograms per liter ( $\mu\text{g/l}$ ). Air stripper treatment is producing effluent concentrations in the range of one  $\mu\text{g/l}$  for each constituent being monitored. Demonstrated reliability and performance to date indicate a remaining useful life of at least ten years.

#### C. Justification of Recommended Corrective Measure

##### 1. Human Health/Environmental

The recommended alternative of corrective action through continuation of the existing IM is consistent with the requirements of 40 CFR 264.100. The RFI, and subsequently obtained data, indicates that the groundwater plume is expanding slowly to the west-northwest; however, in the majority of monitoring wells, constituent concentrations are decreasing. Highest concentrations of TCE and TCA are present in the immediate vicinity of the source at the Sparton Facility.

As previously discussed, the plume does not present a risk of injury to potential receptors and will not cause the loss of any reasonably foreseeable use of the aquifer. Therefore, neither containment of the plume nor restoration of the aquifer are necessary to achieve the corrective action objectives of implementing those measures necessary to protect public health or the environment.



Even if restoration was necessary to protect public health or the environment, which it is not, that goal cannot be achieved. Given the conditions of this site, the most reasonable technical conclusion about the effectiveness of a pump and treat remedy is that it might achieve health-based standards within hundreds of years. NMED has concurred with this conclusion. The remedy proposed in this study should achieve the same result within approximately the same time period.

## 2. Performance

Groundwater extraction in the source area, combined with PTA treatment, is considered a best demonstrated available technology (BDAT) for volatile organic constituents (VOC) such as TCE and TCA. Further, over 7-1/2 years successful experience with the current IM consisting of groundwater extraction and PTA treatment confirms the applicability of this technology to the Sparton site. The IM has achieved a reduction in groundwater VOC concentration and has limited, if not prevented, further migration from on-site. However, VOC concentrations are still up to several orders of magnitude above MAC/MCL in on-site areas.

The ability of this system to achieve significant reduction in contaminant concentration coupled with the location in the area of maximum constituent concentration should provide an effective source removal/groundwater remediation tool. As previously demonstrated, the IM system performance can also be easily monitored through the numerous available sampling points existing at the Sparton site.

Soil vapor extraction (SVE), using a vapor extraction system (VES), is a well-established methodology for remediating both soil-sorbed (residual NAPL) phase and groundwater-dissolved phase VOC contamination. For the subsurface conditions existing at the Sparton site, SVE would be considered a BDAT for unsaturated zone VOC remediation. SVE performance has been confirmed through recent implementation in the Albuquerque area in similar hydrogeologic conditions.

### 3. Reliability

The recommended alternative consists of proven, state-of-the-art technologies that have been designated BDATS. It should be noted that the IM has been operated for over 7-1/2 years without any significant difficulty or breakdown. There has been no evidence of any decrease in system performance.

SVE has been widely implemented and proven to be reliable. Components of a VES are generally "off-the-shelf" and commonly available as modular units. Operation can be easily monitored.

### 4. Implementability

Since the IM system is already in operation and LLFZ well MW-32 is on-site, there are no implementability concerns or restrictions for the enhanced IM. It is anticipated that any implementation of VES would be on-site in localized areas near the original source. The combination of on-site location and wide documented usage confirms implementability of VES. BDAT designation for technologies incorporated in the recommended alternative further confirms the implementability.

## 5. Summary

The recommended corrective measure alternative is a synergistic combination of proven technologies capable of achieving reductions in contaminant levels in the source area and limiting, if not preventing, further migration from on-site areas in an efficient, cost-effective manner. Continued operation of the enhanced IM will meet the requirements for source control and removal and reduction of VOC in the most heavily impacted areas on-site. However, continued operation of the enhanced IM will not achieve MAC/MCL within any reasonable time period. Continued monitoring over the operation period of this alternative will provide ample opportunity to assess the need, if any, for additional measures beyond the recommended system. Any new development in off-site areas will also be periodically evaluated during the operational period relative to potential receptor/exposure pathways. Any significant increase in risk or threat resultant from unexpected off-site development may require additional corrective measure studies.

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**APPENDIX 1**  
**GROUNDWATER MONITORING**

Draft Final CMS - Sparton  
May 6, 1996

OGC-003747

**APPENDIX 1**

**GROUNDWATER MONITORING**

**a) Post-RFI Water Level Data**

Draft Final CMS - Sparten  
May 6, 1996

OGC-003748

# SPARTON

## SPARTON TECHNOLOGY

March 25, 1996

Mr. Robert Pine  
Hydrologist  
Ground Water Protection Bureau-Remediation Section  
New Mexico Environment Department  
1190 St. Francis Dr.  
Santa Fe, New Mexico 87503

Re: Static Water Level Elevation Data

Dear Mr. Pine:

In response to your request of March 15, 1996 I am forwarding static water level elevation data for your review. Enclosed is one floppy disk containing 2 Quattro Pro files and a hard copy of this data. Commencing in February of 1993 we switched from biweekly water level determinations to quarterly. Sampling dates are approximate as water levels for individual wells were determined over several days during sampling events. Water level elevations on 12-8-93 are not reported for all wells, only for those wells that were sampled during an STI-EPA Sampling event.

If you have any questions please contact John Wakefield or me at (505) 892-5300. I trust that this information is sufficient for your needs.

Sincerely,  
SPARTON TECHNOLOGY, INC.

*R.D. Mico*

Richard D. Mico  
Vice President and General Manager

Enclosures:

cc: Mr. Jan Appel  
~~Mr. Pierce Chandler~~  
Mr. John Wakefield

OGC-003749

## SPARTON TECHNOLOGY, INC.

Date: 03/25/96  
 To: R. Pine NMED-GWPRB  
 Page: 1 of 2

Re: Static Water Level Sounder Wells  
 From: J. Wakefield  
 File: SRDBF.WQ1

WELL No.	WLE 09/30/92	WLE 10/13/92	WLE 10/28/92	WLE 11/11/92	WLE 11/25/92	WLE 12/10/92	WLE 12/22/92	WLE 01/07/93	WLE 01/20/93	WLE 05/18/93	WLE 07/30/93
PZ-1	4961.88	4962.06	4962.17	4961.96	4961.84	4961.97	4962.10	4962.38	4962.08	4961.95	4961.43
MW-34	4977.99	4978.14	4978.05	4977.50	4977.04	4976.63	4976.37	4976.09	4975.90	4976.60	4977.66
MW-35	4975.24	4975.35	4975.42	4975.15	4974.87	4974.58	4974.38	4974.16	4972.70	4974.17	4974.60
MW-36	4973.67	4973.77	4973.86	4973.65	4973.44	4973.22	4973.08	4972.94	4972.75	4972.77	4973.28
MW-37	4972.18	4972.28	4972.32	4972.18	4972.01	4971.88	4971.78	4971.74	4971.57	4971.52	4971.71
MW-44	4973.74	4973.87	4973.94	4973.73	4973.51	4973.29	4973.13	4973.00	4972.80	4971.84	4973.38
MW-45	4972.21	4972.32	4972.37	4972.21	4972.04	4971.90	4971.81	4971.77	4971.61	4971.56	4971.80
MW-46	4971.07	4971.16	4971.23	4971.08	4970.97	4970.88	4970.83	4970.86	4970.70	4970.61	4970.66
MW-47	4970.82	4970.96	4971.01	4970.83	4970.75	4970.66	4970.63	4970.60	4970.50	4970.25	4970.43
MW-48	4970.12	4970.24	4970.28	4970.10	4970.03	4969.99	4970.00	4970.06	4969.91	4969.61	4969.64
MW-50	4965.22	4965.35	4965.37	4965.11	4964.94	4965.00	4964.82	4965.06	4964.74	4964.76	4964.58
MW-52	4967.98	4968.10	4968.15	4967.93	4967.81	4967.82	4967.89	4968.04	4967.80	4967.60	4967.57
MW-53	4969.40	4969.52	4969.55	4969.38	4969.27	4969.28	4969.34	4969.46	4969.27	4968.96	4969.10
MW-54	4969.95	4970.06	4970.02	4970.01	4969.96	4969.91	4969.89	4969.87	4969.81	4969.62	4969.57
MW-55	4969.61	4969.71	4969.76	4969.56	4969.47	4969.41	4969.42	4969.47	4969.29	4969.15	4969.18
MW-56	4970.11	4970.22	4970.27	4970.08	4970.01	4969.96	4969.97	4970.03	4969.88	4969.61	4969.71
MW-57	4969.55	4969.62	4969.64	4969.57	4969.52	4969.04	4969.49	4969.55	4969.39	4969.25	4969.17
MW-58	4969.79	4969.91	4969.96	4969.77	4969.68	4969.66	4969.71	4969.80	4969.62	4969.34	4969.51
MW-59	4973.36	4973.45	4973.50	4973.25	4973.08	4972.93	4972.83	4972.73	4972.62	4972.76	4972.85
MW-60	4969.78	4969.90	4969.94	4969.76	4969.70	4969.68	4969.70	4969.75	4969.61	4969.37	4970.24
MW-61	4969.79	4969.90	4969.94	4969.75	4969.71	4969.69	4969.73	4969.78	4969.65	4969.38	4969.37
MW-62	4971.49	4971.62	4971.66	4971.55	4971.42	4971.30	4971.23	4971.14	4971.03	4970.83	4971.17
MW-63	4979.01	4979.13	4979.23	4979.26	4979.25	4979.14	4979.01	4978.82	4978.69	4978.13	4977.74
MW-64	4969.95	4970.03	4970.07	4969.96	4969.89	4969.85	4969.86	4969.93	4969.76	4969.59	4969.57

WELL No.	WLE 10/08/93	WLE 12/08/93	WLE 03/28/94	WLE 04/07/94	WLE 07/19/94	WLE 10/31/94	WLE 02/15/95	WLE 04/24/95	WLE 08/03/95	WLE 10/13/95	WLE 01/17/96
PZ-1	4961.47		4961.65	4961.47	4960.74	4960.28	4960.83	4960.87	4960.20	4959.79	4959.34
MW-34	4977.39	4975.76	4974.74	4975.40	4977.03	4977.12	4975.09	4975.36	4976.88	4976.02	4974.88
MW-35	4974.83	4973.97	4972.80	4973.03	4974.26	4974.30	4972.93	4973.08	4974.07	4973.42	4972.66
MW-36	4973.28	4972.52	4971.83	4971.97	4972.68	4972.65	4971.73	4971.82	4972.41	*1	*1
MW-37	4971.78	4971.42	4970.78	4970.82	4971.04	4971.05	4970.40	4970.57	4970.83	*1	*1
MW-44	4973.39	4972.58	4971.92	4972.00	4972.70	4972.73	4971.89	4971.87	4972.47	4972.03	4971.54
MW-45	4971.78	4971.42	4970.83	4970.81	4971.13	4971.11	4970.63	4970.54	4970.82	4970.82	4970.18
MW-46	4970.60	4970.48	4970.00	4969.91	4969.96	4969.95	4969.51	4969.62	4969.71	4969.35	4969.15
MW-47	4970.46	4970.11	4969.84	4969.71	4969.81	4969.64	4969.41	4969.30	4969.40	4969.16	4968.83
MW-48	4969.61	4969.68	4969.31	4969.18	4969.05	4968.85	4968.86	4968.68	4968.73	4968.50	4968.26
MW-50	4964.57		4964.48	4964.34	4963.90	4963.17	4963.37	4963.44	4963.11	4962.82	4962.28
MW-52	4967.62	4967.31	4967.29	4967.25	4966.89	4966.55	4966.60	4966.53	4966.43	4966.16	4965.85
MW-53	4968.96	4968.92	4968.78	4968.66	4968.33	4968.02	4968.17	4968.00	4967.97	4967.77	4967.52
MW-54	4969.44		4969.06	4969.01	4968.87	4968.84	4968.79	4968.62	4968.54	4968.31	4967.97
MW-55	4969.08	4968.87	4968.68	4968.61	4968.43	4968.32	4968.23	4968.15	4968.13	4967.79	4967.44
MW-56	4969.63	4969.58	4969.31	4969.19	4969.01	4968.86	4968.83	4968.69	4968.71	4968.49	4968.22
MW-57	4969.06	4968.94	4968.82	4968.67	4968.49	4968.35	4968.38	4968.26	4968.17	4967.81	4967.67
MW-58	4969.37	4969.44	4969.12	4968.99	4968.74	4968.50	4968.55	4968.40	4968.39	4968.18	4967.98
MW-59	4972.82	4972.26	4971.76	4971.98	4972.23	4972.43	4971.83	4971.73	4972.00	4971.59	4971.02
MW-60	4969.25	4969.25	4969.07	4969.01	4968.73	4968.54	4968.60	4968.37	4968.37	4968.13	4967.82
MW-61	4969.43	4969.40	4969.11	4969.07	4968.80	4968.55	4968.62	4968.40	4968.41	4968.19	4967.87
MW-62	4971.13	4970.84	4970.22	4970.13	4970.39	4970.36	4970.08	4969.96	4970.15	*1	*1
MW-63	4978.48	4978.60	4977.35	4977.12	4978.44	4980.08	4981.20	4979.29	4979.28	4978.72	4977.75
MW-64	4969.48	4969.52	4969.19	4969.04	4968.90	4968.77	4968.94	4968.62	4968.64	4968.37	4968.14

\*1 Airlines Installed in these wells see AR Report for WLE.

## SPARTON TECHNOLOGY, INC.

Date: 03/22/96  
 To: R. Pine NMED-GWPRB  
 Page: 1 of 2

Re: Static Water Level Airline Wells  
 From: J. Wakefield  
 File: ARDBF.WQ1

WELL No.	WLE 09/30/92	WLE 10/13/92	WLE 10/29/92	WLE 11/11/92	WLE 11/25/92	WLE 12/10/92	WLE 12/22/92	WLE 01/07/93	WLE 01/20/93	WLE 05/18/93	WLE 07/30/93
MW-7	4980.44	4980.77	4980.77	4980.27	4979.85	4979.52	4979.19	4978.94	4978.77	4979.19	4980.27
MW-9	4976.99	4976.99	4976.99	4976.65	4976.24	4975.99	4975.74	4975.49	4975.32	4975.72	4976.22
MW-12	4975.81	4975.81	4975.81	4975.48	4975.14	4974.81	4974.56	4974.39	4974.14	4975.41	4976.08
MW-13	4978.45	4978.45	4978.45	4978.03	4977.70	4977.28	4977.03	4976.78	4976.78	4977.10	4977.93
MW-14	4974.79	4975.04	4975.04	4974.87	4974.37	4974.29	4974.21	4973.87	4973.87	4974.18	4974.34
MW-15	4976.55	4976.71	4976.80	4976.63	4976.63	4976.38	4976.30	4975.96	4975.71	4975.60	4976.20
MW-16	4980.89	4981.14	4981.05	4981.05	4980.80	4980.64	4980.47	4980.47	4980.55	4980.36	4980.61
MW-17	4981.13	4981.22	4981.22	4981.13	4980.88	4980.80	4980.63	4980.47	4980.38	4980.28	4980.86
MW-19	4975.63	4975.63	4975.63	4975.29	4974.96	4974.79	4974.63	4974.46	4974.29	4974.61	4975.11
MW-20	4975.37	4975.37	4975.28	4975.03	4974.62	4974.45	4974.28	4974.20	4974.03	4974.26	4974.68
MW-21	4980.58	4980.66	4980.58	4980.49	4980.41	4980.49	4980.41	4980.24	4980.16	4979.94	4980.19
MW-22	4980.83	4980.83	4980.99	4980.66	4980.33	4979.99	4979.83	4979.58	4979.41	4979.72	4980.39
MW-29	4977.45	4977.45	4977.37	4976.87	4976.53	4976.28	4976.03	4975.78	4975.62	4976.31	4976.89
MW-30	4975.91	4976.16	4975.99	4975.57	4975.32	4974.99	4974.82	4974.66	4974.57	4974.99	4975.41
MW-31	4975.04	4975.13	4975.04	4974.79	4974.54	4974.29	4974.13	4973.96	4973.88	4974.09	4974.50
MW-32	4974.74	4974.82	4974.82	4974.57	4974.32	4974.16	4973.99	4973.82	4973.74	4973.88	4974.29
MW-33	4976.21	4976.21	4976.29	4975.96	4975.79	4975.46	4975.29	4975.13	4974.96	4975.31	4975.72
MW-38	4977.52	4977.52	4977.36	4977.02	4976.52	4976.27	4976.02	4975.86	4975.69	4976.33	4976.99
MW-39	4976.31	4976.31	4976.22	4975.89	4975.47	4975.22	4975.06	4974.89	4974.72	4975.21	4975.71
MW-40	4975.01	4975.17	4975.09	4974.84	4974.59	4974.34	4974.17	4974.01	4973.84	4974.06	4974.56
MW-41	4974.97	4974.97	4974.97	4974.64	4974.47	4974.22	4974.14	4973.97	4973.81	4974.04	4974.29
MW-42	4974.36	4974.44	4974.53	4974.28	4973.61	4973.86	4973.78	4973.61	4973.44	4973.74	4973.99
MW-43	4974.18	4974.35	4974.35	4974.10	4973.85	4973.68	4973.60	4973.43	4973.35	4973.57	4973.82
MW-49	4974.70	4974.87	4974.79	4974.54	4974.29	4974.12	4973.87	4973.79	4973.62	4973.86	4974.36
MW-51	4981.63	4981.71	4981.79	4981.71	4981.71	4981.54	4981.46	4981.29	4981.21	4980.96	4981.29

WLE 07/30/93	WLE 10/08/93	WLE 12/08/93	WLE 03/28/94	WLE 04/07/94	WLE 07/20/94	WLE 10/31/94	WLE 02/14/95	WLE 04/21/95	WLE 08/04/95	WELL No.	WLE 10/13/95	WLE 02/09/96
4980.27	4980.02		4977.69	4978.27	4979.77	4979.81	4978.23	4978.39	4979.64	MW-7	4979.07	4977.99
4976.22	4976.22	4975.22	4974.36	4974.30	4975.55	4976.07	4974.40	4974.58	4975.73	MW-9	4974.83	4973.99
4976.08	4975.91		4973.91	4974.50	4975.58	4975.58	4974.08	4974.25	4975.16	MW-12	4974.75	4973.75
4977.93	4977.93	4976.60	4975.43	4975.93	4977.52	4977.63	4975.80	4975.97	4977.22	MW-13	4976.26	4975.34
4974.34	4974.26	4973.59	4973.34	4973.26	4973.93	4973.93	4972.85	4972.85	4973.60	MW-14	4973.06	4972.72
4976.20	4976.18	4975.60	DRY	DRY	4975.18	4975.76	4975.11	4974.45	4975.36	MW-15	4974.60	DRY
4980.61	4980.86	4980.27	4979.52	4979.52	4980.44	4980.75	4980.34	4979.90	4980.76	MW-16	4980.03	4979.70
4980.86	4980.86		4979.45	4979.45	4980.36	4981.21	4980.46	4980.04	4980.96	MW-17	4980.36	4979.69
4975.11	4974.86	4974.11	4973.02	4973.11	4974.27	4974.81	4973.56	4973.64	4974.48	MW-19	4973.58	4973.16
4974.68	4974.60	4973.76	4972.93	4972.93	4973.85	4974.27	4973.02	4973.10	4973.85	MW-20	4973.32	4972.74
4980.19	4980.28	4980.11	4979.19	4979.19	4980.78	4980.44	4980.43	4979.85	4980.43	MW-21	4980.09	4979.68
4980.39	4980.31	4979.39	4978.56	4978.72	4979.72	4980.37	4978.96	4978.87	4980.12	MW-22	4979.47	4978.64
4976.89	4976.72	4975.39	4974.47	4975.14	4976.14	4976.76	4975.09	4975.26	4976.51	MW-29	4975.57	4974.41
4975.41	4975.32	4974.16	4973.32	4973.91	4974.82	4975.08	4973.66	4973.83	4974.75	MW-30	4974.31	4973.31
4974.50	4974.42	4973.42	4972.75	4973.09	4973.92	4973.77	4972.69	4972.69	4973.60	MW-31	4973.39	4972.48
4974.29	4974.29	4973.46	4972.71	4972.79	4973.71	4973.84	4972.84	4972.84	4973.42	MW-32	4972.79	4972.37
4975.72	4975.72		4974.06	4974.22	4975.22	4975.32	4973.82	4973.99	4974.99	MW-33	4974.53	4973.61
4976.99	4976.74	4975.74	4974.16	4975.33	4976.24	4976.51	4974.84	4974.92	4976.09	MW-38	4975.64	4974.47
4975.71	4975.63	4974.63	4973.46	4974.21	4975.13	4975.31	4973.73	4973.81	4974.81	MW-39	4974.47	4973.47
4974.56	4974.48	4973.48	4972.73	4973.06	4974.06	4974.08	4972.91	4972.91	4973.66	MW-40	4973.43	4972.60
4974.29	4974.37	4973.54	4972.87	4973.12	4973.79	4974.08	4972.91	4972.91	4973.58	MW-41	4973.04	4972.54
4973.99	4973.91	4973.24	4972.58	4972.66	4973.16	4973.62	4972.79	4972.70	4973.20	MW-42	4972.51	4972.09
4973.82	4973.73	4973.23	4972.48	4972.57	4973.23	4973.51	4972.68	4972.59	4973.01	MW-43	4972.31	4971.98
4974.36	4974.28	4973.36	4972.86	4973.19	4973.69	4973.64	4972.64	4972.64	4973.39	MW-49	4972.99	4972.24
4981.29	4981.46	4981.38	4980.71	4980.46	4981.29	4982.18	4981.85	4981.26	4981.60	MW-51 OS	4981.29	4980.96
										MW-36 OS	4971.86	4971.52
										MW-37 OS	4970.40	4970.24
										MW-62 OS	4969.94	4969.61



**APPENDIX 1**  
**GROUNDWATER MONITORING**  
**b) Analytical Summaries**

Draft Final CMS - Sparton  
May 6, 1996

OGC-003754

# Sparton Monitoring Results

## TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-9 UFZ	MW-13 UFZ	MW-14 UFZ	MW-15 UFZ	MW-16 UFZ	MW-19 ULFZ	MW-20 LLFZ	MW-21 UFZ	MW-22 UFZ	MW-29 ULFZ	MW-30 ULFZ	MW-31 ULFZ	MW-32 LLFZ	MW-33 UFZ	MW-34 UFZ
Oct-83	1983	4		21000														
Oct-84	1984	4		9600		12000	4400	37000										
Jul-85	1985	3		7300														
Jan-86	1986	1	10	6100														
Apr-86		2	11	8300														
Jul-86		3	12	5000				20000										
Oct-86		4	13	5000		4900	940	36000	3600	17	2300	230						
Jan-87	1987	1	14	4500		5000	630	21000	2700	12	1700	170						
Apr-87		2	15	3600		1800	580	23000	2900	32	1400	270						
Jul-87		3	16	6400		2100	650	25000	4600	35	2100	370						
Oct-87		4	17	7100		2700	480	28000	3400	25	2000	240						
Jan-88	1988	1	18	5500		6200	370	26000	2900	10	1800	150						
Apr-88		2	19	4800		5000	10	25000	5	28	1100	230						
Jul-88		3	20	3300		5200	380	26000	1800	19	1200	63						
Oct-88		4	21	4200		5600	250	22000	3600	15	1300	120						
Jan-89	1989	1	22	4000		3300	180	16000	3200	12	900	110						
Feb-89		1	22		610	1100	210						5.7	320	120	4800	7500	
Mar-89		1	22		650	3700	210						5.4	320	120	3400	7000	
Apr-89		2	23	4400		4900	200	14000	3700	14	520	150						
Aug-89		3	24	2500		3000	200	13000	2400	20	460	120						<5
Aug-89		3	24															<5
Nov-89		4	25	2300		2200	260	16000	1500	5	1100	91						
Nov-89		4	25															
Jan-90	1990	1	26	2800		2100	190	13000	880	17	1000	110						
Jan-90		1	26															
Apr-90		2	27	2400		1800	160	20000	1000	21	400	130						
Apr-90		2	27															
Jun-90		2	27															
Aug-90		3	28	2200		2100	230	19000	850	15	670	140						
Aug-90		3	28															
Sep-90		3	28															
Oct-90		4	29	1600		1500	140	16000	590	10	850	83						
Oct-90		4	29															
Oct-90		4	29															
Jan-91	1991	1	30	1700		1700	110	16000	680	28	910	75						
Apr-91		2	31	1600		1400	5	12000	690	5.4	400	92						
Jun-91		2	31	1400		1100	91	17000	570	12	500	110	<5	180	60	57	7300	<5
Jul-91		3	32	1300	330	1400	110	16000	190	12	440	110						
Oct-91		4	33	1000		1100	80	12000	170	16	880	93				5100		
Nov-91		4	33													2400		
Dec-91		4	33													2400		
Jan-92	1992	1	34	1200		1300	64	13000	130	5	680	65				5100		
Apr-92		2	35	1400		1400	54	12000	230	5	360	90				6000		
Jul-92		3	36	930		860	49	15000	140	5	390	72				7500		
Sep-92		4	37	1000		1100	66	14000	120	30	460	48				2600		
Jan-93	1993	1	38	690		850	52	13000	57	3	430	51				830		
Apr-93		2	39	820		850	1.9	12000	110	31	240	55				1500		
Jul-93		3	40	730		720	56	11000	62	7	350	47				4400		
Oct-93		4	41	680		700	44	13000	45	23	480	41				780		
Dec-93		4	41	680	330	640	39	13000	39	6	490	41	1	47	10	490		<1
Jan-94	1994	1	42	790		680	36	12000	48	1.1	380	50				580		
Apr-94		2	43	740		730		11000	81	0.2	280	62				1700		
Jul-94		3	44	750		730	52	11000	61	8	210	44				400		
Oct-94		4	45	750		700	31	11000	47	44	360	45				1700		
Oct-94		4	45															
Feb-95	1995	1	46	850		690	45	8700	72	5	270	72				2000		
Apr-95		2	47	790		1000		7100	92	0.2	160	100				1600		
Aug-95		3	48	490		470	21	9100	39	11	200	32				4200		
Oct-95		4	49	650		470	15	7400	48	26	280	34				2800		
Jan-96	1996	1	50	570	380	290		7600	24	1.3	220	46	0.9	19	2.7	760	2000	<0.3

Cluster #1 = 13,29,38  
Cluster #2 = 33,30,39  
Cluster #3 = 14,31,40,49  
Cluster #4 = 15,41,32  
Cluster #5 = 42,43

Cluster #6 = 36,44  
Cluster #7 = 37,45  
Cluster #8 = 51,59  
Cluster #9 = 48,56,55  
Cluster #10 = 61,60

NOTES :  
1.) ND = None Detected  
2.) J value indicates an estimation by lab

# Sparton Monitoring Results

## TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-35 UFZ	MW-36 UFZ	MW-37 UFZ	MW-38 LLFZ	MW-39 LLFZ	MW-40 LLFZ	MW-41 ULFZ	MW-42 ULFZ	MW-43 LLFZ	MW-44 ULFZ	MW-45 ULFZ	MW-46 ULFZ	MW-47 UFZ	MW-48 UFZ	MW-49 3rd FZ
Oct-83	1983	4																
Oct-84	1984	4																
Jul-85	1985	3																
Jan-86	1986	1	10															
Apr-86		2	11															
Jul-86		3	12															
Oct-86		4	13															
Jan-87	1987	1	14															
Apr-87		2	15															
Jul-87		3	16															
Oct-87		4	17															
Jan-88	1988	1	18															
Apr-88		2	19															
Jul-88		3	20															
Oct-88		4	21															
Jan-89	1989	1	22															
Feb-89		1	22															
Mar-89		1	22															
Apr-89		2	23															
Aug-89		3	24	<5	7.9	1100												
Aug-89		3	24	<5	11	1800												
Nov-89		4	25				<5	<5	<5	1100	1100	270						
Nov-89		4	25				<5	<5	<5	960	1200	160						
Jan-90	1990	1	26										<5	1400	4200	310	820	<5
Jan-90		1	26										<5	1400	2300	330	830	<5
Apr-90		2	27															
Apr-90		2	27															
Jun-90		2	27													220	820	
Aug-90		3	28														600	
Aug-90		3	28														1100	
Sep-90		3	28														930	
Oct-90		4	29															
Oct-90		4	29															
Oct-90		4	29															
Jan-91	1991	1	30															
Apr-91		2	31															
Jun-91		2	31	<5	22	2000	<5	<5	<5	620	1000	280	<5	770	1300	120	410	<5
Jul-91		3	32															
Oct-91		4	33	<5	19	1400					930	440			5200		220	
Nov-91		4	33												2600			
Dec-91		4	33															
Jan-92	1992	1	34	<5	15	1200					740	260			2300		280	
Apr-92		2	35	<5	14	960					690	340			1300		290	
Jul-92		3	36	<5	10	800					640	200			960		340	
Sep-92		4	37	<5	8.3	810				510	600	180			4200		240	
Jan-93	1993	1	38	<1	7	510					680	200			1200		360	
Apr-93		2	39	<1	4	340					320	130			1200		310	
Jul-93		3	40	<1	25	800				370	620	850	<1		1400		330	
Oct-93		4	41	<1	3	600					600	160			2100		420	
Dec-93		4	41	<1	3	980	<1	<1	<1	350	620	150	<1	160	1800	93	350	<1
Jan-94	1994	1	42	<1	3	860					570	150			2500		350	
Apr-94		2	43	<1	2	850					490	120			2700		340	
Jul-94		3	44	<1	3	370					530	160			3200		370	
Oct-94		4	45	ND	2	940				420	510	110			2100		300	
Oct-94		4	45															
Feb-95	1995	1	46	<5	3	770					340	79			2600		253	
Apr-95		2	47	<5	3	750					340	98			2400		300	
Aug-95		3	48		2	750					340	100			3000		250	
Oct-95		4	49		2	750					350	110			3300		270	
Jan-96	1996	1	50	<0.3	1.9	720	<0.3	<0.3	<0.3	290	470	95	<0.3	59	3200	36	350	<0.3

File: alwells.wk4

Printed: 02/09/96

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B&V File: 026802.0100

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# Sparton Monitoring Results

## TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-51 UFZ	MW-52 UFZ	MW-53 UFZ	MW-55 LLFZ	MW-56 ULFZ	MW-57 UFZ	MW-58 UFZ	MW-59 ULFZ	MW-60 ULFZ	MW-61 UFZ	MW-62 UFZ	MW-63 UFZ	MW-64 ULFZ	Comments
Oct-83	1983	4															
Oct-84	1984	4															
Jul-85	1985	3															
Jan-86	1986	1	10														
Apr-86		2	11														
Jul-86		3	12														
Oct-86		4	13														
Jan-87	1987	1	14														
Apr-87		2	15														
Jul-87		3	16														
Oct-87		4	17														
Jan-88	1988	1	18														
Apr-88		2	19														
Jul-88		3	20														
Oct-88		4	21														
Jan-89	1989	1	22														
Feb-89		1	22														
Mar-89		1	22														
Apr-89		2	23														
Aug-89		3	24														
Aug-89		3	24														
Nov-89		4	25														#42&43 actual 12-12-89
Nov-89		4	25														#42&43 actual 12-21-89
Jan-90	1990	1	26														#49 - actual 01-25-90
Jan-90		1	26														#49 - actual 01-31-90
Apr-90		2	27	8.5													
Apr-90		2	27	6.2													
Jun-90		2	27	6.7	<1	<1											#51 - actual 05-07-90
Aug-90		3	28				13	50									
Aug-90		3	28				9.2	29									
Sep-90		3	28				12	98	<1	20	<1						
Oct-90		4	29								<5	<1	<1	<5	<1	<5	
Oct-90		4	29						22		<5	<5	<5	2.2	<5	<1	
Oct-90		4	29						22		<5	<5	<5	<5	<5	<5	
Jan-91	1991	1	30														
Apr-91		2	31														
Jun-91		2	31	<5	<5	<5	45	200	<5	29	<5	<5	<5	<5	<5	<5	EPA split sample
Jul-91		3	32														
Oct-91		4	33	<5	<5		74	210		31	<5	<5		<5			
Nov-91		4	33														
Dec-91		4	33														
Jan-92	1992	1	34	11	6.8		96	260		34	<5		<5				
Apr-92		2	35	<5	9.8		120	290		37	<5		<5				
Jul-92		3	36	<5	14		130	290		37	<5		<5				
Sep-92		4	37	<5	16		120	240		39	<5		<5				
Jan-93	1993	1	38	<1		21	190	370		48		1		2			
Apr-93		2	39	<1		23	110	230		43	<1			2			
Jul-93		3	40	<1		33	240	320		62		4	490	3			
Oct-93		4	41	1		30	310	430		64		2	500	3			#61 - actual 09-03-93
Dec-93		4	41	2	<1	32	380	410	<1	74	<1	7	610	3	<1	<1	EPA split sample
Jan-94	1994	1	42	<1		38	370	430		85		3	530	2			
Apr-94		2	43	0.6		34	390	370		93		6		2			#51 = J value
Jul-94		3	44	<1		43	550	370		110		9	800	3			
Oct-94		4	45	<5	<5	40	580	420	<5	97		24	870	2			10 #62.36 = J value, EPA split sample
Oct-94		4	45			38											#53 duplicate sample
Feb-95	1995	1	46	<5		21	580	340		100		16	960	2			11 #36 & 62 = J values
Apr-95		2	47	1		41	640	370		120		44	1400	2			18 #36, 51 & 62 = J values
Aug-95		3	48	<5		42	680	360	<5	130		66	1700	3			17 #36 & 62 = J values
Oct-95		4	49	<1		48	130	350	<1	140		100	2000	2			8
Jan-96	1996	1	50	<0.3	<0.3	100	940	430	<0.3	270	<0.3	170	1900	1.8	<0.3	15	EPA split sample

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BSV File: 028602.0100

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OGC-003757

# SPARTON TECHNOLOGY, INC.

Date: 2-26-96

To: J. Appel, R. Chandler, R. Mico, G. Richardson

Re: Final results for STI-NMED 1st Q 1996 event.

From: J. Wakefield

File: MWALL.WQ1

Page: 1 of 11

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
PZ-1 UFZ	04/24/90 01/11/96	<1 <0.3	<0.2	<1.0	<0.01	
MW-7 UFZ	4th Q 1983 4th Q 1984 3rd Q 1987 01/16/93	83 530 370 340	17 110 34 14	14 180 110 92	0.021 <0.01 0.04	0.02 <0.01
MW-9 UFZ	01/11/93 04/14/93 07/29/93 10/06/93 11/29/93 01/19/94 04/06/94 07/20/94 10/27/94 01/08/95 04/19/94 08/01/95 10/11/95 01/16/96	690 820 730 680 680 790 740 750 750 850 790 490 650 570	71 69 42 35 35 34 22 50 51 57 39 43 30 25	200 190 110 84 110 120 71 91 97 120 91 52 71 82	<0.010 <0.01 <0.01	<0.02 <0.05
MW-12 UFZ	3rd Q 1984 3rd Q 1987 01/17/96	61 3700 1000	<5 380 29	<5 1700 61	<0.005 <0.01 0.02	<0.005 <0.01
MW-13 UFZ	02/14/89 03/13/89 07/17/91 11/29/93 01/16/96	610 650 330 330 380	47 48 26 20 14	250 220 80 59 54	<0.01 <0.01 <0.010 <0.01	
MW-14 UFZ	01/11/93 04/14/93 07/29/93 10/06/93 11/29/93 01/19/94 04/06/94 07/20/94 10/27/94 02/08/95 04/19/95 08/01/95 10/10/95 01/12/96	850 850 720 700 640 680 730 730 700 690 1000 470 470 290	42 41 31 31 31 27 19 34 50 33 17 29 18 4.6	20 19 14 16 14 6.3 13 <25 16 12 10 9 11 5.8	0.573 1 1.53	0.6 0.91

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-15 UFZ	01/12/93	52	5	16	<0.010	
	04/15/93	1.9	<0.2	<0.2		
	07/27/93	56	3	23		
	10/06/93	44	2.7	18		
	12/07/93	39	2	14		
	01/19/94	36	1.8	14	<0.010	<0.02
	04/06/94	DRY	DRY	DRY		
	07/20/94	52	2	15		
	10/28/94	31	0.8	11		
	02/08/95	45	2	13		
	04/20/95	DRY	DRY	DRY	<0.01	<0.05
	08/02/95	21	1 J	7		
	10/11/95	15	<0.2	2.4		
	01/17/96	DRY	DRY	DRY		
MW-16 UFZ	01/11/93	13000	400	5900	0.376	0.4
	04/14/93	12000	470	5900		
	07/29/93	11000	310	4200		
	10/06/93	13000	360	6200		
	11/29/93	13000	360	5100		
	01/19/94	12000	360	4400		
	04/06/94	11000	190	3200		
	07/20/94	11000	230	3700		
	10/28/94	11000	280	4000		
	02/08/95	8700	340	3100		
	04/21/95	7100	200	2100	0.57 0.19	0.52
	08/01/95	9100	280	2700		
	10/11/95	7400	140	2200		
	01/16/96	7600	93	1900		
MW-17 UFZ	4th Q 1984	4300	260	2300	0.27	<0.01
	3rd Q 1987	4200	430	4000	0.32	<0.01
	01/17/96	3800	<100	1100		
MW-19 ULFZ	01/11/93	57	3	2	<0.02	<0.02
	04/15/93	110	11	0.8		
	07/29/93	62	3	1		
	10/06/93	45	2.6	<0.2		
	11/29/93	39	2	<1		
	01/19/94	48	2.4	<0.2	<0.01	<0.05
	04/06/94	81	2.8	0.8		
	07/20/94	61	<4	<4		
	10/27/94	47	2.5	1.1		
	02/08/95	72	4	2		
	04/19/95	92	3.1	<1	<0.01	<0.05
	08/02/95	39	3 J	1 J		
	10/11/95	48	1.7	1.3		
	01/17/96	24	0.7	<1.0		

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-20 LLFZ	01/11/93	3	<1	<1	<0.02	<0.02
	04/15/93	31	1.6	13		
	07/29/93	7	<1	<1		
	10/06/93	23	1.1	1.0		
	12/02/93	6	<1	<1		
	01/19/94	1.1	<0.2	<0.2	<0.010	<0.02
	04/06/94	0.2	<0.2	<0.2		
	07/20/94	8	<1	<1		
	10/27/94	44	1.1	1.4		
	02/08/95	5	<1	<1		
	04/19/95	0.2	<0.2	<1	<0.01	<0.05
	08/02/95	11	<5	<5		
	10/11/95	26	1.2	2.1		
	01/17/96	1.3	<0.2	<1.0		
MW-21 UFZ	01/11/93	430	38	330	<0.02	<0.02
	04/14/93	240	21	190		
	07/29/93	350	17	210		
	10/06/93	480	30	330		
	11/29/93	490	33	290		
	07/20/94	380	23	240	<0.010	<0.02
	07/20/94	280	11	150		
	07/20/94	210	17	110		
	10/27/94	360	32	210		
	02/08/95	270	19	140		
	04/19/95	160	6.0	70	<0.01	<0.05
	08/02/95	200	13	92		
	10/10/95	280	12	120		
	01/12/96	220	10	95		
MW-22 UFZ	01/11/93	51	26	75	<0.02	<0.02
	04/15/93	55	22	68		
	07/29/93	47	13	47		
	10/06/93	41	22	51		
	12/07/93	41	20	51		
	01/19/94	50	22	57	<0.010	<0.02
	04/06/94	62	14	52		
	07/20/94	44	18	50		
	10/28/94	45	16	31		
	02/08/95	72	20	54		
	04/21/95	100	10	48	<0.01	<0.05
	08/02/95	32	8	23		
	10/11/95	34	6.9	23		
	01/16/96	46	6.2	29		

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-29 ULFZ	02/15/89				<0.01	
	02/22/89	5.7	<5.0	<5.0		
	03/13/89	5.4	<5.0	<5.0	<0.01	
	06/19/91	<5.0	<5.0	<5.0	<0.010	
	12/06/93	1	<1	<1		
	01/16/96	0.9	<0.2	<1.0	<0.01	
MW-30 ULFZ	02/14/89	320	19	11	0.09	
	03/14/89	320	19	<12	0.06	
	06/18/91	180	13	5.8	0.070	
	12/06/93	47	3	1		
	01/17/96	19	0.5	<1.0	<0.01	
MW-31 ULFZ	02/13/89	120	<5.0	<5.0	<0.01	
	03/15/89	120	<5.0	<5.0	<0.01	
	06/19/91	60	<5.0	<5.0	<0.010	
	12/07/93	10	<1	2		
	01/12/96	2.7	<0.2	<1.0	0.09	
MW-32 LLFZ	01/12/93	830	130	74		
	04/14/93	1500	470	200		
	07/27/93	4400	1000	380	<0.010	
	10/06/93	780	140	71		
	12/07/93	490	80	40		
	01/18/94	580	98	45		
	04/05/94	1700	250	110		
	07/19/94	400	58	62		
	10/25/94	1700	310	88	<0.010	
	02/07/95	2000	430	99		
	04/18/95	1600	320	82		
	08/01/95	4200	810	170		
	10/10/95	2800	420	120		
	01/11/96	760	110	36	<0.01	
MW-33 UFZ	02/14/89	7500	750	2500	0.14	
	03/14/89	7000	730	2500	<0.01	
	06/17/91	7300	1000	1800	0.48	
	01/16/96	2000	200	160	4.11	
MW-34 UFZ	08/16/89	<5.0	<5.0	<5.0	0.09	
	03/15/89	<5.0	<5.0	<5.0	0.55	
	06/14/91	<5.0	<5.0	<5.0	<0.010	
	12/07/93	<1	<1	<1		
	01/10/96	<0.3	<0.2	<1.0	<0.01	



Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-35 UFZ	01/14/93	<1	<1	<1		
	04/14/93	<1	<1	<1		
	07/28/93	<1	<1	<1		
	10/05/93	<1	<1	<1		
	12/02/93	<1	<1	<1		
	01/18/94	<1	<1	<1		
	04/05/94	<1	<1	<1		
	07/19/94	<1	<1	<1		
	02/07/95	<5	<5	<5		
	04/18/95	<5	<5	<5		
	3rd Q 95	Not Sampled MW-57 Substituted.				
	4th Q 95	Not Sampled MW-57 Substituted.				
	01/11/96	<0.3	<0.2	<1.0	0.02	
MW-36 UFZ	01/14/93	7	<1	<1		
	04/13/93	4	<1	<1		
	07/27/93	25	5	2	0.052	
	10/05/93	3	<1	<1		
	12/07/93	3	<1	<1		
	01/17/94	3	<1	<1		
	04/04/94	2	<1	<1		
	07/18/94	3	<1	<1		
	02/07/95	3 J	<5	<5		
	04/18/95	3 J	<5	<5		
	08/01/95	2 J	<5	<5		
	10/10/95	2	<1	<1		
	01/10/96	1.9	<0.2	<1.0	0.03	
MW-37 UFZ	01/14/93	510	19	4		
	04/13/93	340	18	4		
	07/28/93	800	28	8		
	10/04/93	600	<10	<10		
	11/30/93	980	46	<20		
	01/18/94	860	38	<10		
	04/05/94	850	37	<25		
	07/19/94	370	9	3		
	02/07/95	770	40	5		
	04/18/95	750	42	6		
	08/01/95	750	37	6		
	10/10/95	750	31	5		
	01/10/96	720	25	<10	<0.01	
MW-38 LLFZ	11/06/89	<5.0	<5.0	<5.0	<0.01	
	11/20/89	<5.0	<5.0	<5.0	<0.01	
	06/18/91	<5.0	<5.0	<5.0	<0.010	
	11/29/93	<1	<1	<1		
	01/16/96	<0.3	<0.2	<1.0	0.02	

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-39 LLFZ	11/06/89	<5.0	<5.0	<5.0	<0.01	
	11/20/89	<5.0	<5.0	<5.0	<0.01	
	06/18/91	<5.0	<5.0	<5.0	0.020	
	12/06/93	<1	<1	<1		
	01/17/96	<0.3	<0.2	<1.0	0.13	
MW-40 LLFZ	11/07/89	<5.0	<5.0	<5.0	<0.01	
	11/21/89	<5.0	<5.0	<5.0	<0.01	
	06/19/91	<5.0	<5.0	<5.0	<0.010	
	12/02/93	<1	<1	<1		
	01/12/96	<0.3	<0.2	<1.0	<0.01	
MW-41 ULFZ	11/07/89	1100	150	310	0.02	
	11/20/89	960	110	290	0.02	
	06/19/91	620	70	190	0.016	
	09/21/92	510	59	130	<0.010	
	07/27/93	370	59	95	<0.010	
	12/07/93	350	46	80		
	10/25/94	420	58	68	<0.010	<0.02
	01/11/96	290	15	20	<0.01	
MW-42 ULFZ	01/12/93	680	100	100		
	04/14/93	320	100	85		
	07/28/93	620	79	80		
	10/05/93	600	93	84		
	11/29/93	620	100	91		
	01/18/94	570	97	84		
	04/05/94	490	79	77		
	07/19/94	530	97	76		
	02/07/95	340	84	60		
	04/19/95	340	71	49		
	08/01/95	340	80	52		
	10/10/95	350	56	43		
	01/10/96	470	55	57	<0.01	
MW-43 LLFZ	01/12/93	200	41	61		
	04/14/93	130	38	54		
	07/28/93	850	150	200		
	10/05/93	160	31	41		
	11/29/93	150	32	48		
	01/18/94	150	38	49		
	04/05/94	120	25	31		
	07/19/94	160	46	39		
	02/07/95	79	28	23		
	04/19/95	98	32	24		
	08/01/95	100	27	26		
	10/10/95	110	25	28		
	01/10/96	95	23	29	<0.01	

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-44 ULFZ	01/04/90	<5.0	<5.0	<5.0	<0.01	
	01/16/90	<5.0	<5.0	<5.0	<0.01	
	06/14/91	<5.0	<5.0	<5.0	<0.010	
	07/27/93	<1	<1	<1	<0.010	
	12/07/93	<1	<1	<1		
	01/10/96	<0.3	<0.2	<1.0	<0.01	
MW-45 ULFZ	01/04/90	1400	<100	<100	0.53	
	01/17/90	1400	<50	<50	0.57	
	06/14/91	770	<50	<50	0.16	
	11/30/93	160	<10	<10		
	01/09/96	59	<4.0	<20	0.03	
MW-46 ULFZ	01/14/93	1200	22	75		
	04/13/93	1200	7	17		
	07/28/93	1400	44	76		
	10/05/93	2100	73	68		
	12/01/93	1800	<100	<100		
	03/14/94	2500	60	110		
	04/05/94	2700	120	69		
	07/19/94	3200	230	<100		
	02/07/95	2600	120	65		
	04/18/95	2400	190	80		
	08/01/95	3000	130	76		
	10/10/95	3300	230	88		
	01/09/96	3200	220	96	0.19	
MW-47 UFZ	01/03/90	310	<25	<25	0.25	
	01/16/90	330	<12	<12	0.27	
	06/11/91	120	<6.0	<6.0	0.14	
	12/01/93	93	3	<1		
	01/09/96	36	0.7	<1.0	0.05	
MW-48 UFZ	01/13/93	360	7	1		
	04/12/93	310	8	<1		
	07/28/93	330	12	<5		
	10/04/93	420	12	2		
	12/01/93	350	12	<10		
	01/17/94	350	10	<10		
	04/04/94	340	12	<10		
	07/18/94	370	16	<10		
	02/06/95	253	13	1 J		
	04/17/95	300	11	<5		
	07/31/95	250	10	<5		
	10/09/95	270	8	<2		
	01/08/96	350	7.0	<1.0	0.13	

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-49 3rdFZ	01/25/90	12	<5.0	<5.0	<0.01	
	01/31/90	6.9	<5.0	<5.0	<0.010	
	06/20/91	<5.0	<5.0	<5.0	<0.010	
	12/07/93	<1	<1	<1		
	01/12/96	<0.3	<0.2	<1.0	<0.01	
MW-51 UFZ	01/14/93	<1	<1	<1		
	04/13/93	<1	<1	<1		
	07/28/93	<1	<1	<1		
	10/05/93	1	<1	<1		
	11/29/93	2	<1	<1		
	03/14/94	<1	<1	<1		
	04/05/94	0.6 J	<1	<1		
	07/19/94	<1	<1	<1		
	02/07/95	<5	<5	<5		
	04/18/95	1 J	<5	<5		
	08/01/95	<5	<5	<5		
	10/10/95	<1	<1	<1		
	01/11/96	<0.3	<0.2	<1.0	<0.01	
MW-52 UFZ	06/05/90	<1				
	06/07/90	<1				
	06/13/91	<5	<5	<5	<0.010	
	12/01/93	<1	<1	<1		
	10/25/94	<5	<5	<5	0.010	
	01/09/96	<0.3	<0.2	<1.0	0.01	
MW-53 UFZ  Bld. Dup.	01/14/93	21	<1	<1		
	04/13/93	23	<1	<1		
	07/26/93	33	<1	<1	0.109	
	10/04/93	30	<1	<1		
	12/02/93	32	<1	<1		
	01/17/94	38	<1	<1		
	04/04/94	34	0.6 J	<1		
	07/18/94	43	<2	<2		
	10/25/94	40	<5	<5	0.087	
	10/25/94	38	<5	<5	0.086	
	02/06/95	21	<5	<5		
	04/17/95	41	<5	<5		
	07/31/95	42	<5	<5		
	10/09/95	48	1	<1		
	01/09/96	100	1.1	<1.0	0.06	

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L	
MW-55 LLFZ	01/13/93	190	<1	<1	0.129	0.50	
	04/12/93	110	<1	<1			
	07/26/93	240	<1	<1			
	10/04/93	310	2	<1			
	12/01/93	380	<10	<10			
	01/17/94	370	<10	<10	0.422		
	04/04/94	390	<10	<10			
	07/18/94	550	<20	<20			
	10/24/94	580	5	<5			
	02/06/95	580	6	<5			
	04/17/95	640	8	<5			
	07/31/95	680	8	<5			
	10/09/95	130	<10	<1			
	01/08/96	940	8.4	<1.0			
MW-56 ULFZ	01/13/93	370	4	<1	0.421		
	04/12/93	230	<2	<2			
	07/26/93	320	9	<1			
	10/04/93	430	7	<1			
	11/30/93	410	<10	<10			
	01/17/94	430	<10	<10	0.391		
	04/04/94	370	8 J	<10			
	07/18/94	370	10	<10			
	10/24/94	420	9	<5			
	02/06/95	340	8 J	<25			
	04/17/95	370	13	<5			
	07/31/95	360	11	<5			
	10/09/95	350	9	<4			
	01/08/96	430	11	<1.0			
MW-57 UFZ	08/31/90	<1			0.044	<0.02	
	06/13/91	<5.0	<5.0	<5.0			
	12/01/93	<1	<1	<1	0.020		
	10/24/94	<5	<5	<5			
	07/31/95	<5	<5	<5			
	10/10/95	<1	<1	<1	0.02		
	01/10/96	<0.3	<0.2	<1.0			
MW-58 UFZ	01/14/93	48	<1	<1	0.165		
	04/13/93	43	<1	<1			
	07/26/93	62	<1	<1			
	10/04/93	64	<1	<1			
	12/02/93	74	2	<1			
	01/17/94	85	2	<1	0.15		
	04/04/94	93	3	<1			
	07/18/94	110	4	1			
	02/06/95	100	4 J	<5			
	04/17/95	120	4 J	<5			
	07/31/95	130	4 J	<5			
	10/09/95	140	4	<4			
	01/08/96	270	3.4	<1.0			

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +6 mg/L
MW-59 ULFZ	09/21/90	<1				
	10/04/90	<5	<5	<5	<0.010	
	10/15/91	<5	<5	<5	<0.010	
	06/14/91	<5	<5	<5	<0.010	
	12/07/93	<1	<1	<1		
	01/12/96	<0.3	<0.2	<1.0	<0.01	
MW-60 ULFZ	01/14/93	1	<1	<1		
	04/12/93	<1	<1	<1		
	07/27/93	4	<1	<1	<0.010	
	10/05/93	2	<1	<1		
	11/30/93	7	<1	<1		
	01/17/94	3	<1	<1		
	04/04/94	6	<1	<1		
	07/18/94	9	<1	<1		
	10/24/94	24	<5	<5	<0.010	<0.02
	02/06/95	16	<5	<5		
	04/17/95	44	<5	<5		
	07/31/95	66	3 J	<5		
	10/09/95	100	4	<1		
	01/08/96	170	4.8	<1.0	<0.01	
MW-61 UFZ	07/27/93	490	15	7	<0.010	
	09/03/93	500	20	6		
	12/02/93	610	24	<20		
	01/18/94	530	18	<10		
	07/18/94	800	36	<25		
	10/25/94	870	32	8	<0.010	<0.02
	02/09/95	960	52	11		
	04/17/95	1400	55	13		
	07/31/95	1700	70	17		
	10/09/95	2000	54	20		
	01/08/96	1900	34	13	0.04	
MW-62 UFZ	01/13/93	2	6	9		
	04/12/93	2	6	9		
	07/26/93	3	18	14	<0.010	
	10/04/93	3	9	10		
	12/06/93	3	8	10		
	01/17/94	2	8	9		
	04/04/94	2	8	10		
	07/19/94	3	15	13		
	02/09/95	2 J	10	9		
	04/17/95	2 J	8	8		
	08/01/95	3 J	9	8		
	10/09/95	2	7	7		
	01/09/96	1.8	7.0	7.2	<0.01	

Well ID	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L	Cr +δ mg/L
MW-63 UFZ	10/04/90	<5	<5	<5	<0.010	
	10/15/90	<5	<5	<5	<0.010	
	06/14/91	<5	<5	<5	<0.010	
	11/30/93	<1	<1	<1		
	01/12/96	<0.3	<0.2	<1.0	<0.01	
MW-64 ULFZ	10/08/90	<5	<5	<5	<0.010	
	10/15/90	<5	<5	<5	<0.010	
	06/14/91	<5	<5	<5	<0.010	
	11/30/93	<1	<1	<1		
	10/24/94	10	<5	<5	<0.010	<0.02
	02/06/95	11	<5	<5		
	04/18/95	18	<5	<5		
	07/31/95	17	<5	<5		
	10/09/95	8	<1	<1		
	01/10/96	15	0.6	<1.0	<0.01	

J=Estimated value, analyte concentration below detection limit.  
Blanks indicate that the parameter was not analyzed.

# SPARTON TECHNOLOGY, INC.

Date: 2-26-96  
 To: J. Appel  
 P. Chandler  
 R. Mico  
 G. Richardson

Re: SGMP Data  
 From: J. Wakefield  
 File: MWSGMPN.WQ1  
 Page: 1 of 8

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-32 LLFZ	02/16/89	4800	<500	<500	0.02
	03/16/89	3400	340	300	0.03
	04/08/91	4900	720		
	06/20/91	57	7.2	<5.0	<0.010
	10/04/91	5100	540	<420	
	11/06/91	2400	350	<250	
	12/12/91	2400	380	200	
	01/29/92	5100	850	440	
	04/22/92	6000	1100	510	
	07/22/92	7500	870	540	
	09/21/92	2600	550	260	<0.010
	01/12/93	830	130	74	
	04/14/93	1500	470	200	
	07/27/93	4400	1000	380	<0.010
	10/06/93	780	140	71	
	12/07/93	490	80	40	
	01/18/94	580	98	45	
	04/05/94	1700	250	110	
	07/19/94	400	58	62	
	10/25/94	1700	310	88	<0.010
	02/07/95	2000	430	99	
	04/18/95	1600	320	82	
	08/01/95	4200	810	170	
	10/10/95	2800	420	120	
	01/11/96	760	110	36	<0.01
MW-35 UFZ	08/15/89	<5.0	<5.0	<5.0	0.25
	08/28/89	<5.0	<5.0	<5.0	0.02
	06/14/91	<5.0	<5.0	<5.0	
	10/04/91	<5.0	<5.0	<5.0	
	01/08/92	<5.0	<5.0	<5.0	
	04/02/92	<5.0	<5.0	<5.0	
	07/21/92	<5.0	<5.0	<5.0	
	09/24/92	<5.0	<5.0	<5.0	
	01/14/93	<1	<1	<1	
	04/14/93	<1	<1	<1	
	07/28/93	<1	<1	<1	
	10/05/93	<1	<1	<1	
	12/02/93	<1	<1	<1	
	01/18/94	<1	<1	<1	
	04/05/94	<1	<1	<1	
	07/19/94	<1	<1	<1	
	10/26/94	<5	<5	<5	
	02/07/95	<5	<5	<5	
	04/18/95	<5	<5	<5	
	3rd Q 95	Not Sampled MW-57 Substituted.			
	4th Q 95	Not Sampled MW-57 Substituted.			
	01/11/96	<0.3	<0.2	<1.0	0.02



Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-36 UFZ	08/15/89	7.9	<5.0	<5.0	0.26
	08/28/89	11	<5.0	<5.0	0.07
	04/17/91	22	<5.0	<5.0	<0.010
	06/14/91	22	<5.0	<5.0	
	10/02/91	19	<5.0	<5.0	
	01/08/92	15	<5.0	<5.0	
	04/02/92	14	<5.0	<5.0	0.052
	07/21/92	10	<5.0	<5.0	
	09/22/92	8.3	<5.0	<5.0	
	01/14/93	7	<1	<1	
	04/13/93	4	<1	<1	
	07/27/93	25	5	2	
	10/05/93	3	<1	<1	
	12/07/93	3	<1	<1	
	01/17/94	3	<1	<1	
	04/04/94	2	<1	<1	
	07/18/94	3	<1	<1	
	10/26/94	2 J	<5	<5	
	02/07/95	3 J	<5	<5	
	04/18/95	3 J	<5	<5	
	08/01/95	2 J	<5	<5	
	10/10/95	2	<1	<1	0.03
	01/10/96	1.9	<0.2	<1.0	
MW-37 UFZ	08/15/89	1100	<50	<50	0.23
	08/28/89	1800	67	<50	0.05
	04/17/91	710	<50		<0.010
	06/14/91	2000	<120	<120	
	10/04/91	1400	<85	<85	
	01/08/92	1200	52	<50	
	04/02/92	960	<85	<85	0.052
	07/21/92	800	37	<25	
	09/24/92	810	38	<33	
	01/14/93	510	19	4	
	04/13/93	340	18	4	
	07/28/93	800	28	8	
	10/04/93	600	<10	<10	
	11/30/93	980	46	<20	
	01/18/94	860	38	<10	
	04/05/94	850	37	<25	
	07/19/94	370	9	3	
	10/26/94	940	40 J	<50	
	02/07/95	770	40	5	
	04/18/95	750	42	6	
	08/01/95	750	37	6	
	10/10/95	750	31	5	<0.01
	01/10/96	720	25	<10	

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-42 ULFZ	12/12/89	1100	140	200	<0.01
	12/21/89	1200	130	200	<0.01
	04/04/91	880	130		
	06/14/91	1000	160	220	<0.010
	10/04/91	930	120	170	
	01/29/92	740	120	130	
	04/22/92	690	120	120	
	07/21/92	640	100	110	
	09/24/92	600	95	110	
	01/12/93	680	100	100	
	04/14/93	320	100	85	
	07/28/93	620	79	80	
	10/05/93	600	93	84	
	11/29/93	620	100	91	
	01/18/94	570	97	84	
	04/05/94	490	79	77	
	07/19/94	530	97	76	
	10/27/94	510	81	70	
	02/07/95	340	84	60	
	04/19/95	340	71	49	
	08/01/95	340	80	52	
	10/10/95	350	56	43	
	01/10/96	470	55	57	<0.01
MW-43 LLFZ	12/12/89	270	55	100	<0.01
	12/12/89	160	46	86	<0.01
	04/04/91	300	58		
	06/20/91	280	59	79	<0.010
	10/04/91	440	93	120	
	01/29/92	260	68	88	
	04/22/92	340	58	69	
	07/21/92	200	37	59	
	09/24/92	180	41	46	
	01/12/93	200	41	61	
	04/14/93	130	38	54	
	07/28/93	850	150	200	
	10/05/93	160	31	41	
	11/29/93	150	32	48	
	01/18/94	150	38	49	
	04/05/94	120	25	31	
	07/19/94	160	46	39	
	10/27/94	110	30	34	
	02/07/95	79	28	23	
	04/19/95	98	32	24	
	08/01/95	100	27	26	
	10/10/95	110	25	28	
	01/10/96	95	23	29	<0.01

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-46 ULFZ	01/04/90	4200	<250	<250	0.11
	01/17/90	2300	<100	100	0.17
	09/04/90	4800			
	04/05/91	1200	<120	<120	
	06/13/91	1300	<50	86	0.34
	10/02/91	5200	<250	<250	
	11/06/91	2600	90	80	
	01/08/92	2300	<100	<100	
	04/02/92	1300	<160	<160	
	07/21/92	960	41	77	
	09/24/92	4200	170	<170	
	01/14/93	1200	22	75	
	04/13/93	1200	7	17	
	07/28/93	1400	44	76	
	10/05/93	2100	73	68	
	12/01/93	1800	<100	<100	
	03/14/94	2500	60	110	
	04/05/94	2700	120	69	
	07/19/94	3200	230	<100	
	10/26/94	2100	110	70 J	
	02/07/95	2600	120	65	
	04/18/95	2400	190	80	
	08/01/95	3000	130	76	
	10/10/95	3300	230	88	
	01/09/96	3200	220	96	0.18
MW-48 UFZ	01/03/90	820	<50	<50	0.14
	01/16/90	170	<5.0	<5.0	0.16
	06/19/90	820			
	08/20/90	1100	<50	<50	0.32
	09/04/90	930	<50	<50	0.26
	04/03/91	400	<25		
	06/11/91	410	<25	<25	0.27
	10/02/91	220	<25	<25	
	01/08/92	280	<10	<10	
	04/01/92	290	<25	<25	
	07/20/92	340	<12	<12	
	09/22/92	240	<20	<20	0.59
	01/13/93	360	7	1	
	04/12/93	310	8	<1	
	07/28/93	330	12	<5	
	10/04/93	420	12	2	
	12/01/93	350	12	<10	
	01/17/94	350	10	<10	
	04/04/94	340	12	<10	
	07/18/94	370	16	<10	
	10/26/94	300	10	<10	
	02/06/95	253	13	1 J	
	04/17/95	300	11	<5	
	07/31/95	250	10	<5	
	10/09/95	270	8	<2	
	01/08/96	350	7.0	<1.0	0.13

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-51 UFZ	04/25/90	8.5	<5.0	<5.0	<0.010
	04/26/90	6.2			
	05/07/90	6.7	<5.0	<5.0	0.062
	04/03/91	5.0	<5.0	<5.0	
	06/14/91	5.0	<5.0	<5.0	<0.010
	10/02/91	<5.0	<5.0	<5.0	
	01/09/92	11	<5.0	<5.0	
	04/22/92	<5.0	<5.0	<5.0	
	07/21/92	<5.0	<5.0	<5.0	
	09/24/92	<5.0	<5.0	<5.0	
	01/14/93	<1	<1	<1	
	04/13/93	<1	<1	<1	
	07/28/93	<1	<1	<1	
	10/05/93	1	<1	<1	
	11/29/93	2	<1	<1	
	03/14/94	<1	<1	<1	
	04/05/94	0.6 J	<1	<1	
	07/19/94	<1	<1	<1	
	10/26/94	<5	<5	<5	
	02/07/95	<5	<5	<5	
	04/18/95	1 J	<5	<5	
	08/01/95	<5	<5	<5	
	10/10/95	<1	<1	<1	
	01/11/96	<0.3	<0.2	<1.0	<0.01
MW-53 UFZ  Bld. Dup.	06/20/90	<1			
	04/04/91	<5.0	<5.0		
	06/11/91	<5.0	<5.0	<5.0	0.019
	10/01/91	<5.0	<5.0	<5.0	
	01/07/92	6.8	<5.0	<5.0	
	04/01/92	9.8	<5.0	<5.0	
	07/21/92	14	<5.0	<5.0	
	09/22/92	16	<5.0	<5.0	
	01/14/93	21	<1	<1	
	04/13/93	23	<1	<1	
	07/26/93	33	<1	<1	0.109
	10/04/93	30	<1	<1	
	12/02/93	32	<1	<1	
	01/17/94	38	<1	<1	
	04/04/94	34	0.6 J	<1	
	07/18/94	43	<2	<2	
	10/25/94	40	<5	<5	0.087
	10/25/94	38	<5	<5	
	02/06/95	21	<5	<5	
	04/17/95	41	<5	<5	
	07/31/95	42	<5	<5	
	10/09/95	48	1	<1	
	01/09/96	100	1.1	<1.0	0.06

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-55 LLFZ	08/20/90	13	<5.0	<5.0	<0.010
	09/04/90	12	<5.0	<5.0	<0.010
	04/16/91	31	<5.0		
	06/10/91	45	<5.0	<5.0	<0.010
	10/01/91	74	<5.0	<5.0	
	01/07/92	96	<5.0	<5.0	
	04/01/92	120	<10	<10	
	07/20/92	130	<5.0	<5.0	
	09/22/92	120	<8.5	<8.5	
	01/13/93	190	<1	<1	
	04/12/93	110	<1	<1	
	07/26/93	240	<1	<1	0.129
	10/04/93	310	2	<1	
	12/01/93	380	<10	<10	
	01/17/94	370	<10	<10	
	04/04/94	390	<10	<10	
	07/18/94	550	<20	<20	
	10/24/94	580	5	<5	0.422
	02/06/95	580	6	<5	
	04/17/95	640	8	<5	
	07/31/95	680	8	<5	
	10/09/95	130	<10	<1	
	01/08/96	940	8.4	<1.0	1.04
MW-56 ULFZ	08/20/90	50	<5.0	<5.0	0.028
	09/04/90	98	<5.0	<5.0	0.049
	04/16/91	160	<10		
	06/10/91	200	<10	<10	0.18
	10/01/91	210	<5.0	<5.0	
	01/07/92	260	<10	<10	
	04/01/92	290	<25	<25	
	07/20/92	290	<12	<12	
	09/22/92	240	<20	<20	0.34
	01/13/93	370	4	<1	
	04/12/93	230	<2	<2	
	07/26/93	320	9	<1	0.421
	10/04/93	430	7	<1	
	11/30/93	410	<10	<10	
	01/17/94	430	<10	<10	
	04/04/94	370	8 J	<10	
	07/18/94	370	10	<10	
	10/24/94	420	9	<5	0.391
	02/06/95	340	8 J	<25	
	04/17/95	370	13	<5	
	07/31/95	360	11	<5	
	10/09/95	350	9	<4	
	01/08/96	430	11	<1.0	0.26

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-57 UFZ	08/31/90	<1			
	06/13/91	<5.0	<5.0	<5.0	0.044
	12/01/93	<1	<1	<1	
	10/24/94	<5	<5	<5	0.020
	07/31/95	<5	<5	<5	
	10/10/95	<1	<1	<1	
	01/10/96	<0.3	<0.2	<1.0	0.02
MW-58 UFZ	10/05/90	22	<5.0	<5.0	<0.010
	10/15/90	22	<5.0	<5.0	<0.010
	04/03/91	34	<5.0		
	06/11/91	29	<5.0	<5.0	0.017
	10/01/91	31	<5.0	<5.0	
	01/08/92	34	<5.0	<5.0	
	04/01/92	37	<5.0	<5.0	
	07/20/92	37	<5.0	<5.0	
	09/24/92	39	<5.0	<5.0	
	01/14/93	48	<1	<1	
	04/13/93	43	<1	<1	
	07/26/93	62	<1	<1	0.165
	10/04/93	64	<1	<1	
	12/02/93	74	2	<1	
	01/17/94	85	2	<1	
	04/04/94	93	3	<1	
	07/18/94	110	4	1	
	10/26/94	97	3 J	<5	
	02/06/95	100	4 J	<5	
	04/17/95	120	4 J	<5	
	07/31/95	130	4 J	<5	
	10/09/95	140	4	<4	
	01/08/96	270	3.4	<1.0	0.15
MW-60 ULFZ	10/04/90	<5.0	<5.0	<5.0	<0.010
	10/15/90	<5.0	<5.0	<5.0	<0.010
	04/05/91	<5.0	<5.0		
	06/10/91	<5.0	<5.0	<5.0	<0.010
	10/01/91	<5.0	<5.0	<5.0	
	01/08/92	<5.0	<5.0	<5.0	
	04/01/92	<5.0	<5.0	<5.0	
	07/20/92	<5.0	<5.0	<5.0	
	09/24/92	<5.0	<5.0	<5.0	
	01/14/93	1	<1	<1	
	04/12/93	<1	<1	<1	
	07/27/93	4	<1	<1	<0.010
	10/05/93	2	<1	<1	
	11/30/93	7	<1	<1	
	01/17/94	3	<1	<1	
	04/04/94	6	<1	<1	
	07/18/94	9	<1	<1	
	10/24/94	24	<5	<5	<0.010
	02/06/95	16	<5	<5	
	04/17/95	44	<5	<5	
	07/31/95	66	3 J	<5	
	10/09/95	100	4	<1	
	01/08/96	170	4.8	<1.0	<0.01

Well ID Flow Zone	Sample Date	TCE ug/L	1,1-DCE ug/L	1,1,1-TCA ug/L	Cr Total mg/L
MW-61 UFZ	10/04/90	<5.0	<5.0	<5.0	<0.010
	10/15/90	<5.0	<5.0	<5.0	<0.010
	06/10/91	<5.0	<5.0	<5.0	<0.010
	07/27/93	490	15	7	<0.010
	09/03/93	500	20	6	
	12/02/93	610	24	<20	
	01/18/94	530	18	<10	
	07/18/94	800	36	<25	
	10/25/94	870	32	8	<0.010
	02/09/95	960	52	11	
	04/17/95	1400	55	13	
	07/31/95	1700	70	17	
	10/09/95	2000	54	20	
	01/08/96	1900	34	13	0.04
MW-62 UFZ	10/04/90	11	6.8	<5.0	0.012
	10/15/90	12	7.2	<5.0	<0.010
	06/10/91	<5.0	9.6	12	<0.010
	10/01/91	<5.0	8	10	
	01/08/92	<5.0	7.3	11	
	04/01/92	<5.0	7.2	10	
	07/20/92	<5.0	9.5	15	
	09/24/92	<5.0	8.3	11	
	01/13/93	2	6	9	
	04/12/93	2	6	9	
	07/26/93	3	18	14	<0.010
	10/04/93	3	9	10	
	12/06/93	3	8	10	
	01/17/94	2	8	9	
	04/04/94	2	8	10	
	07/19/94	3	15	13	
	10/27/94	2 J	8	9	
	02/09/95	2 J	10	9	
	04/17/95	2 J	8	8	
	08/01/95	3 J	9	8	
	10/09/95	2	7	7	
	01/09/96	1.8	7.0	7.2	<0.01
MW-64 ULFZ	10/08/90	<5	<5	<5	<0.010
	10/15/90	<5	<5	<5	<0.010
	06/13/91	<5	<5	<5	<0.010
	11/30/93	<1	<1	<1	
	10/24/94	10	<5	<5	<0.010
	02/06/95	11	<5	<5	
	04/18/95	18	<5	<5	
	07/31/95	17	<5	<5	
	10/09/95	8	<1	<1	
	01/10/96	15	0.6	<1.0	<0.01

J=Estimated value, analyte concentration below detection limit.  
Blanks indicate that the parameter was not analyzed.

## **APPENDIX 1**

### **GROUNDWATER MONITORING**

- c) TCE Concentration Time-History Plots for  
Well Clusters and Other Selected Wells**



# Sparton Monitoring Results

## TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-9 UFZ	MW-13 UFZ	MW-14 UFZ	MW-15 UFZ	MW-16 UFZ	MW-19 ULFZ	MW-20 LLFZ	MW-21 UFZ	MW-22 UFZ	MW-29 ULFZ	MW-30 ULFZ	MW-31 ULFZ	MW-32 LLFZ	MW-33 UFZ	MW-34 UFZ
Oct-83	1983	4		21000														
Oct-84	1984	4		9600		12000	4400	37000										
Jul-85	1985	3		7300														
Jan-86	1986	1	10	6100														
Apr-86		2	11	8300														
Jul-86		3	12	5000				20000										
Oct-86		4	13	5000		4900	940	36000	3600	17	2300	230						
Jan-87	1987	1	14	4500		5000	630	21000	2700	12	1700	170						
Apr-87		2	15	3600		1800	580	23000	2900	32	1400	270						
Jul-87		3	16	6400		2100	650	25000	4600	35	2100	370						
Oct-87		4	17	7100		2700	480	28000	3400	25	2000	240						
Jan-88	1988	1	18	5500		6200	370	26000	2900	10	1800	150						
Apr-88		2	19	4800		5000	10	25000	5	28	1100	230						
Jul-88		3	20	3300		5200	380	26000	1800	19	1200	63						
Oct-88		4	21	4200		5600	250	22000	3600	15	1300	120						
Jan-89	1989	1	22	4000		3300	180	16000	3200	12	900	110						
Feb-89		1	22		610	1100	210						5.7	320	120	4800	7500	
Mar-89		1	22		650	3700	210						5.4	320	120	3400	7000	
Apr-89		2	23	4400		4900	200	14000	3700	14	520	150						
Aug-89		3	24	2500		3000	200	13000	2400	20	460	120						<5
Aug-89		3	24															<5
Nov-89		4	25	2300		2200	260	16000	1500	5	1100	91						
Nov-89		4	25															
Jan-90	1990	1	26	2800		2100	190	13000	880	17	1000	110						
Jan-90		1	26															
Apr-90		2	27	2400		1800	160	20000	1000	21	400	130						
Apr-90		2	27															
Jun-90		2	27															
Aug-90		3	28	2200		2100	230	19000	850	15	670	140						
Aug-90		3	28															
Sep-90		3	28															
Oct-90		4	29	1600		1500	140	16000	590	10	850	83						
Oct-90		4	29															
Oct-90		4	29															
Jan-91	1991	1	30	1700		1700	110	16000	680	28	910	75						
Apr-91		2	31	1600		1400	5	12000	690	5.4	400	92						
Jun-91		2	31	1400		1100	91	17000	570	12	500	110	<5	180	60	57	7300	<5
Jul-91		3	32	1300	330	1400	110	16000	190	12	440	110						
Oct-91		4	33	1000		1100	80	12000	170	16	880	93				5100		
Nov-91		4	33													2400		
Dec-91		4	33													2400		
Jan-92	1992	1	34	1200		1300	64	13000	130	5	680	65				5100		
Apr-92		2	35	1400		1400	54	12000	230	5	360	90				6000		
Jul-92		3	36	930		860	49	15000	140	5	390	72				7500		
Sep-92		4	37	1000		1100	66	14000	120	30	460	48				2600		
Jan-93	1993	1	38	690		850	52	13000	57	3	430	51				830		
Apr-93		2	39	820		850	1.9	12000	110	31	240	55				1500		
Jul-93		3	40	730		720	56	11000	62	7	350	47				4400		
Oct-93		4	41	680		700	44	13000	45	23	480	41				780		
Dec-93		4	41	680	330	640	39	13000	39	6	490	41	1	47	10	490		<1
Jan-94	1994	1	42	790		680	36	12000	48	1.1	380	50				580		
Apr-94		2	43	740		730		11000	81	0.2	280	62				1700		
Jul-94		3	44	750		730	52	11000	61	8	210	44				400		
Oct-94		4	45	750		700	31	11000	47	44	360	45				1700		
Oct-94		4	45															
Feb-95	1995	1	46	850		690	45	8700	72	5	270	72				2000		
Apr-95		2	47	790		1000		7100	92	0.2	160	100				1600		
Aug-95		3	48	490		470	21	9100	39	11	200	32				4200		
Oct-95		4	49	650		470	15	7400	48	26	280	34				2800		
Jan-96	1996	1	50	570	380	290		7600	24	1.3	220	46	0.9	19	2.7	760	2000	<0.3

Cluster #1 = 13,29,38  
Cluster #2 = 33,30,39  
Cluster #3 = 14,31,40,49  
Cluster #4 = 15,41,32  
Cluster #5 = 42,43

Cluster #6 = 36,44  
Cluster #7 = 37,45  
Cluster #8 = 51,59  
Cluster #9 = 48,56,55  
Cluster #10 = 61,60

NOTES :  
1.) ND = None Detected  
2.) J value indicates an estimation by lab

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# Sparton Monitoring Results

## TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-35 UFZ	MW-36 UFZ	MW-37 UFZ	MW-38 LLFZ	MW-39 LLFZ	MW-40 LLFZ	MW-41 ULFZ	MW-42 ULFZ	MW-43 LLFZ	MW-44 ULFZ	MW-45 ULFZ	MW-46 ULFZ	MW-47 UFZ	MW-48 UFZ	MW-49 3rd FZ
Oct-83	1983	4																
Oct-84	1984	4																
Jul-85	1985	3																
Jan-86	1986	1	10															
Apr-86		2	11															
Jul-86		3	12															
Oct-86		4	13															
Jan-87	1987	1	14															
Apr-87		2	15															
Jul-87		3	16															
Oct-87		4	17															
Jan-88	1988	1	18															
Apr-88		2	19															
Jul-88		3	20															
Oct-88		4	21															
Jan-89	1989	1	22															
Feb-89		1	22															
Mar-89		1	22															
Apr-89		2	23															
Aug-89		3	24	<5	7.9	1100												
Aug-89		3	24	<5	11	1800												
Nov-89		4	25				<5	<5	<5	1100	1100	270						
Nov-89		4	25				<5	<5	<5	960	1200	160						
Jan-90	1990	1	26										<5	1400	4200	310	820	<5
Jan-90		1	26										<5	1400	2300	330	830	<5
Apr-90		2	27															
Apr-90		2	27															
Jun-90		2	27													220	820	
Aug-90		3	28														600	
Aug-90		3	28														1100	
Sep-90		3	28														930	
Oct-90		4	29															
Oct-90		4	29															
Oct-90		4	29															
Jan-91	1991	1	30															
Apr-91		2	31															
Jun-91		2	31	<5	22	2000	<5	<5	<5	620	1000	280	<5	770	1300	120	410	<5
Jul-91		3	32															
Oct-91		4	33	<5	19	1400					930	440			5200		220	
Nov-91		4	33												2600			
Dec-91		4	33															
Jan-92	1992	1	34	<5	15	1200					740	260			2300		280	
Apr-92		2	35	<5	14	960					690	340			1300		290	
Jul-92		3	36	<5	10	800					640	200			960		340	
Sep-92		4	37	<5	8.3	810				510	600	180			4200		240	
Jan-93	1993	1	38	<1	7	510					680	200			1200		360	
Apr-93		2	39	<1	4	340					320	130			1200		310	
Jul-93		3	40	<1	25	800				370	620	850	<1		1400		330	
Oct-93		4	41	<1	3	600					600	160			2100		420	
Dec-93		4	41	<1	3	980	<1	<1	<1	350	620	150	<1	160	1800	93	350	<1
Jan-94	1994	1	42	<1	3	860					570	150			2500		350	
Apr-94		2	43	<1	2	850					490	120			2700		340	
Jul-94		3	44	<1	3	370					530	160			3200		370	
Oct-94		4	45	ND	2	940				420	510	110			2100		300	
Oct-94		4	45															
Feb-95	1995	1	46	<5	3	770					340	79			2600		253	
Apr-95		2	47	<5	3	750					340	98			2400		300	
Aug-95		3	48		2	750					340	100			3000		250	
Oct-95		4	49		2	750					350	110			3300		270	
Jan-96	1996	1	50	<0.3	1.9	720	<0.3	<0.3	<0.3	290	470	95	<0.3	59	3200	36	350	<0.3

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# Sparton Monitoring Results TCE Concentrations

Date	Year	Qtr.	Qtr. #	MW-51 UFZ	MW-52 UFZ	MW-53 UFZ	MW-55 LLFZ	MW-56 ULFZ	MW-57 UFZ	MW-58 UFZ	MW-59 ULFZ	MW-60 ULFZ	MW-61 UFZ	MW-62 UFZ	MW-63 UFZ	MW-64 ULFZ	Comments
Oct-83	1983	4															
Oct-84	1984	4															
Jul-85	1985	3															
Jan-86	1986	1	10														
Apr-86		2	11														
Jul-86		3	12														
Oct-86		4	13														
Jan-87	1987	1	14														
Apr-87		2	15														
Jul-87		3	16														
Oct-87		4	17														
Jan-88	1988	1	18														
Apr-88		2	19														
Jul-88		3	20														
Oct-88		4	21														
Jan-89	1989	1	22														
Feb-89		1	22														
Mar-89		1	22														
Apr-89		2	23														
Aug-89		3	24														
Aug-89		3	24														
Nov-89		4	25														#42&43 actual 12-12-89
Nov-89		4	25														#42&43 actual 12-21-89
Jan-90	1990	1	26														#49 - actual 01-25-90
Jan-90		1	26														#49 - actual 01-31-90
Apr-90		2	27	8.5													
Apr-90		2	27	6.2													
Jun-90		2	27	6.7	<1	<1											#51 - actual 05-07-90
Aug-90		3	28				13	50									
Aug-90		3	28				9.2	29									
Sep-90		3	28				12	98	<1	20	<1						
Oct-90		4	29							22	<5	<1	<1	<5	<1	<5	
Oct-90		4	29							22	<5	<5	<5	2.2	<5	<1	
Oct-90		4	29							22	<5	<5	<5	<5	<5	<5	
Jan-91	1991	1	30														
Apr-91		2	31														
Jun-91		2	31	<5	<5	<5	45	200	<5	29	<5	<5	<5	<5	<5	<5	EPA split sample
Jul-91		3	32														
Oct-91		4	33	<5	<5		74	210		31	<5	<5		<5			
Nov-91		4	33														
Dec-91		4	33														
Jan-92	1992	1	34	11	6.8		96	260		34	<5		<5				
Apr-92		2	35	<5	9.8		120	290		37	<5		<5				
Jul-92		3	36	<5	14		130	290		37	<5		<5				
Sep-92		4	37	<5	16		120	240		39	<5		<5				
Jan-93	1993	1	38	<1		21	190	370		48		1		2			
Apr-93		2	39	<1		23	110	230		43	<1			2			
Jul-93		3	40	<1		33	240	320		62		4	490	3			
Oct-93		4	41	1		30	310	430		64		2	500	3			#61 - actual 09-03-93
Dec-93		4	41	2	<1	32	380	410	<1	74	<1	7	610	3	<1	<1	EPA split sample
Jan-94	1994	1	42	<1		38	370	430		85		3	530	2			
Apr-94		2	43	0.6		34	390	370		93		6		2			#51 = J value
Jul-94		3	44	<1		43	550	370		110		9	800	3			
Oct-94		4	45	<5	<5	40	580	420	<5	97		24	870	2			#62,36 = J value, EPA split sample
Oct-94		4	45			38											#53 duplicate sample
Feb-95	1995	1	46	<5		21	580	340		100		16	960	2			#36 & 62 = J values
Apr-95		2	47	1		41	640	370		120		44	1400	2			#36, 51 & 62 = J values
Aug-95		3	48	<5		42	680	360	<5	130		66	1700	3			#36 & 62 = J values
Oct-95		4	49	<1		48	130	350	<1	140		100	2000	2			8
Jan-96	1996	1	50	<0.3	<0.3	100	940	430	<0.3	270	<0.3	170	1900	1.8	<0.3	15	EPA split sample

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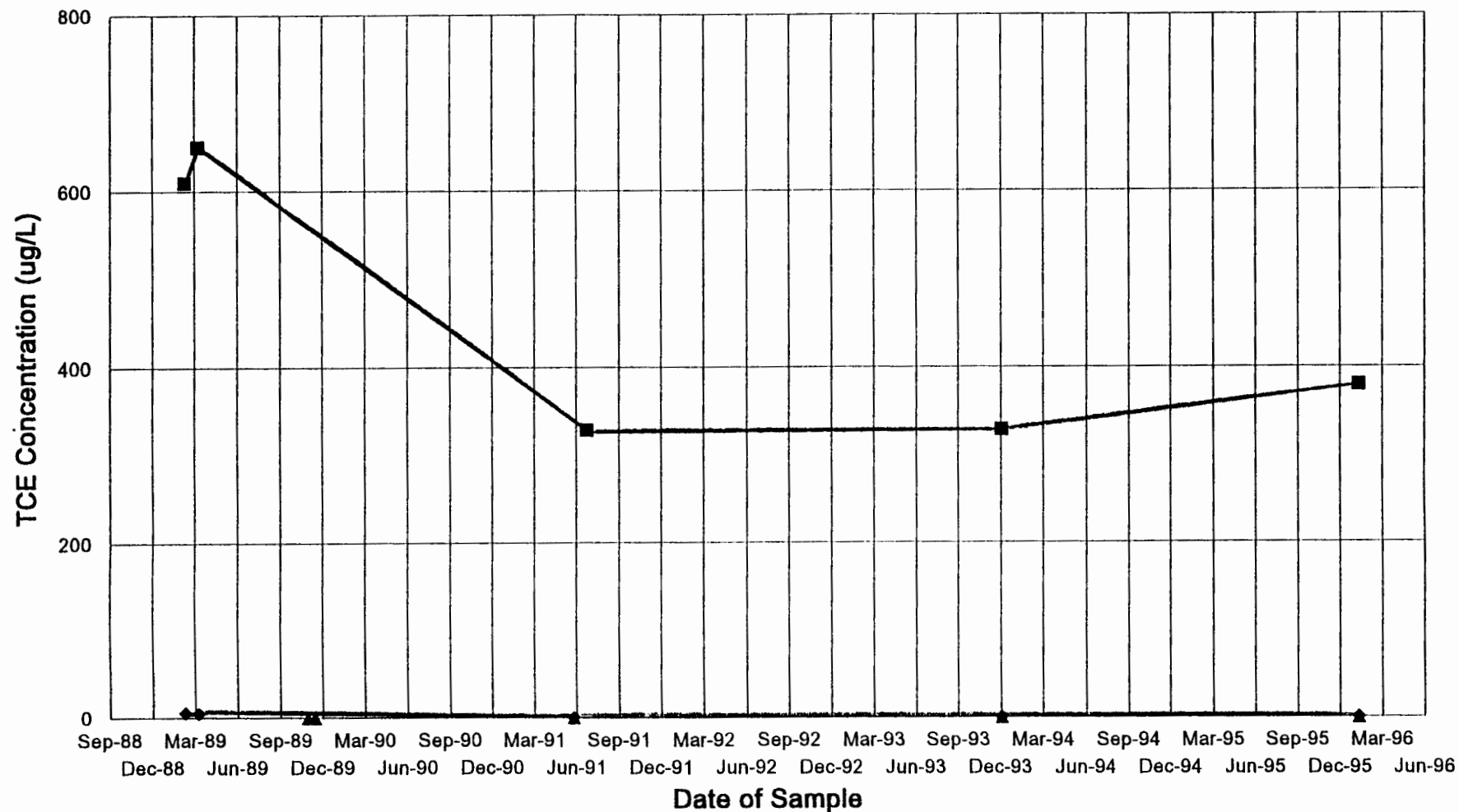
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Coors Road Facility



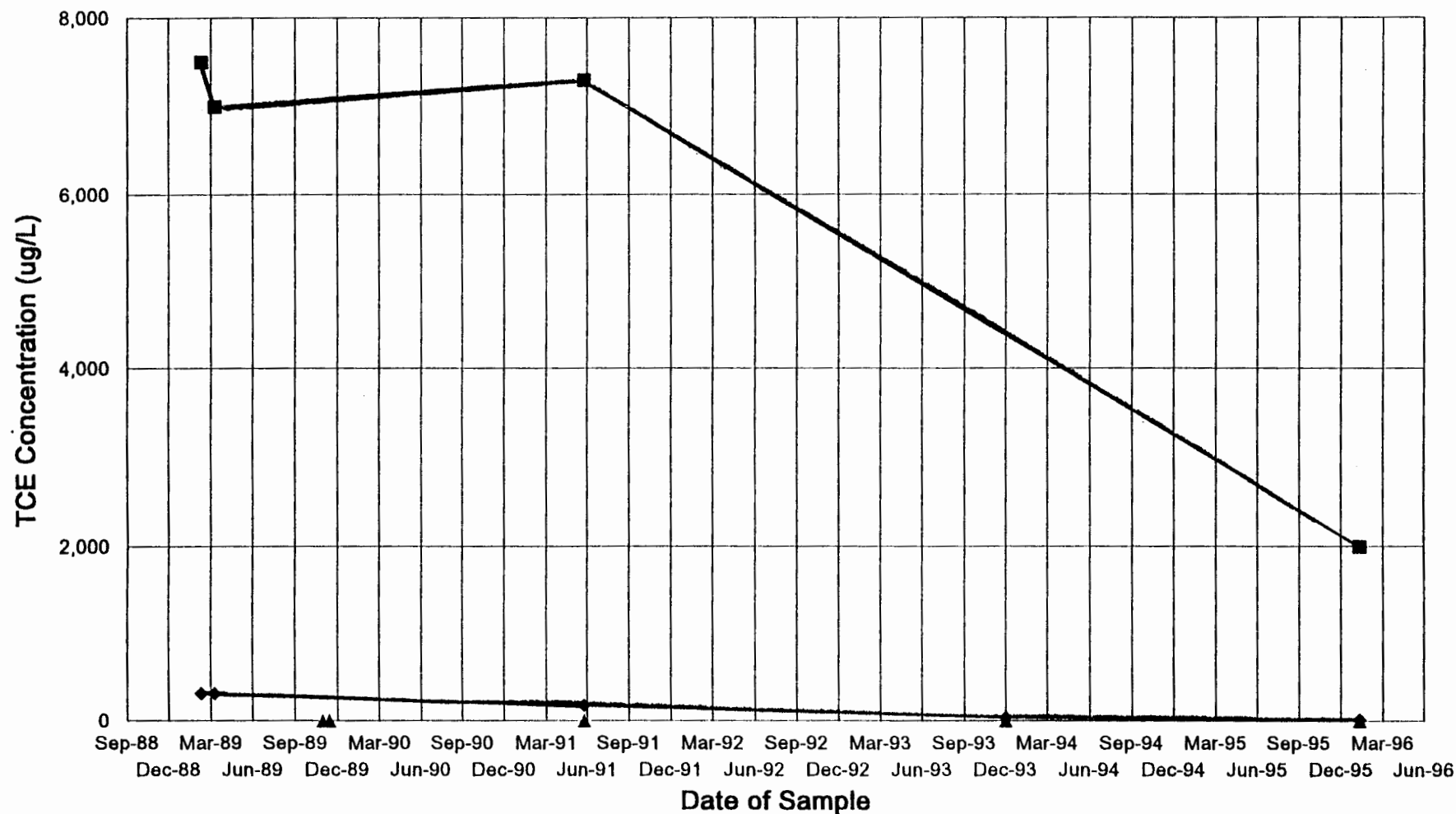
■ Monitor Well #13 (UFZ) ♦ Monitor Well #29 (ULFZ) ▲ Monitor Well #38 (LLFZ)

Cluster #1  
Onsite

**MW# 38 - ALL SAMPLES - NO DETECT (<5ug/L)**

# Sparton Technologies, Inc

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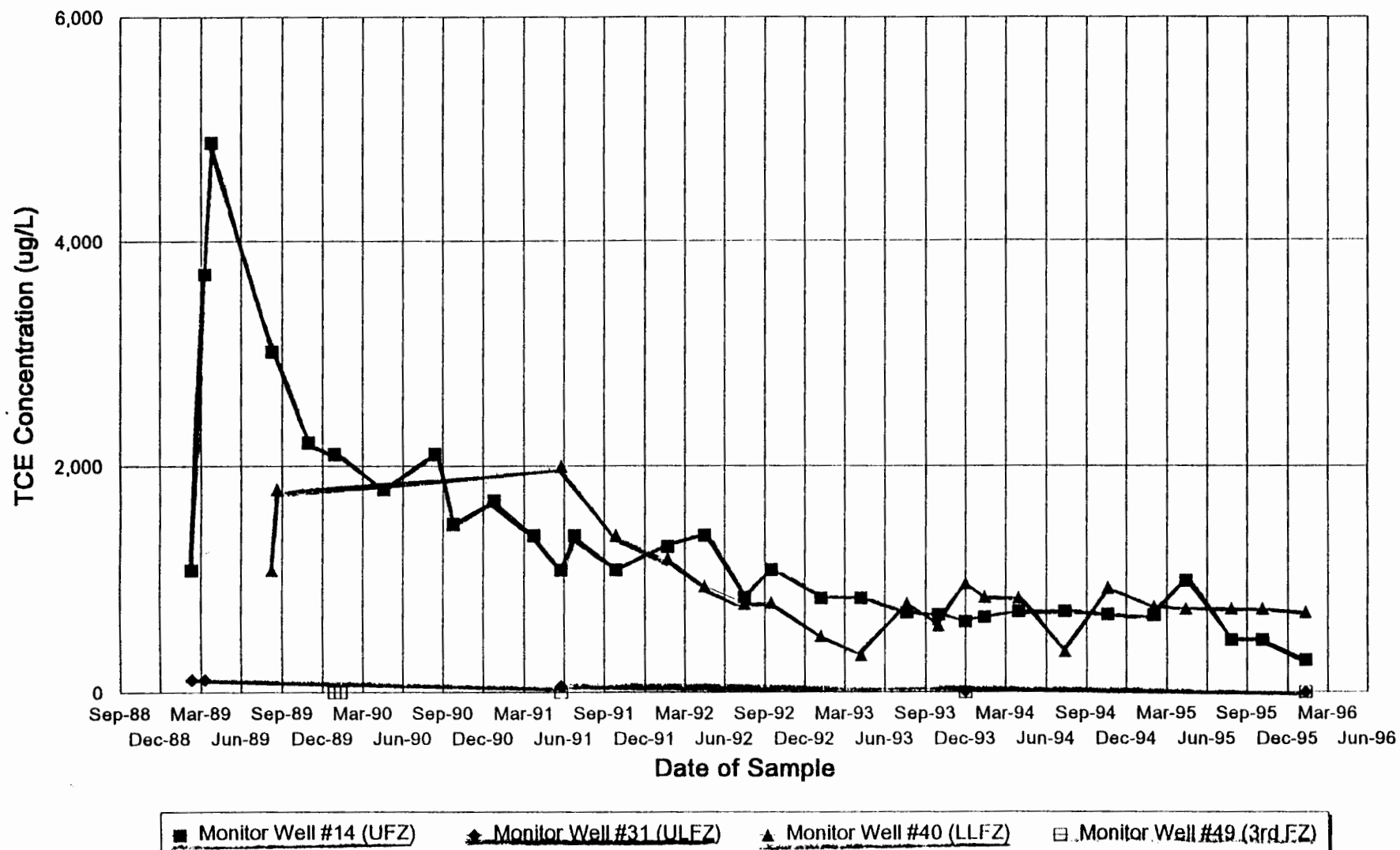
■ Monitor Well #33 (UFZ) ♦ Monitor Well #30 (ULFZ) ▲ Monitor Well #39 (LLFZ)

Cluster #2  
Onsite

**MW# 39 - ALL SAMPLES - NO DETECT (<5ug/L)**

# Sparton Technologies, Inc

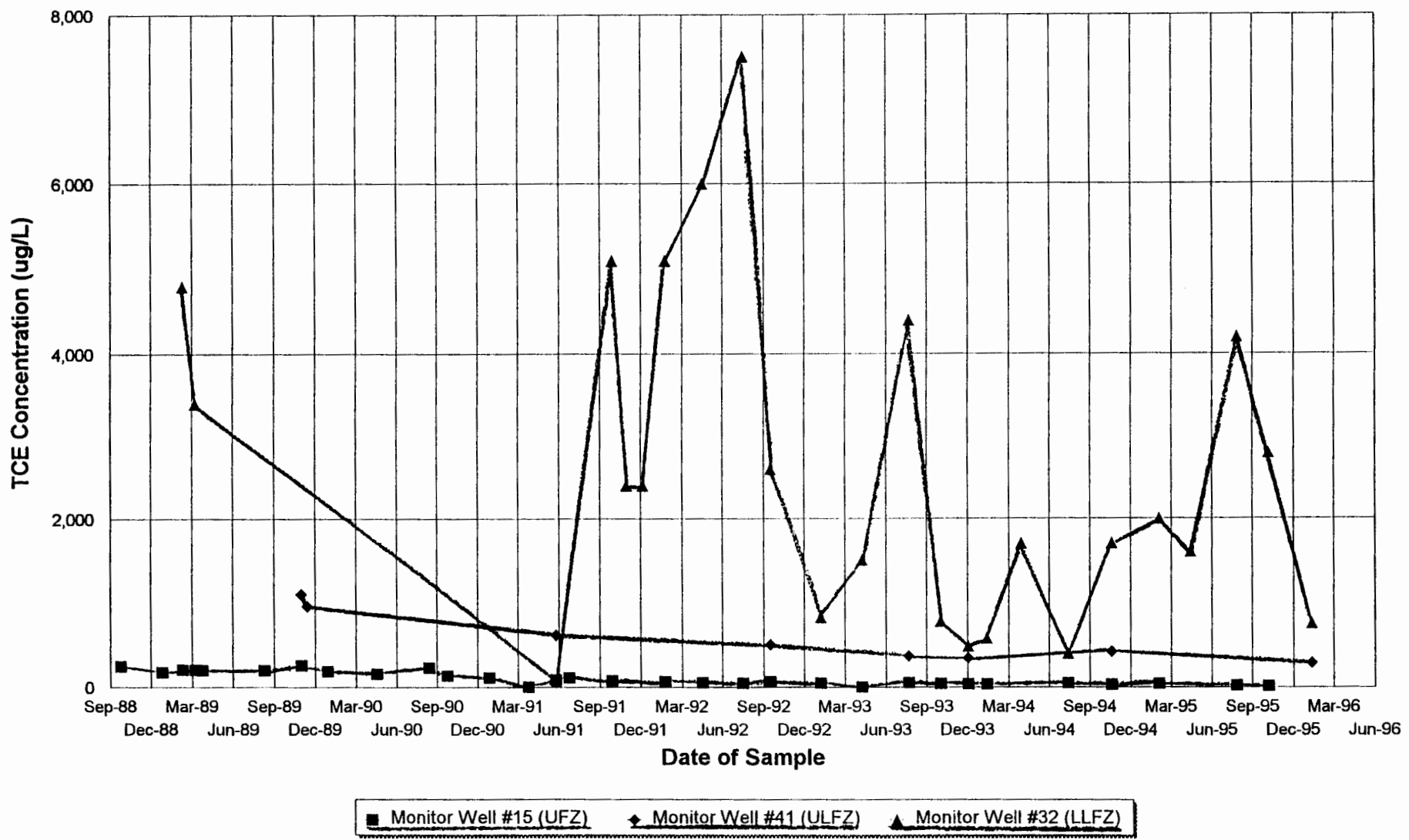
Coors Road Facility



Cluster #3  
Onsite

**MW# 49 - ALL SAMPLES - NO DETECT (<5ug/L)**

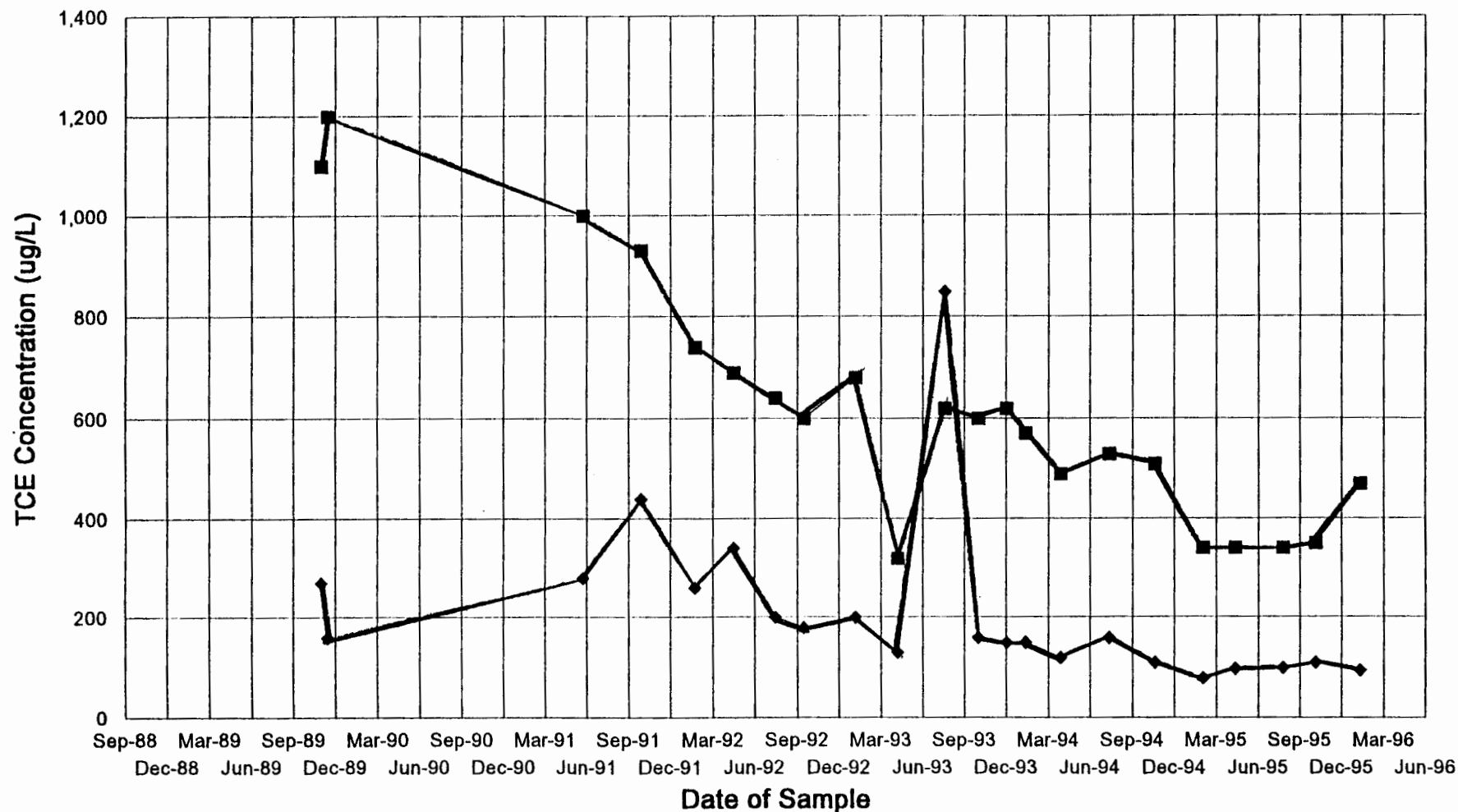
**Sparton Technologies, Inc**  
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Cluster #4  
Onsite

# Sparton Technologies, Inc

Coors Road Facility



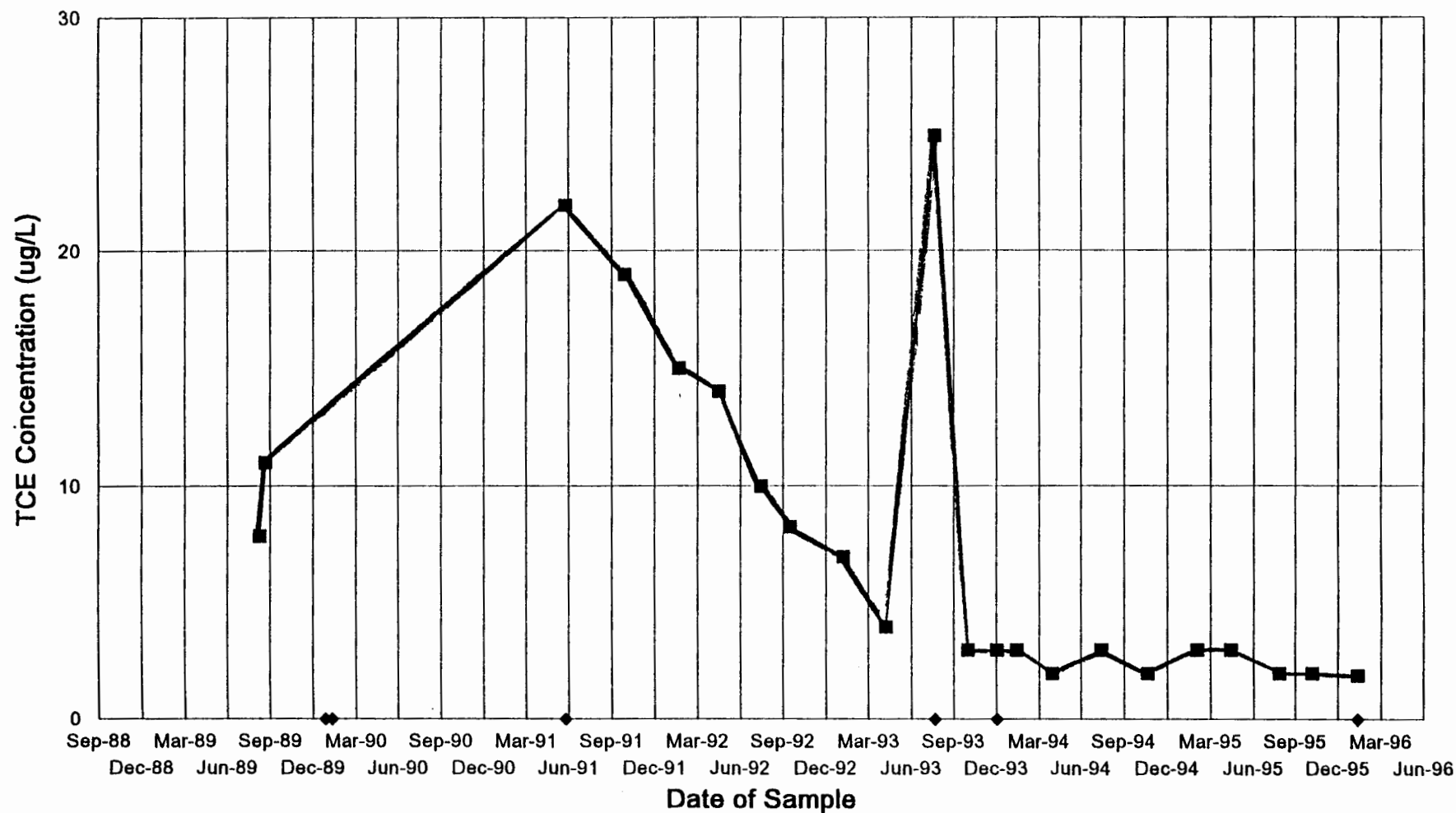
■ Monitor Well #42 (ULFZ) ◆ Monitor Well #43 (LLFZ)

Cluster #5  
Offsite



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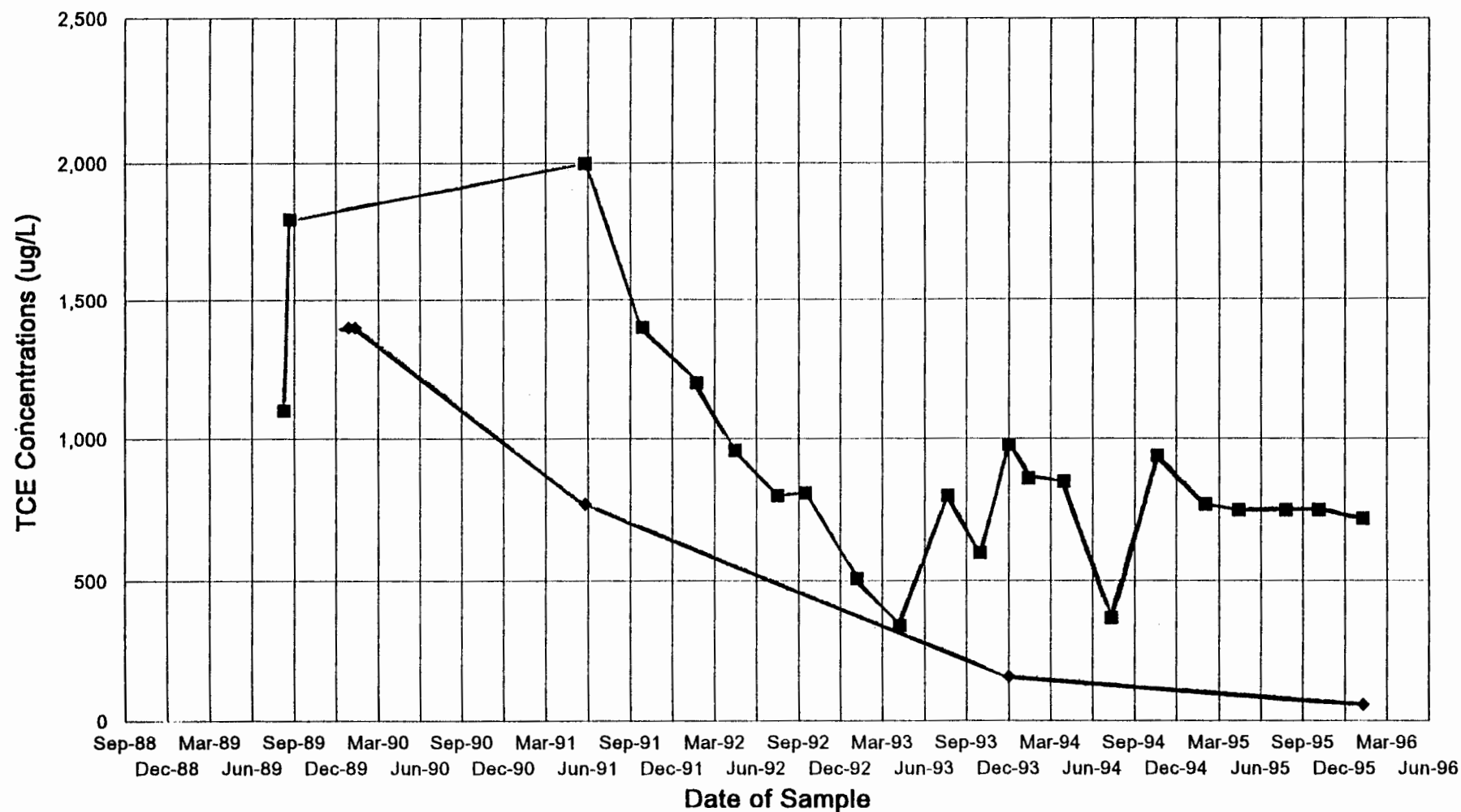
■ Monitor Well #36 (UFZ) ▲ Monitor Well #44 (ULFZ)

Cluster #6  
Offsite

**MW # 44 - ALL SAMPLES - NO DETECT (<5ug/L)**

# Sparton Technologies, Inc.

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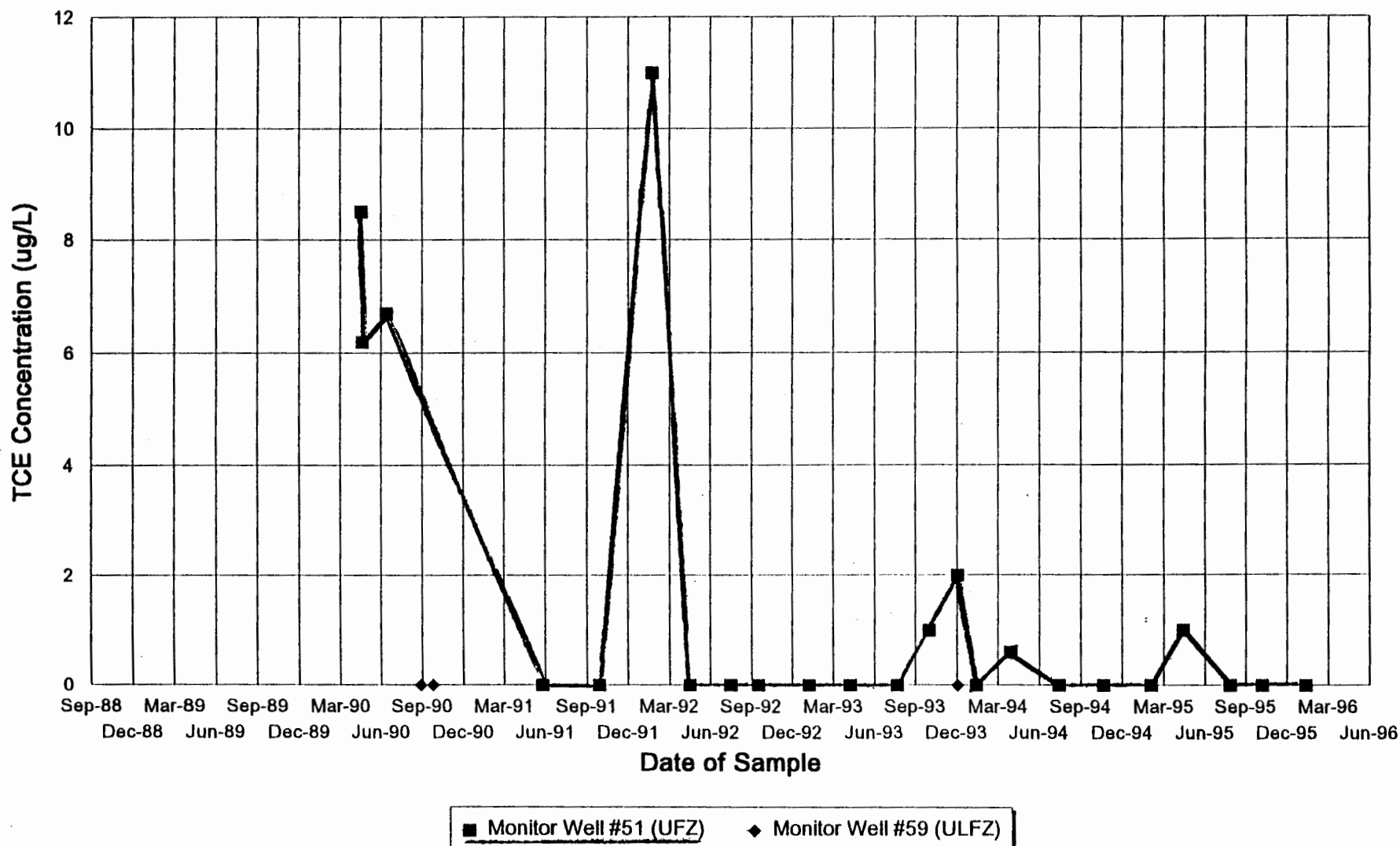


■ Monitor Well 37 (UFZ) ♦ Monitor Well 45 (ULFZ)

Cluster #7  
Offsite

# Sparton Technologies, Inc

Coors Road Facility

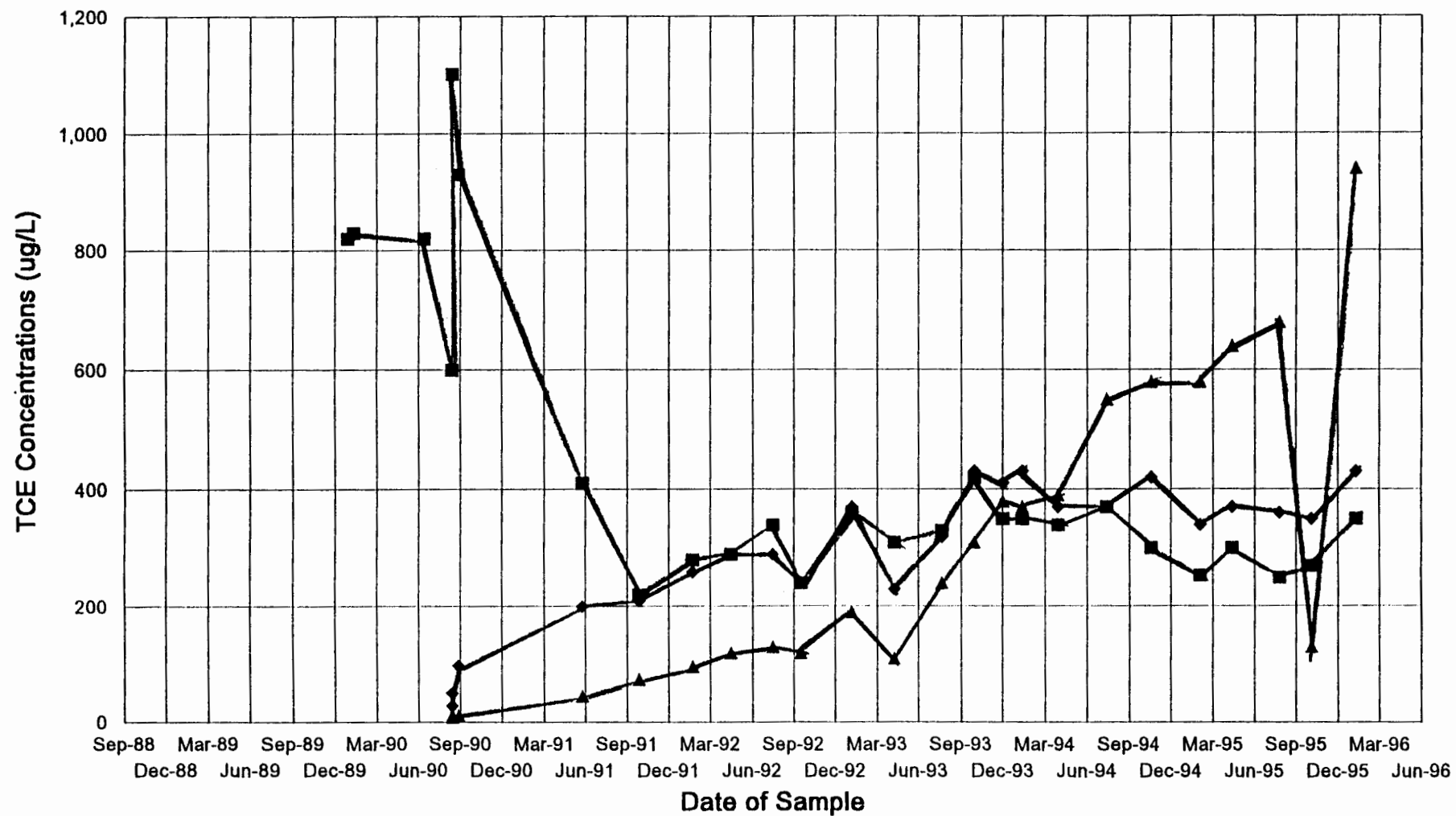


Cluster #8  
Offsite

**MW# 59 - ALL SAMPLES - NO DETECT (<5ug/L)**

# Sparton Technologies, Inc

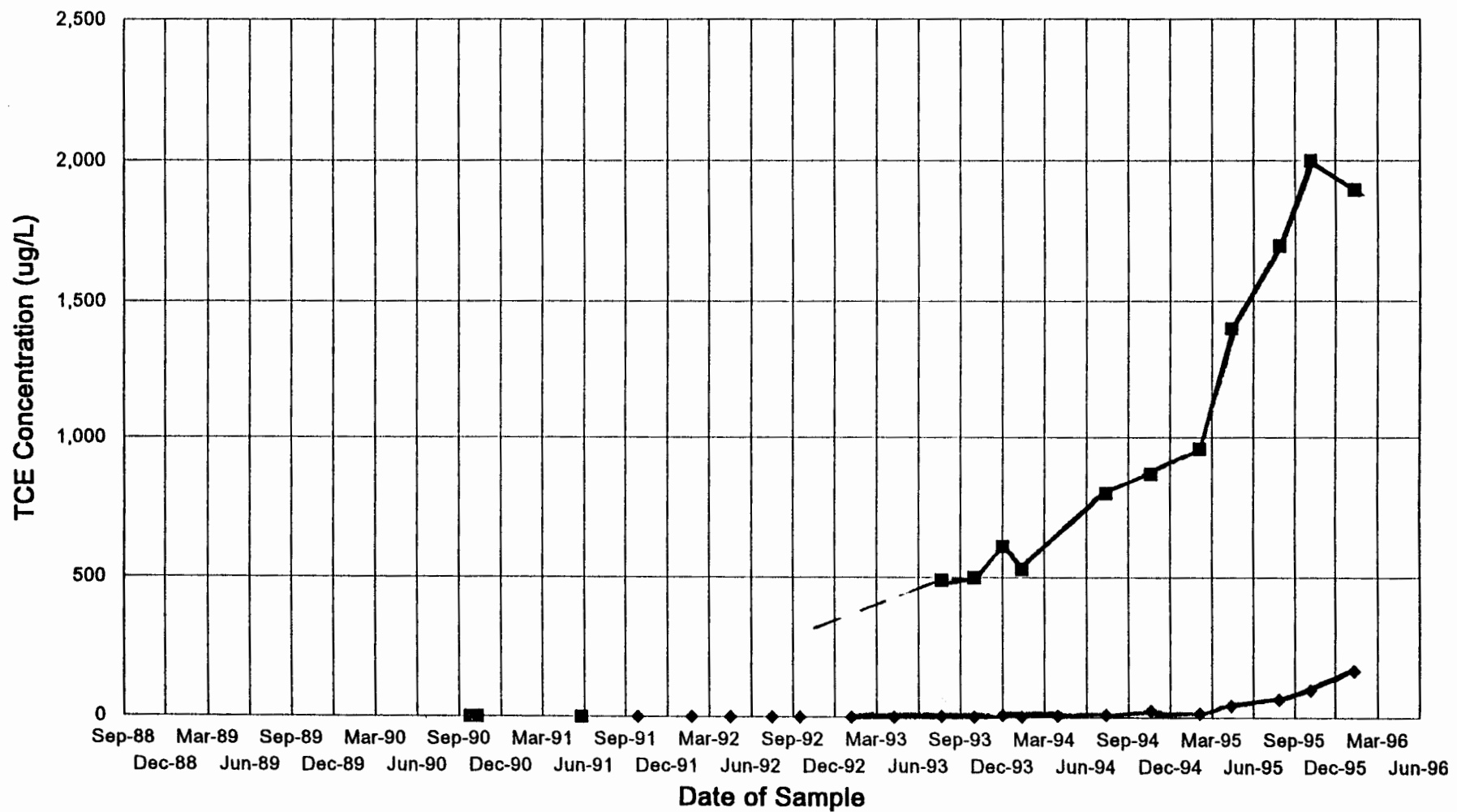
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Cluster #9  
Offsite

■ Monitor Well 48 (UFZ)    ◆ Monitor Well 56 (ULFZ)    ▲ Monitor Well 55 (LLFZ)

**Sparton Technologies, Inc**  
Coors Road Facility

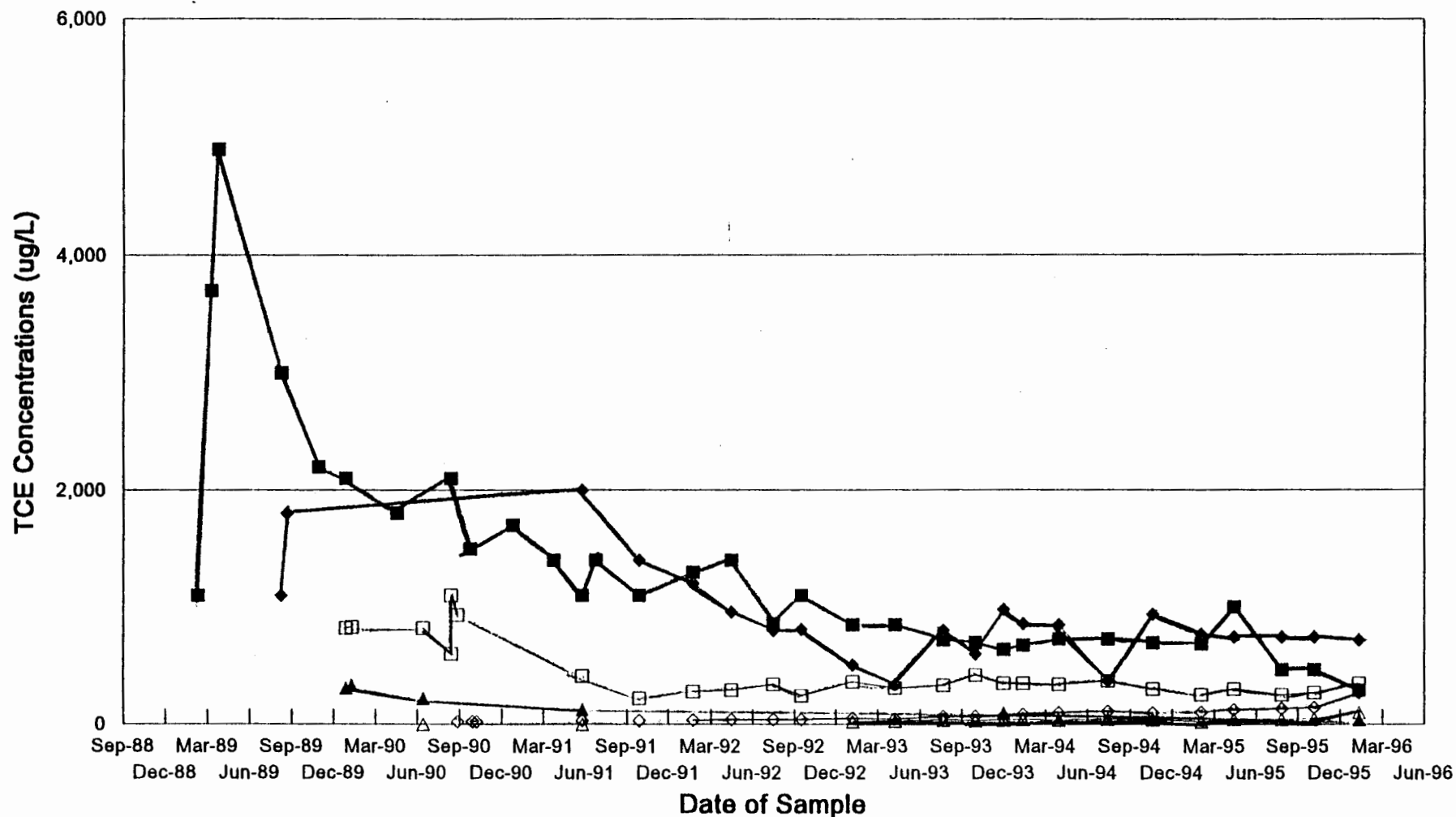


■ Monitor Well #61 (UFZ)    ◆ Monitor Well #60 (ULFZ)

Cluster #10  
Offsite

# Sparton Technologies, Inc.

Coors Road Facility

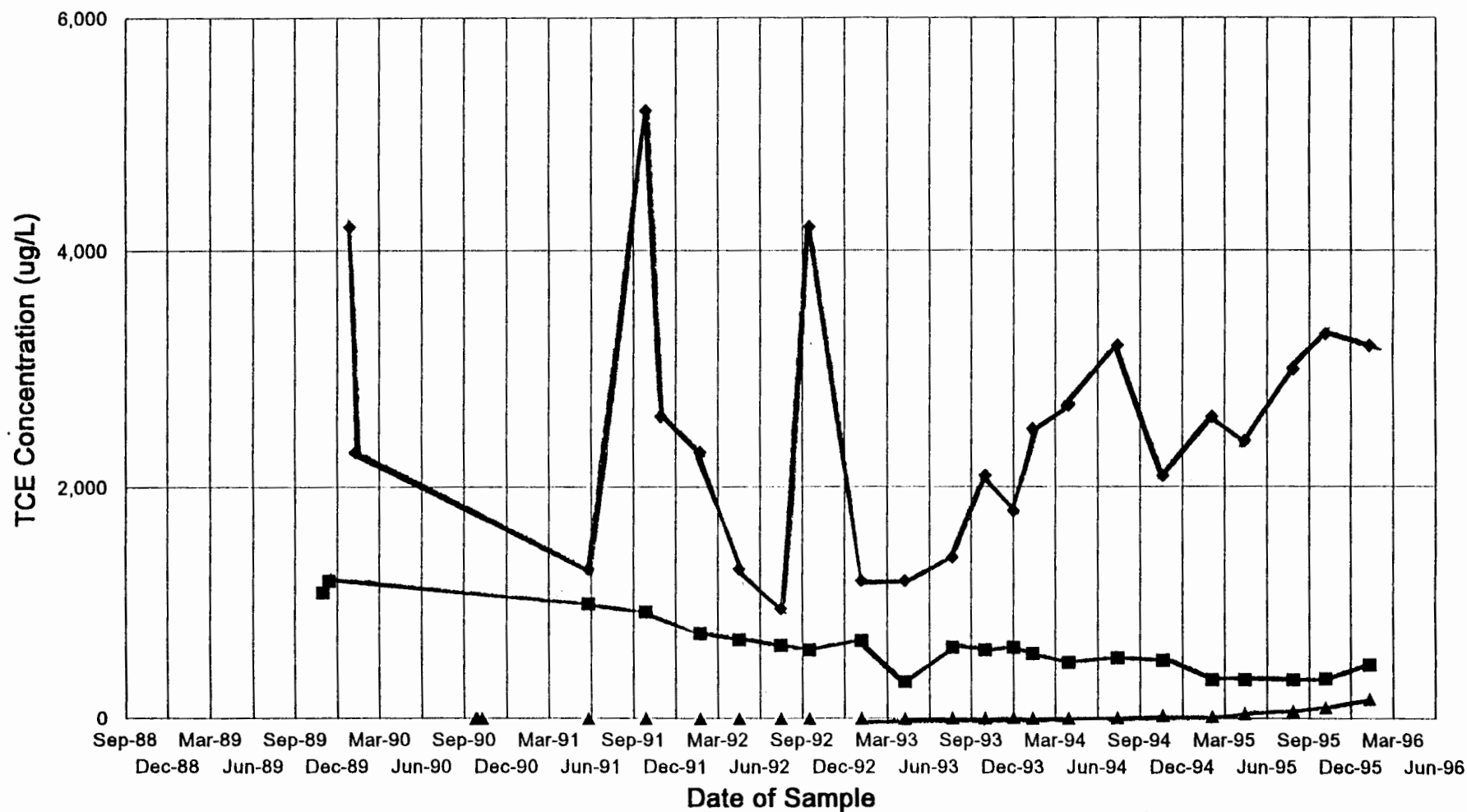


■ Monitor Well #14    ◆ Monitor Well #37    ▲ Monitor Well #47    □ Monitor Well #48    ◇ Monitor Well #58    △ Monitor Well #53

Plume Axis - UFZ  
Offsite

# Sparton Technologies, Inc.

Coors Road Facility

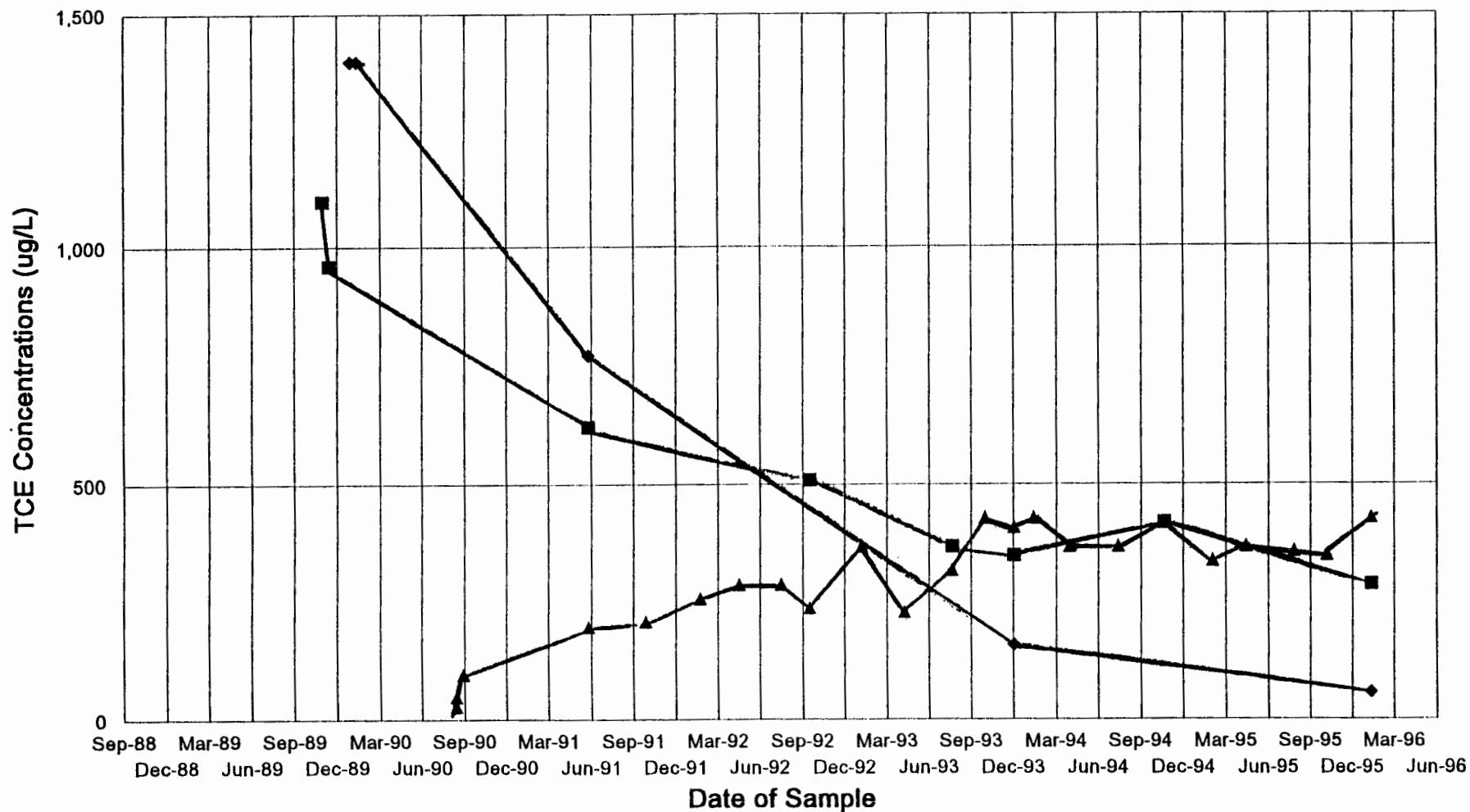


■ Monitor Well #42    ♦ Monitor Well #46    ▲ Monitor Well #60

Plume Axis - ULFZ #1  
Offsite

# Sparton Technologies, Inc.

Coors Road Facility



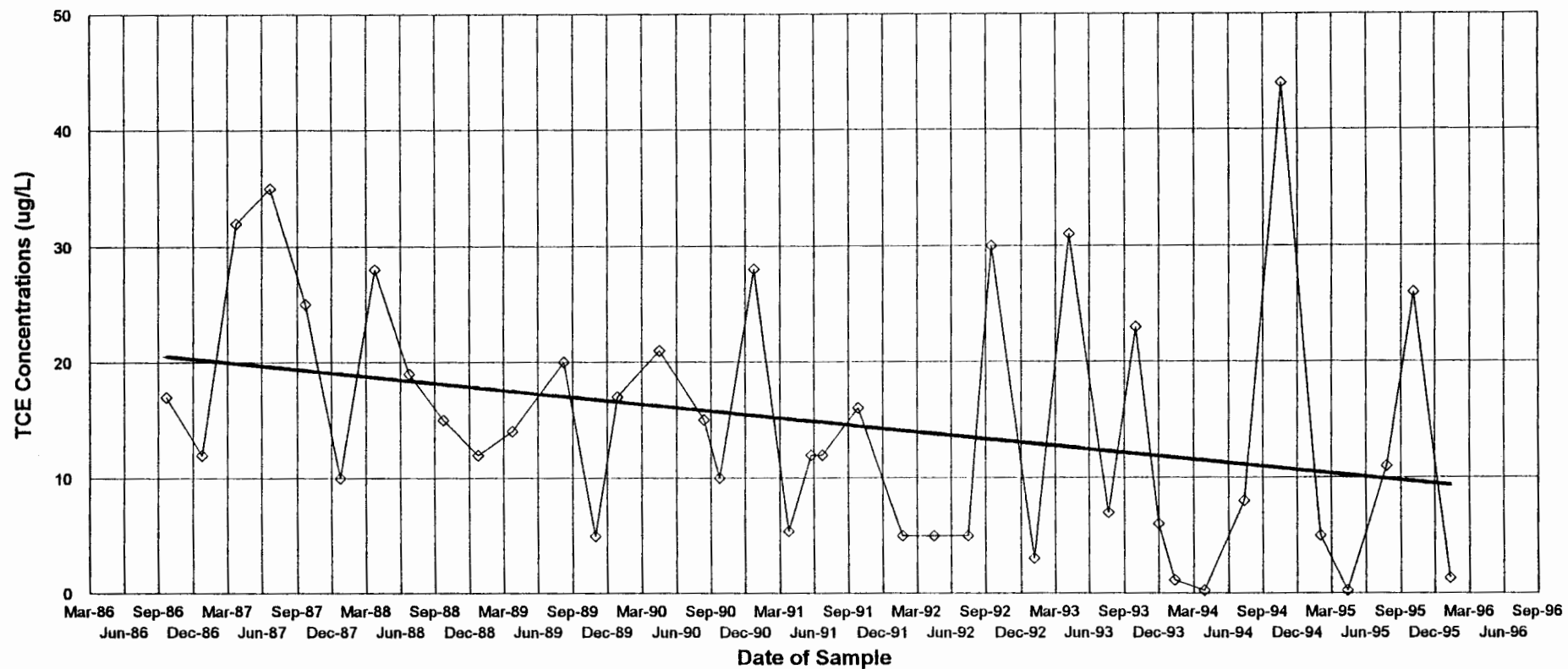
■ Monitor Well #41    ◆ Monitor Well #45    ▲ Monitor Well #56

Plume Axis - ULFZ #2  
Offsite



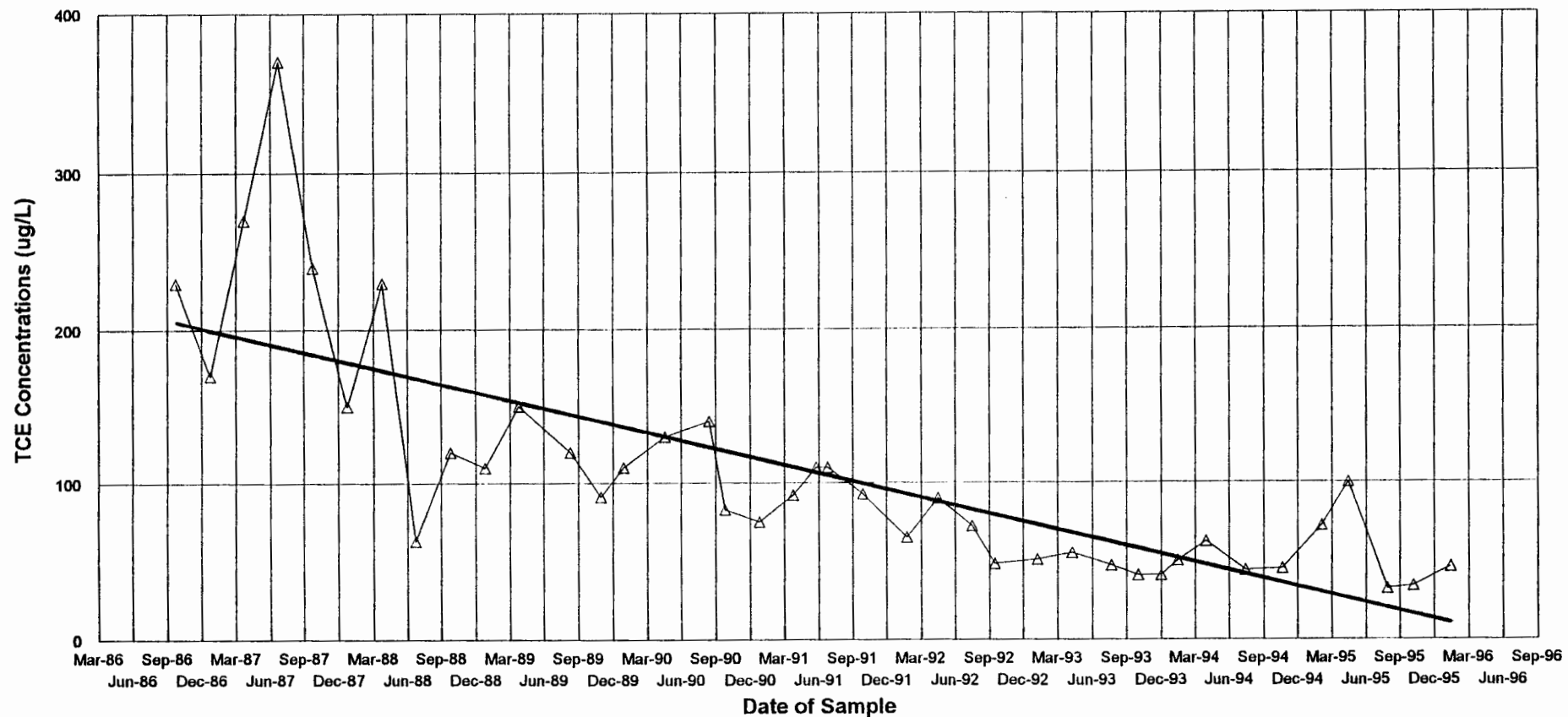
# Sparton Technologies, Inc

Coors Road Facility



◇ MW-20 (LLFZ) — Regression Line

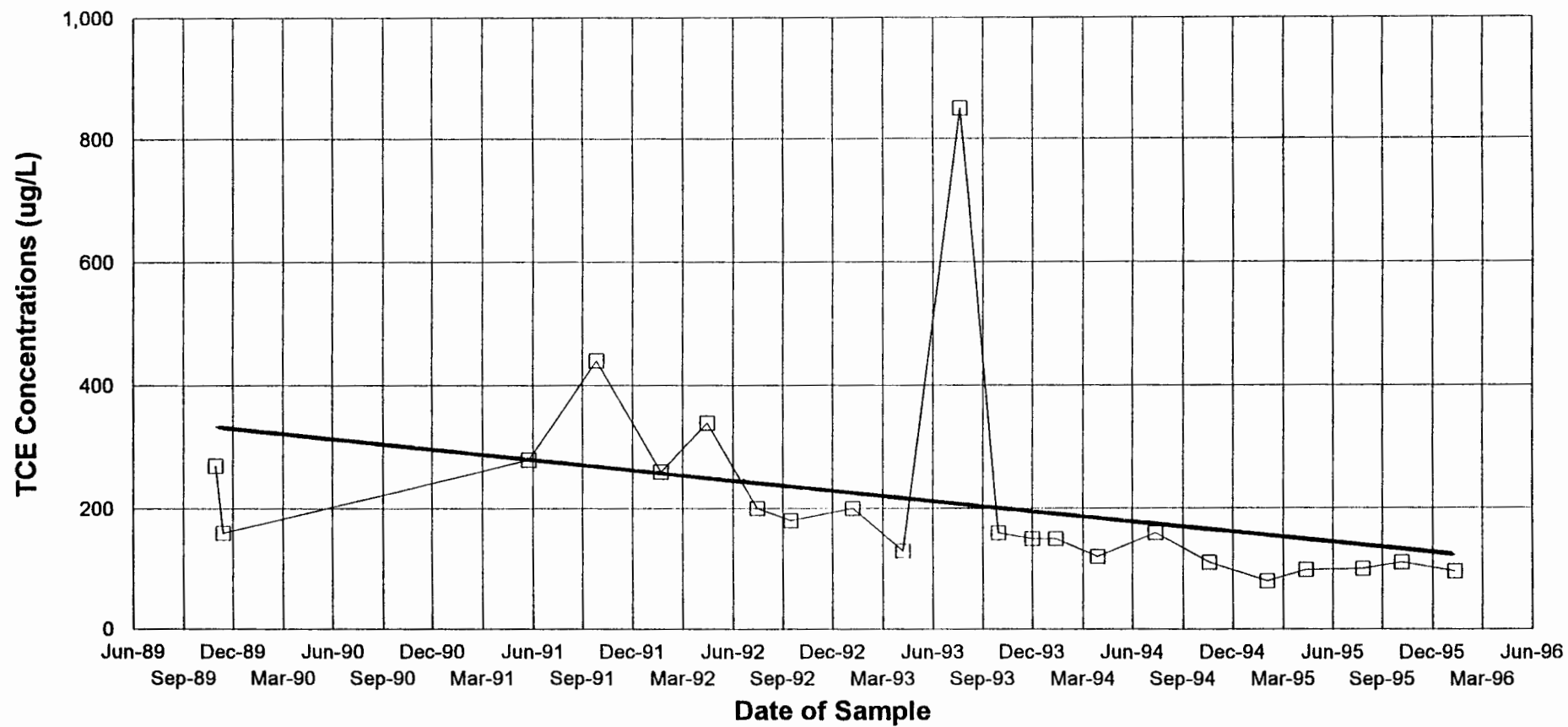
**Sparton Technologies, Inc**  
Coors Road Facility



△ MW-22 (UFZ) — Regression Line

# Sparton Technologies, Inc

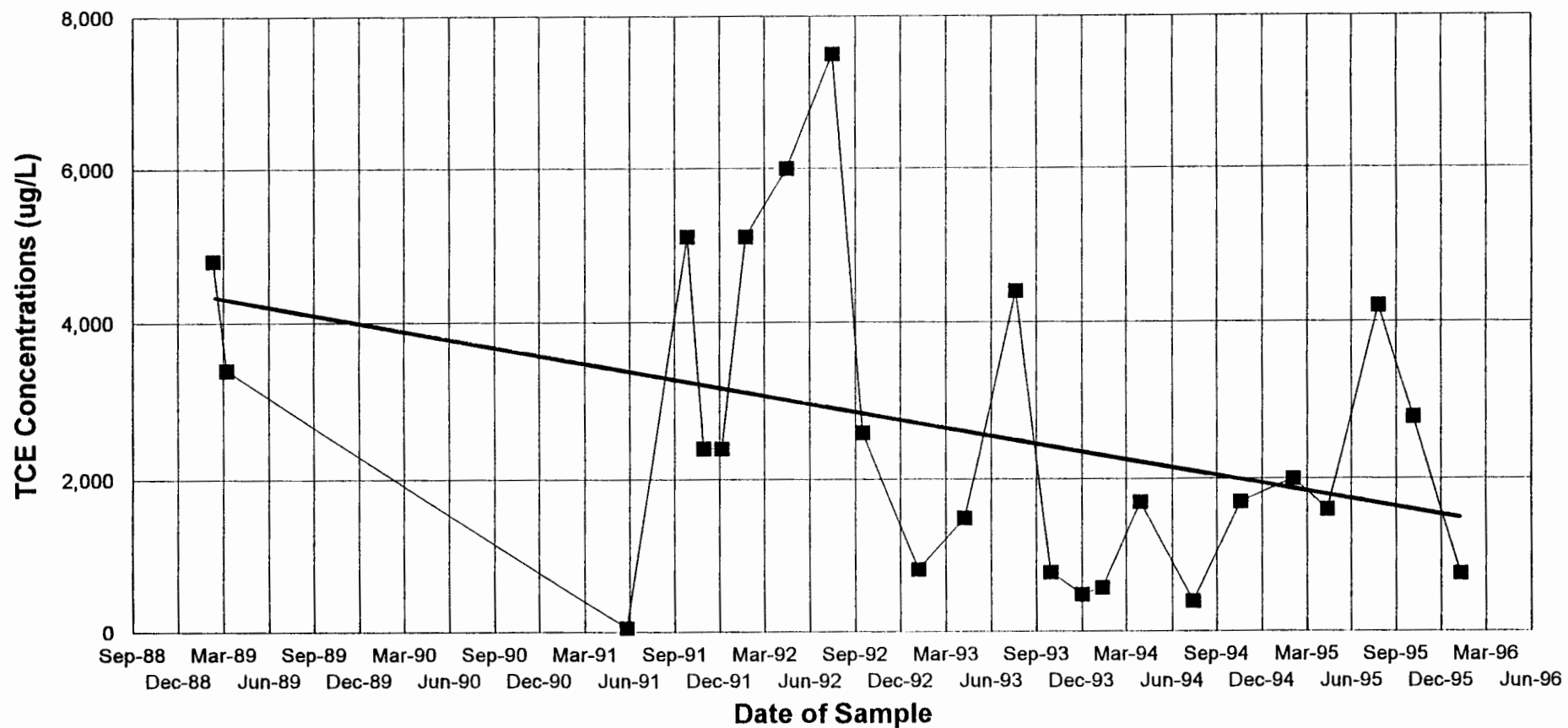
Coors Road Facility



□ MW-43 (LLFZ) — Regression Line

# Sparton Technologies, Inc

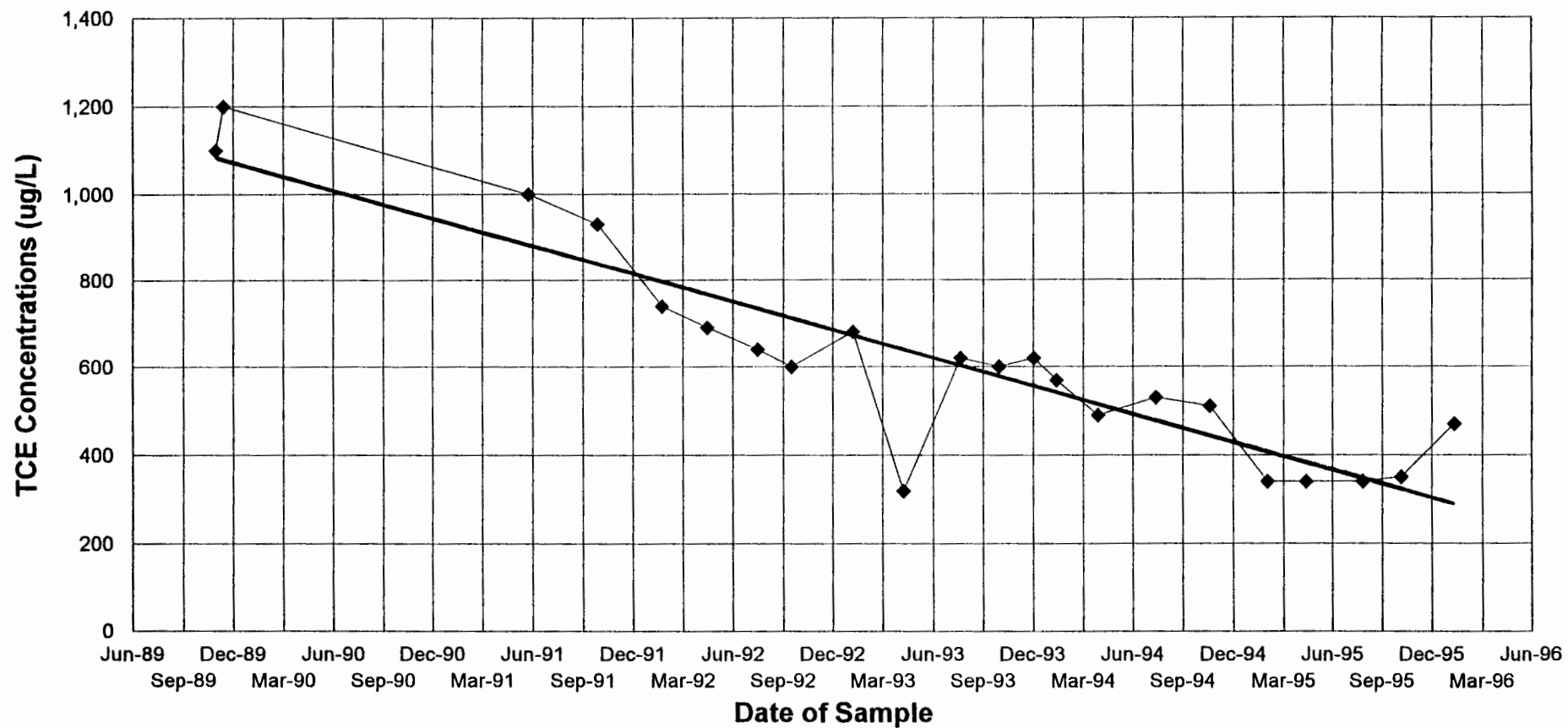
Coors Road Facility



■ MW-32 (LLFZ) — Regression Line

**Sparton Technologies, Inc**

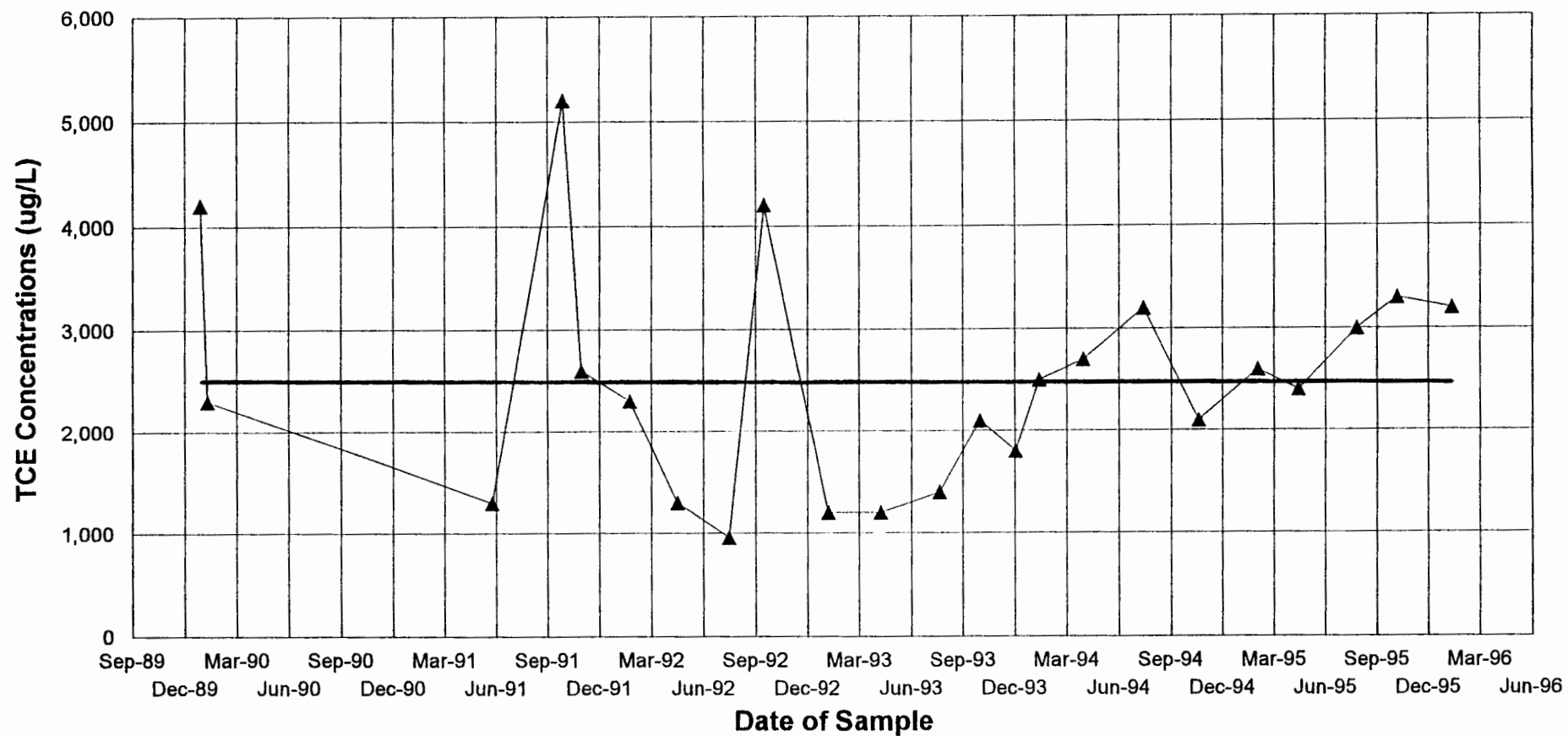
Coors Road Facility



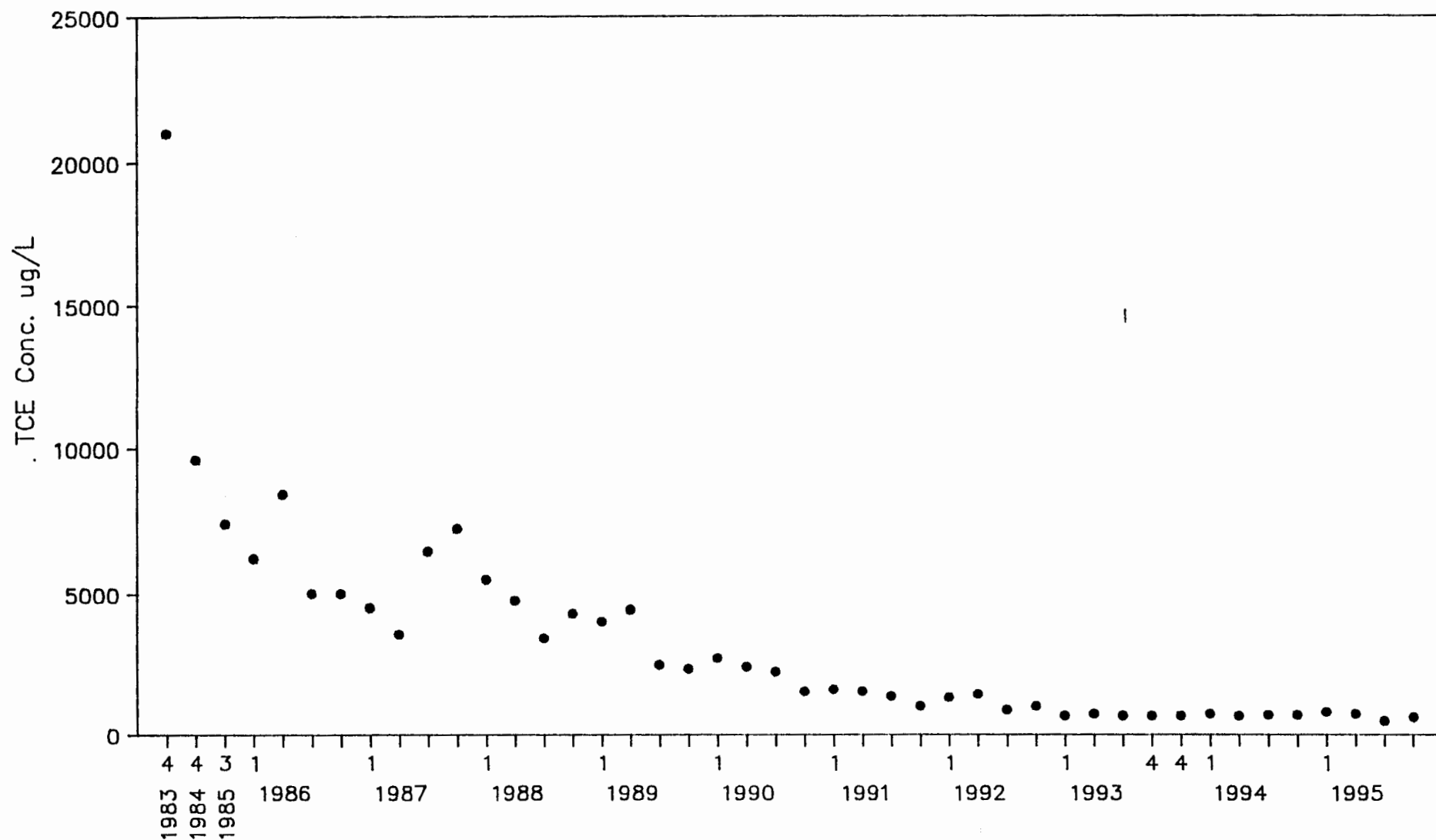
◆ MW-42 (ULFZ) — Regression Line

**Sparton Technologies, Inc**

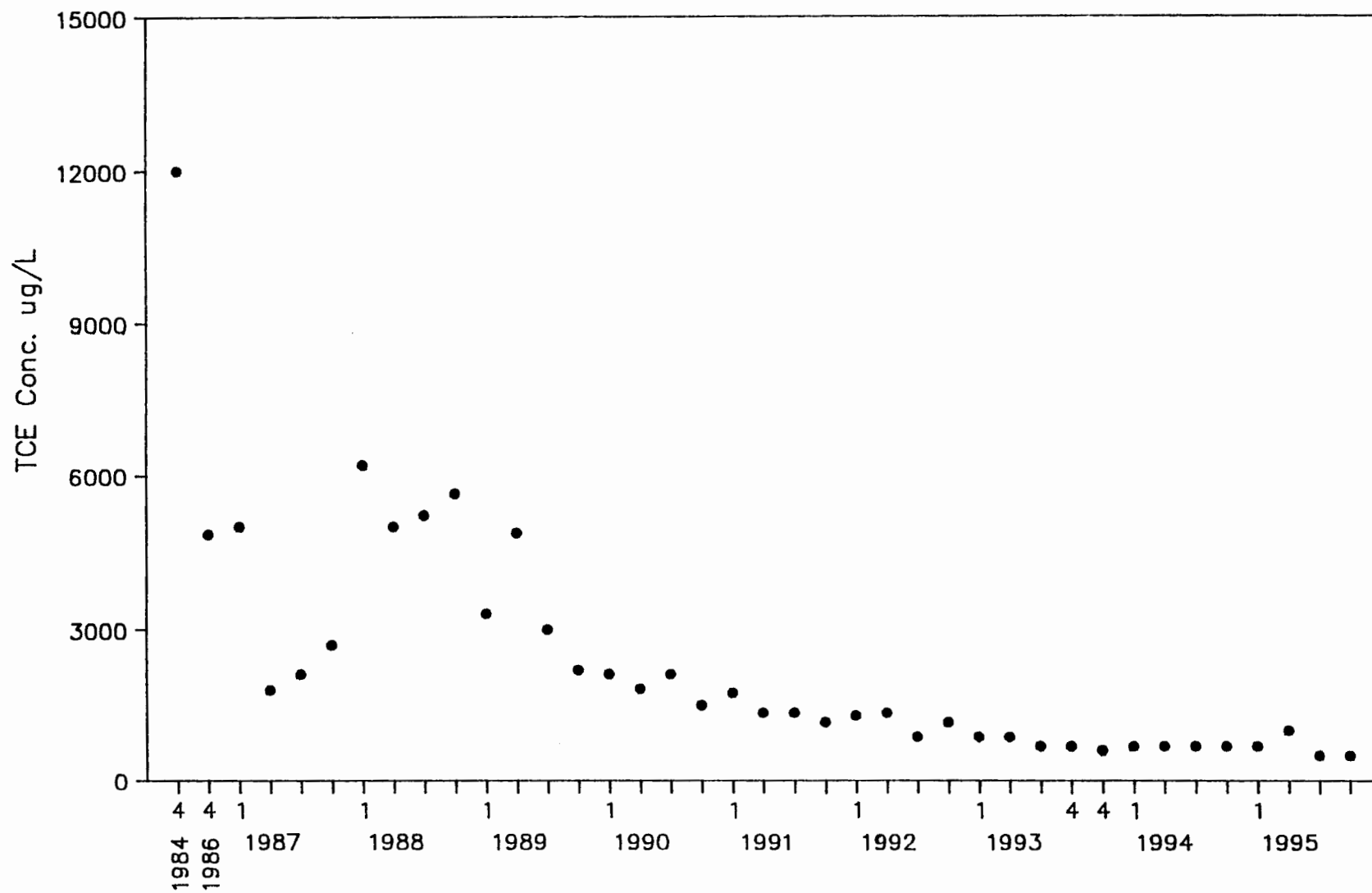
Coors Road Facility



▲ MW-46 (ULFZ) — Regression Line

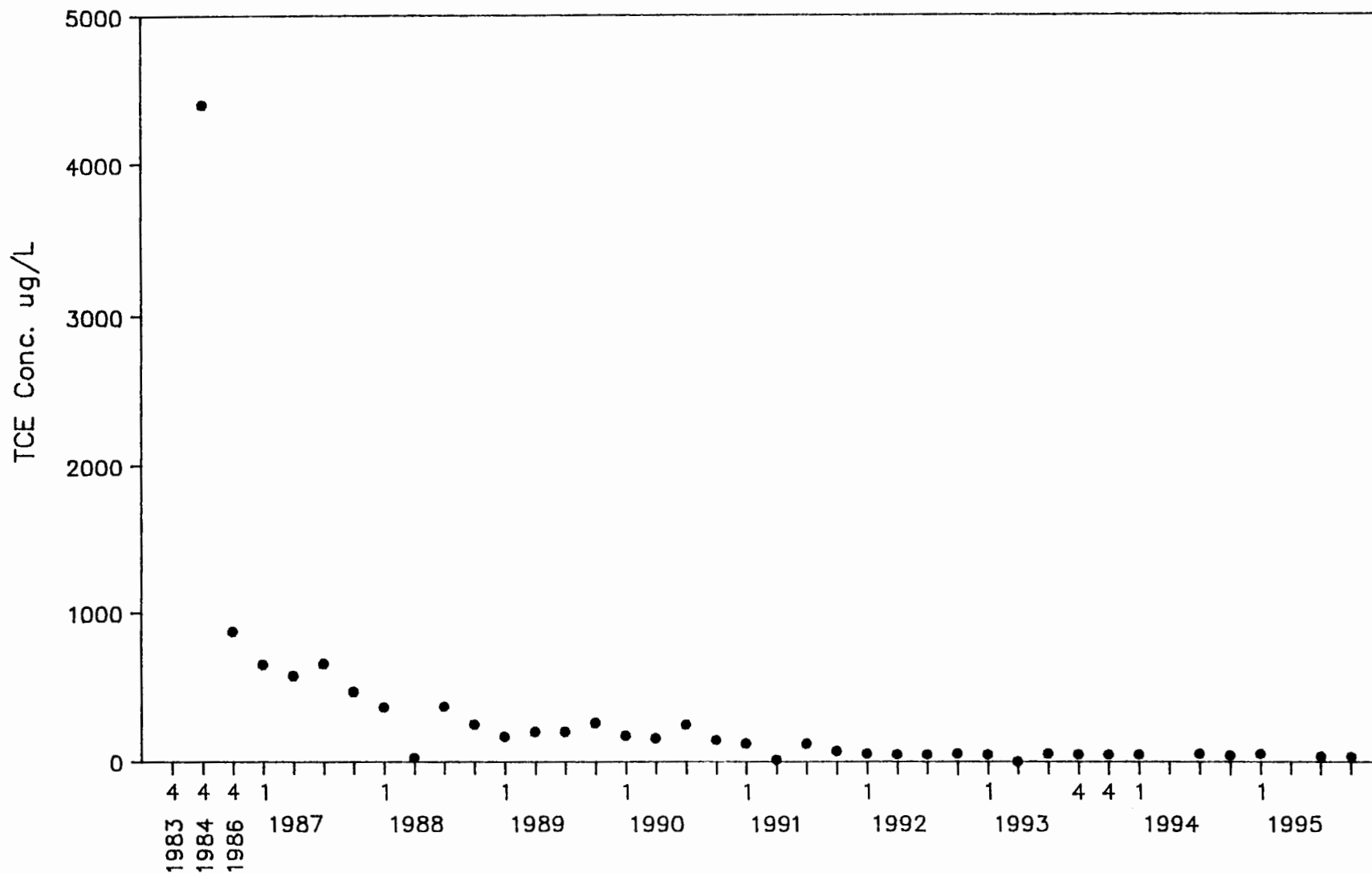


TCE CONCENTRATION VS TIME  
MW-9 (UPPER FLOW ZONE)  
SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO

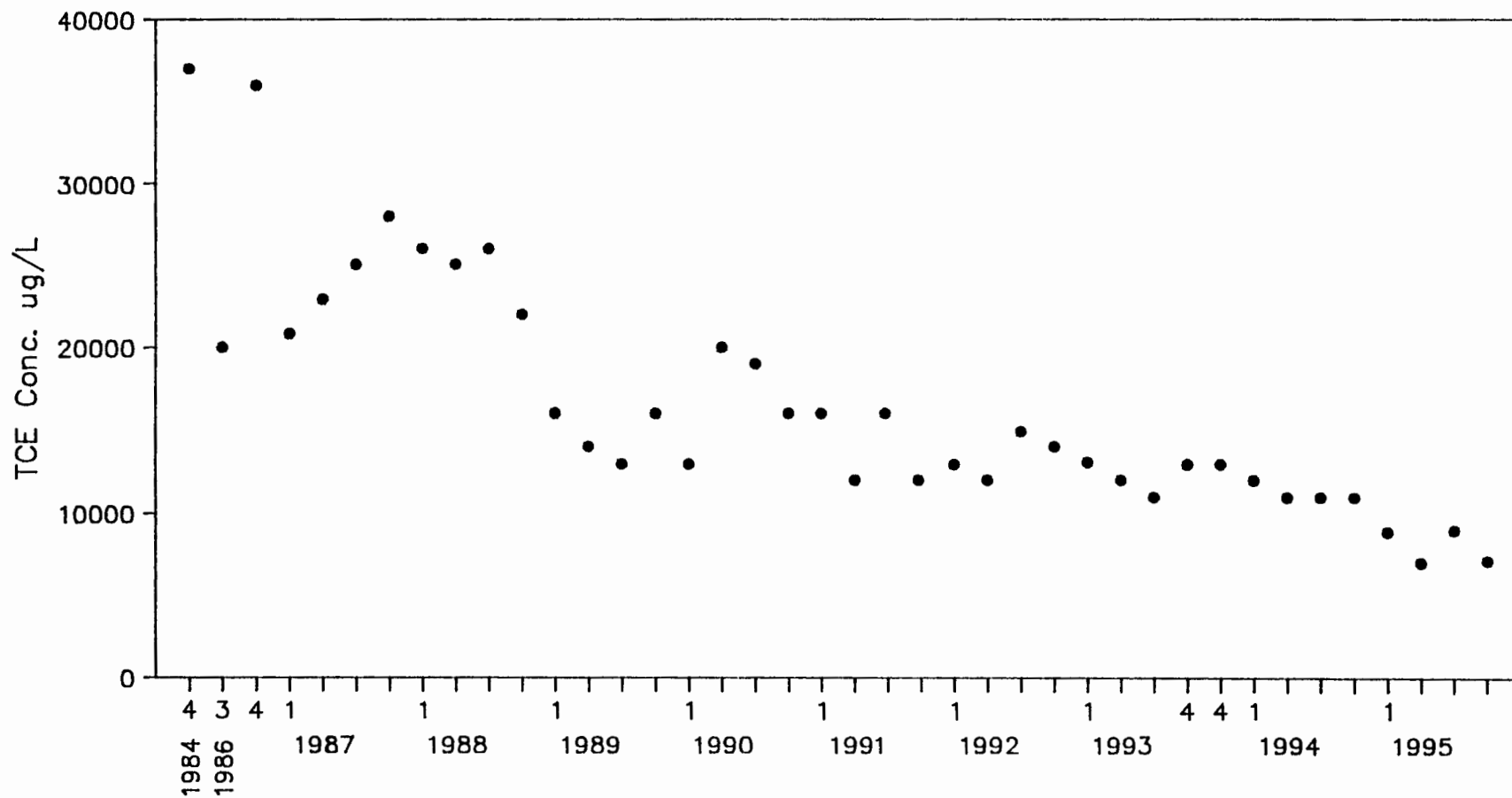


TCE CONCENTRATION VS TIME  
MW-14 (UPPER FLOW ZONE)  
SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO

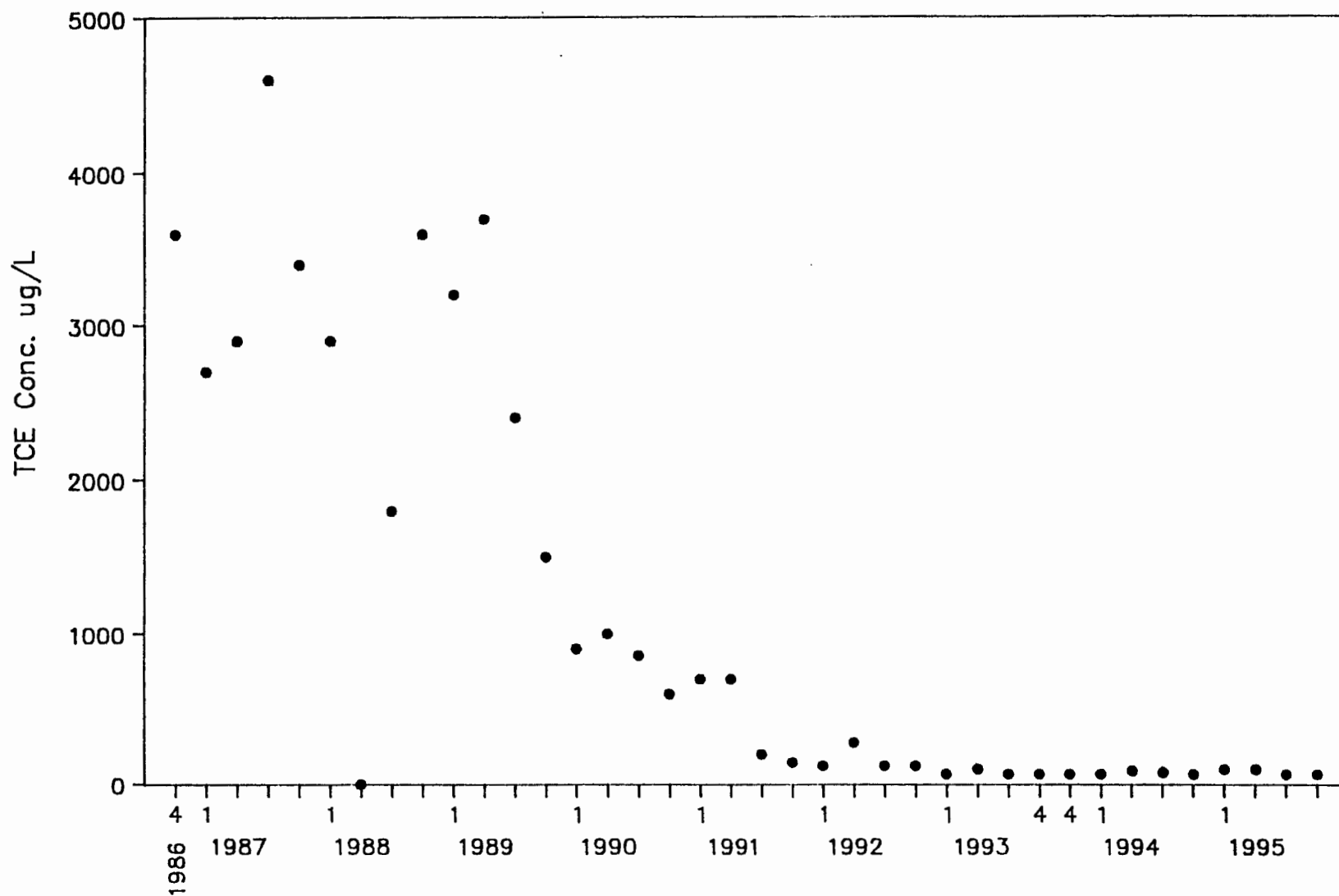




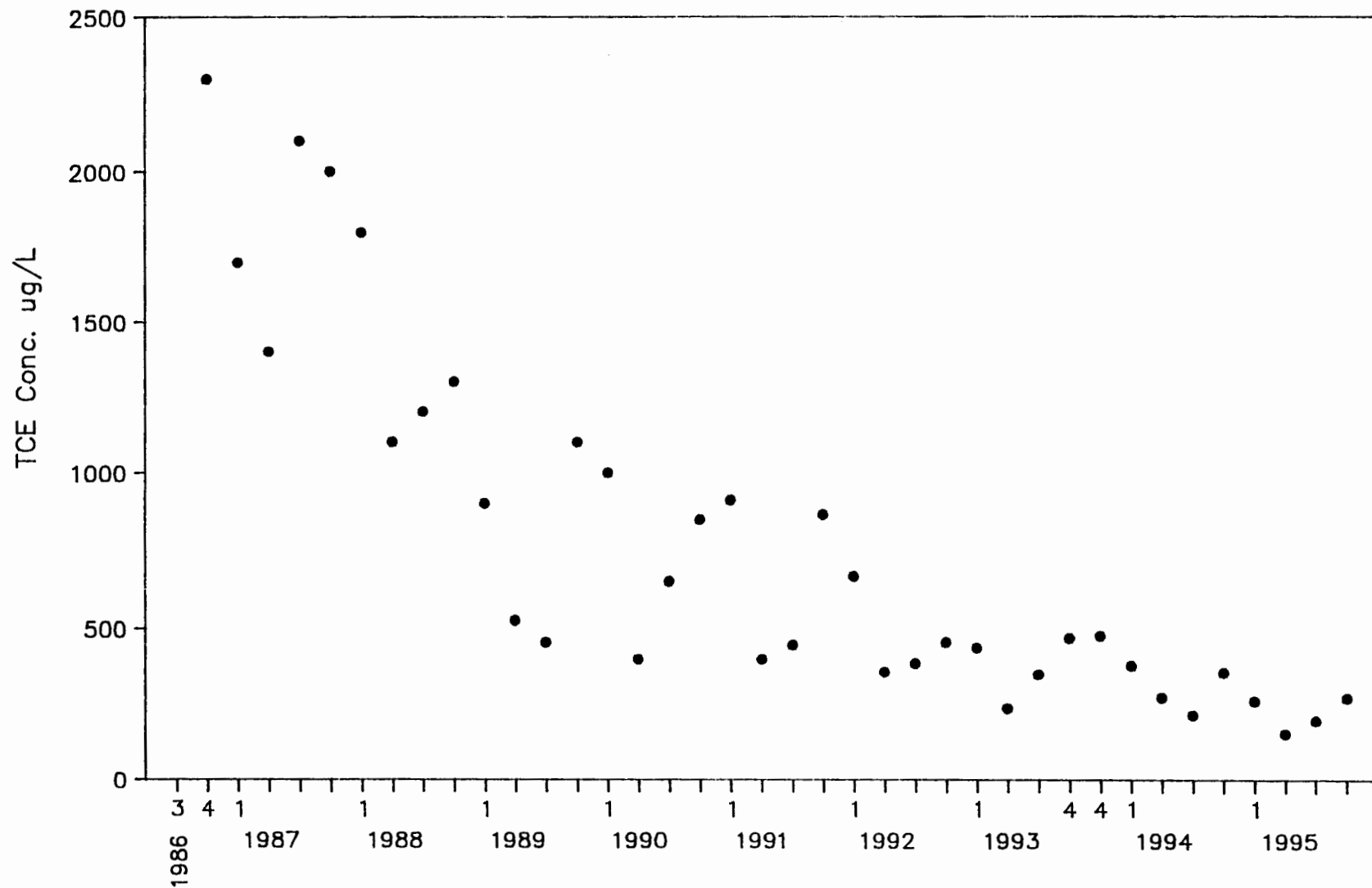
TCE CONCENTRATION VS TIME  
MW-15 (UPPER FLOW ZONE)  
SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO



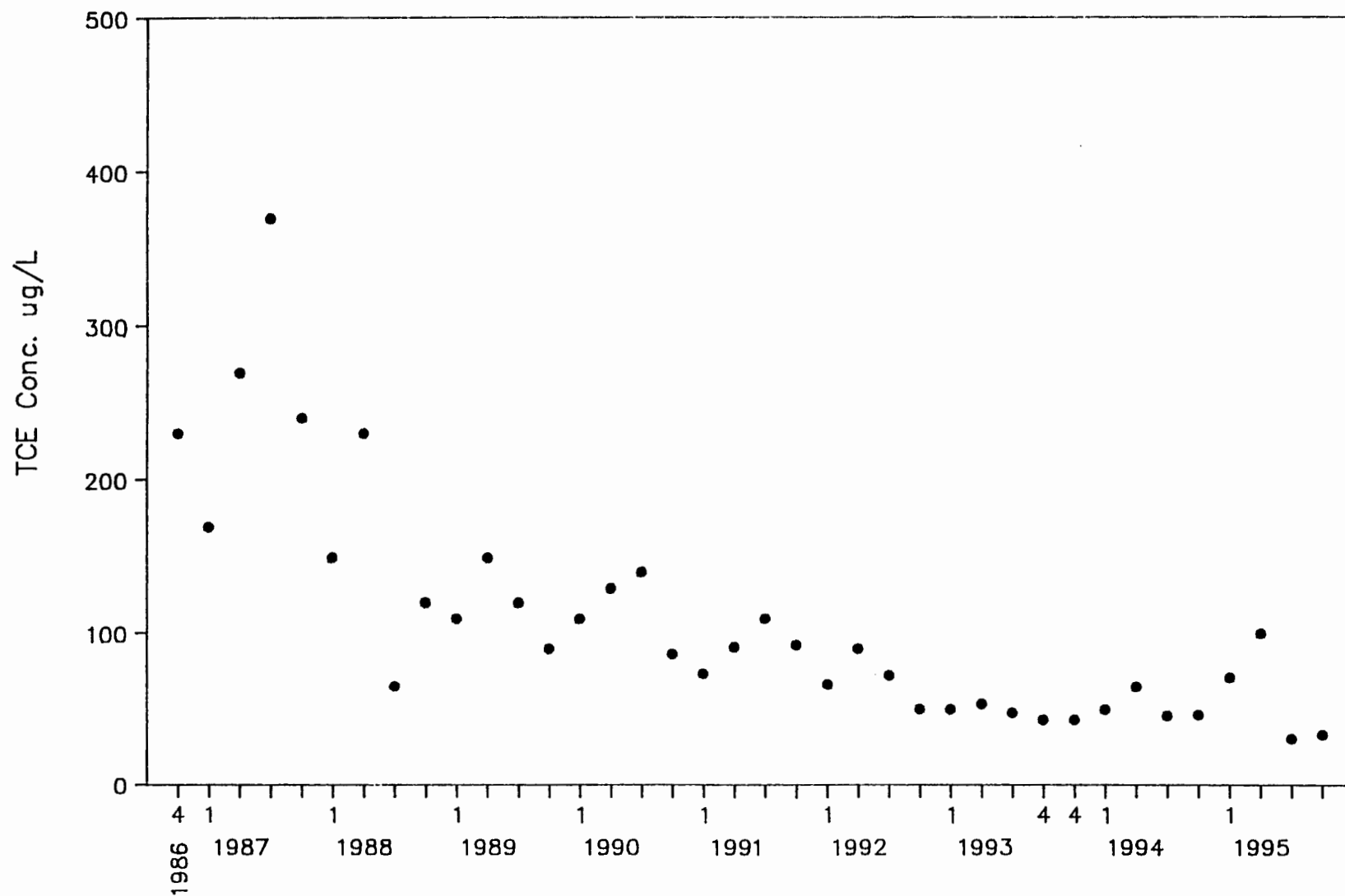
TCE CONCENTRATION VS TIME  
 MW-16 (UPPER FLOW ZONE)  
 SPARTON TECHNOLOGY, INC.  
 ALBUQUERQUE, NEW MEXICO



TCE CONCENTRATION VS TIME  
 MW-19 (UPPER LOWER FLOW ZONE)  
 SPARTON TECHNOLOGY, INC.  
 ALBUQUERQUE, NEW MEXICO



TCE CONCENTRATION VS TIME  
MW-21 (UPPER FLOW ZONE)  
SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO



TCE CONCENTRATION VS TIME  
MW-22 (UPPER FLOW ZONE)  
SPARTON TECHNOLOGY, INC.  
ALBUQUERQUE, NEW MEXICO

## **APPENDIX 2**

### **SOIL GAS MONITORING**

- a) Results of 1984, 1987 and 1991 Surface  
Soil-Gas Screening from RFI Report**

A Report Prepared for:

Sparton Technology, Inc.  
4901 Rockaway Boulevard, SE  
Rio Rancho, New Mexico

RCRA FACILITY INVESTIGATION  
Sparton Technology, Inc.  
Coors Road Facility  
Albuquerque, New Mexico

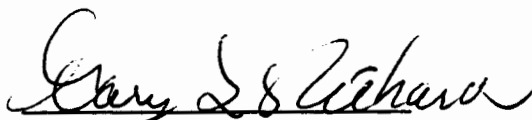
Prepared by Harding Lawson Associates  
9800 Richmond Avenue, Suite 150  
Houston, Texas 77042

December 14, 1990

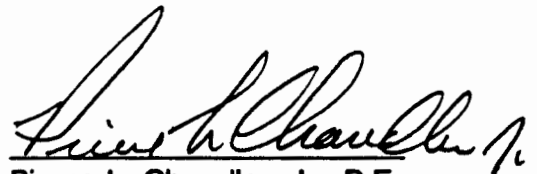
Revised by HDR Engineering, Inc.  
12700 Hillcrest Avenue, Suite 125  
Dallas, Texas 75230-2096

in conjunction with  
Metric Corporation  
8429 Washington Place NE, Suite A  
Albuquerque, New Mexico 87113

May 1, 1992



Gary L. Richardson, P.E.  
Executive Vice President  
Metric Corporation



Pierce L. Chandler, Jr., P.E.  
Senior Project Manager  
HDR Engineering, Inc.

## TABLE OF CONTENTS (Continued)

### LIST OF ATTACHMENTS

---

- |                  |                                                     |
|------------------|-----------------------------------------------------|
| <b>Volume I</b>  | 1. Alternate Groundwater Monitoring Database        |
|                  | 2. Contaminant Properties                           |
|                  | 3. Plume Delineation Database                       |
| <b>Volume II</b> | 4. Boring Logs and Well Completion Diagrams         |
|                  | 5. Groundwater Flow                                 |
|                  | 6. Unsaturated Zone Boring Logs and Analytical Data |
|                  | 7. Off-Site Investigation                           |
|                  | 8. Description of Vicinity Wells                    |
|                  | 9. June 1991 Sampling and Analysis                  |
|                  | 10. Pumping Test Analysis                           |
|                  | 11. November 1991 Sampling and Analysis of MW-32    |



**ATTACHMENT 7**

**Off-Site Investigation**

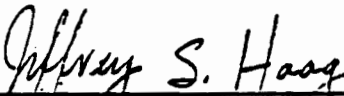
Report Prepared for


Sparton Corporation  
2400 East Ganson Street  
Jackson, Michigan 49202

OFF-SITE INVESTIGATION  
SPARTON TECHNOLOGY, INC.  
COORS ROAD PLANT  
ALBUQUERQUE, NEW MEXICO

HLA Job No. 6310,036.12

by

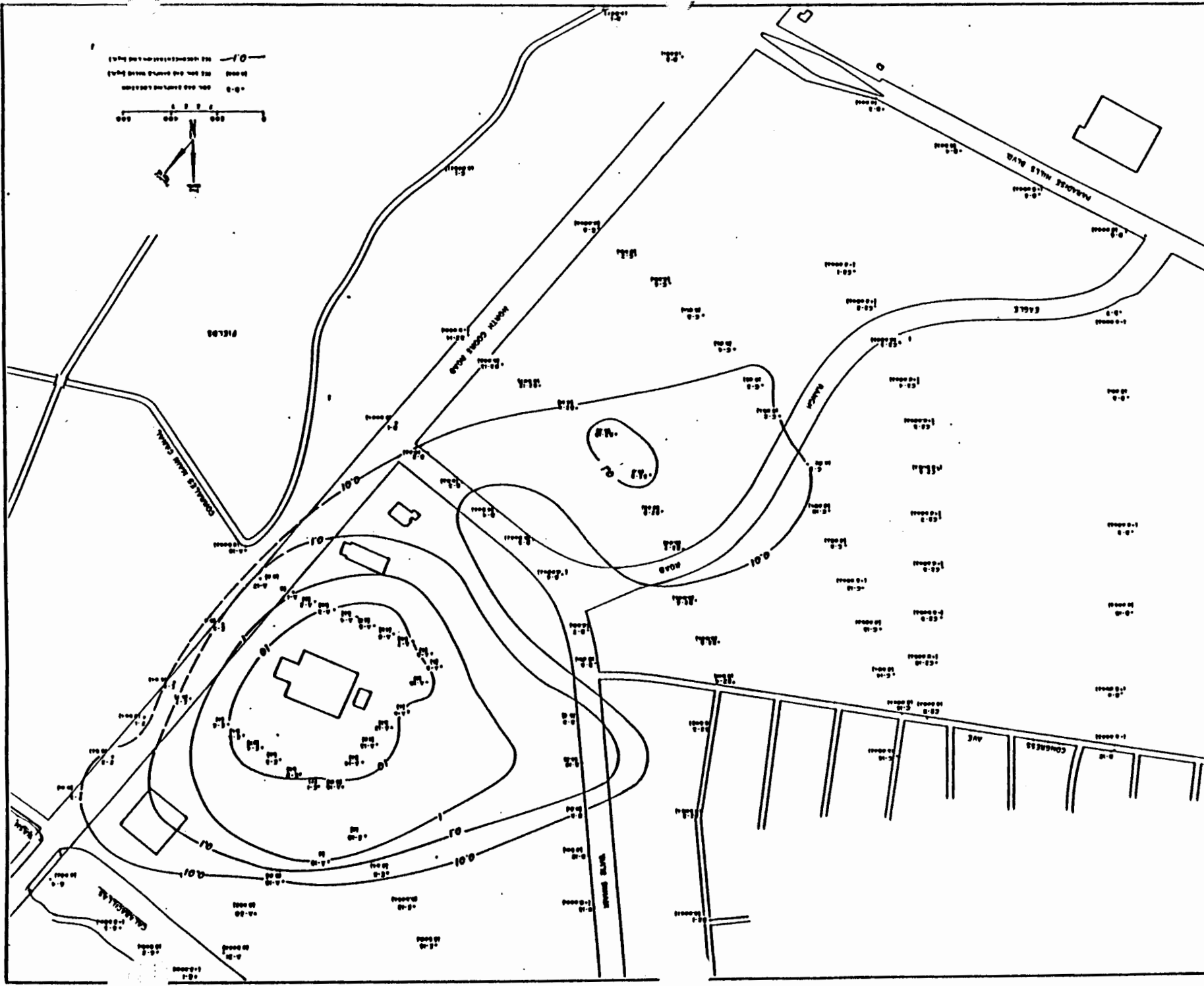
  
\_\_\_\_\_  
Jeffrey S. Haag, C.P.G.  
Senior Hydrogeologist

  
\_\_\_\_\_  
Stephen D. Phillips, C.P.G.  
Associate Hydrogeologist

Harding Lawson Associates  
6220 Westpark Drive, Suite 100  
Houston, Texas 77057  
Telephone: (713) 789-8050

October 19, 1987





**Harding Lawson Associates**  
Engineers, Geologists  
& Geophysicists

# **TCE CONCENTRATION CONTOURS** **SPARTON TECHNOLOGY, INC.** **ALBUQUERQUE, NEW MEXICO**

PLATE **4**

DRAWN:

**S.K.**

JOB NUMBER  
**6310.036.12**

APPROVED  
**J.S.H.**

DATE  
**9/10/87**

REVISED

DATE

CONFIDENTIAL  
CONSULTING REPORT

Harding Lawson Associates  
6300 Westpark, Suite 100  
Houston, Texas 77057

Soil gas investigation of volatile organic  
compounds at the Sparton Technology, Inc.  
site, 9621 Coors Road NW, Albuquerque,  
New Mexico 87114

By

Glenn M. Thompson Ph.D.  
Tracer Research Corporation  
1687 West Grant Road  
Tucson, Arizona 85745

602-623-0200

May 25, 1984

-CONFIDENTIAL-

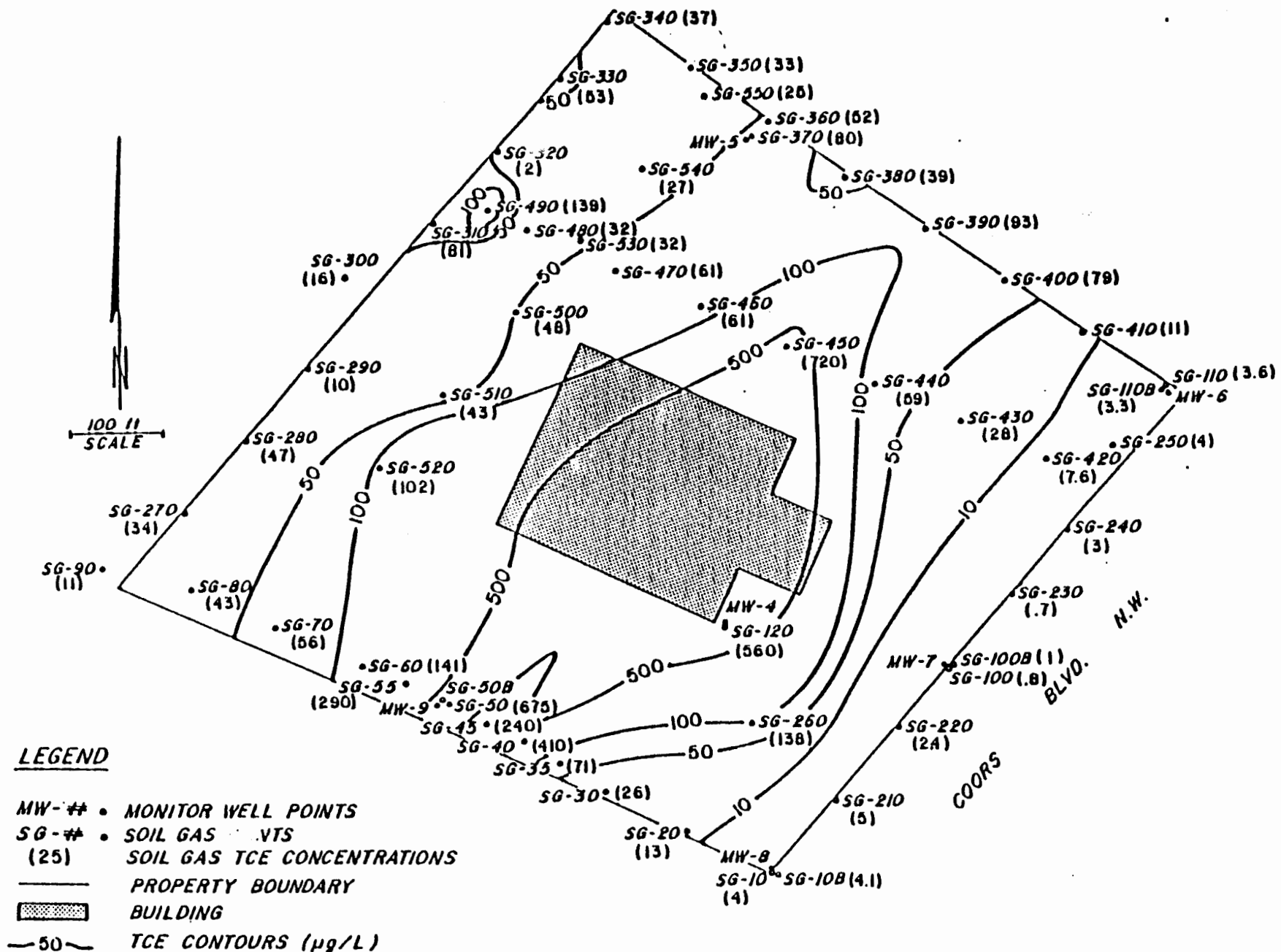


Figure 1. TCE in Soil-Gas Contour Map.

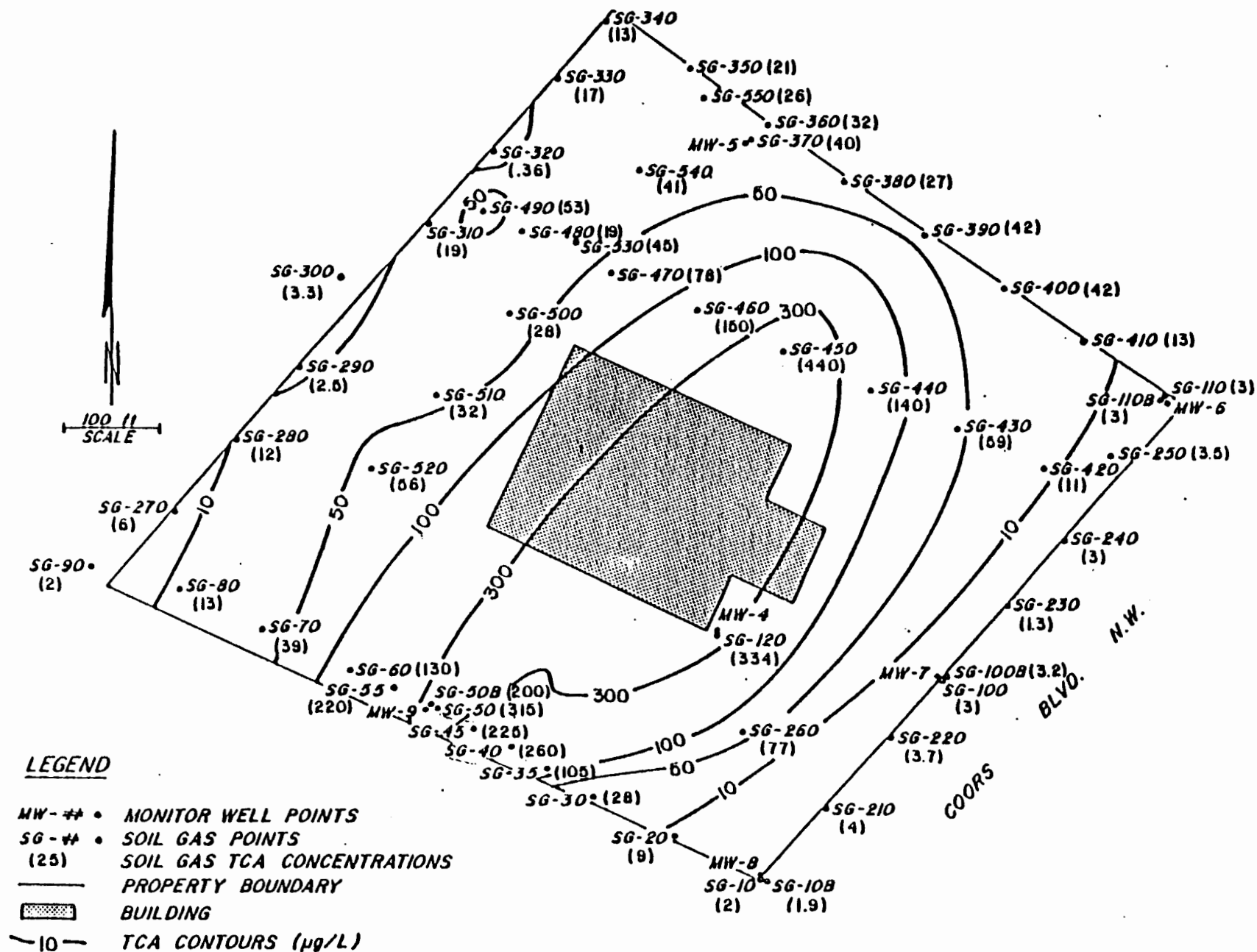


Figure 2. TCA in Soil-Gas Contour Map.

**ATTACHMENT 9**

**June 1991 Sampling and Analysis**





**PREPARED FOR:**

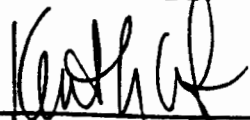
**Metric Corporation  
8429 Washington Place NE  
Suite A  
Albuquerque, New Mexico 87113  
(505)828-2801**

**SHALLOW SOIL GAS INVESTIGATION**

**SPARTAN TECHNOLOGY BUILDING  
9621 NORTH COORS ROAD  
ALBUQUERQUE, NEW MEXICO**

**JUNE 1991  
REVISED 12/91**

**SUBMITTED BY:**

  
\_\_\_\_\_  
Tracer Research Corporation

**191263S.REP  
1-91-263-S**

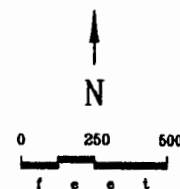
ARROYO  
RIVER

ADOBE WELLS

## EXPLANATION

- 61 Sampling Probe Location
- (12) Soil Gas Sample Value ( $\mu\text{g/l}$ )
- 10 — Isoconcentration Line ( $\mu\text{g/l}$ )

PARADISE

SPARTAN  
BUILDING

SPARTAN TECHNOLOGY

9821 NORTH COORS  
ALBUQUERQUE, NEW MEXICO

TRICHLOROETHANE (TCA)

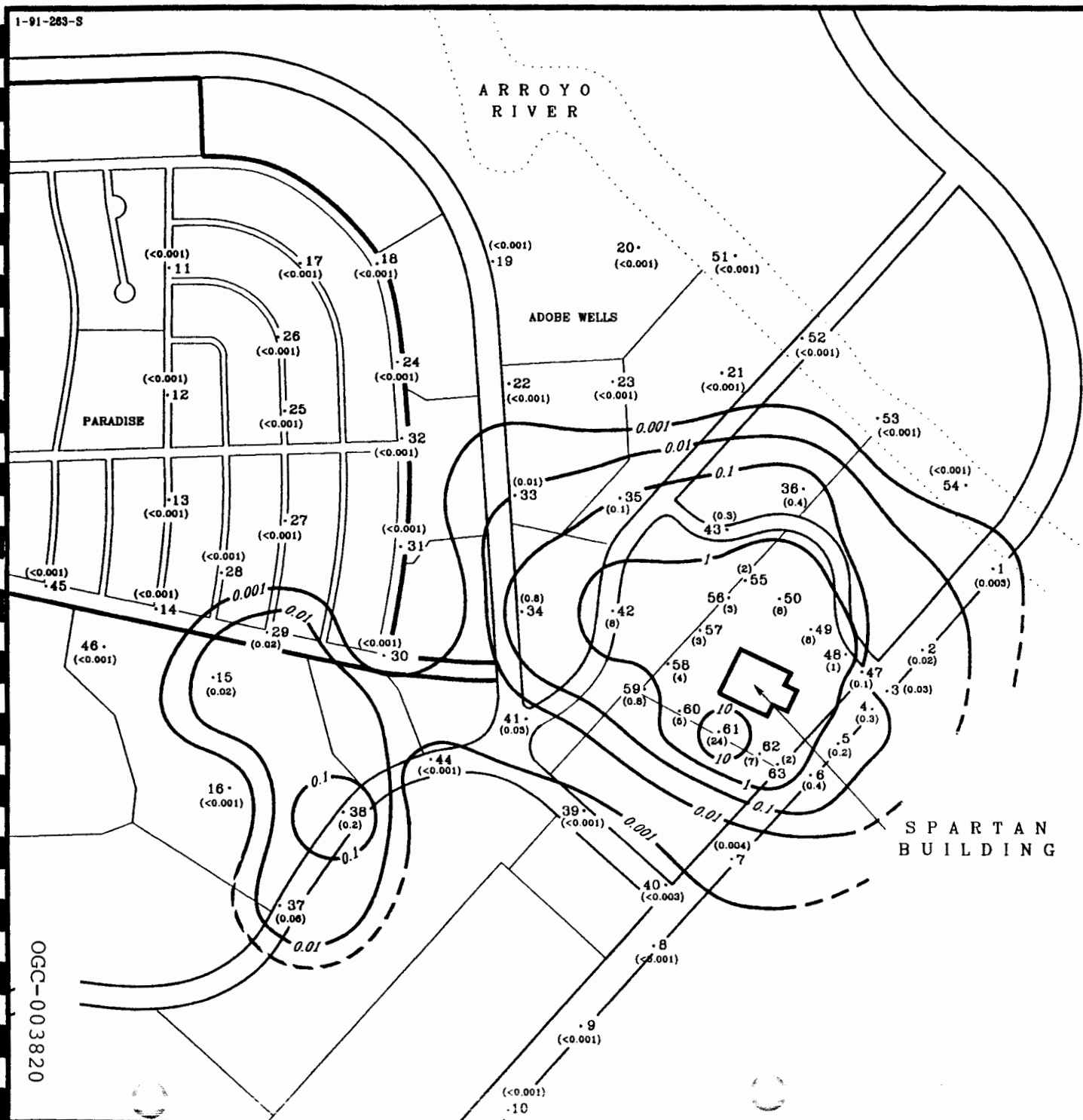
Figure 2

OGC-003819

ARROYO  
RIVER

## EXPLANATION

- 61 Sampling Probe Location  
 (84) Soil Gas Sample Value ( $\mu\text{g/l}$ )  
 -10- Isoconcentration Line ( $\mu\text{g/l}$ )



SPARTAN TECHNOLOGY

9621 NORTH COORS  
ALBUQUERQUE, NEW MEXICO

TRICHLOROETHENE (TCE)

Figure 3

**APPENDIX 2**

**SOIL GAS MONITORING**

**b) April 1996 Deep Soil-Gas Investigation Results**

Draft Final CMS - Sparton  
May 6, 1996

OGC-003821

# Sparton Technologies, Inc.

## Soil Gas to Groundwater Comparison

Monitor Well (#)	Location	TCE					TCA				
		Jan. 1996 GW Conc. (ug/l)	Predicted Soil Gas Conc. (ppmv)	Actual Soil Gas Conc. (ug/l)	Actual Soil Gas Conc. (ppmv)	Actual to Predicted	Jan. 1996 GW Conc. (ug/l)	Predicted Soil Gas Conc. (ppmv)	Actual Soil Gas Conc. (ug/l)	Actual Soil Gas Conc. (ppmv)	Actual to Predicted
7	OnSite	340.00	24.48	0.25	0.056	0.23%	92.00	2.76	ND <0.1	NA	NA
13	OnSite	380.00	27.36	14.00	3.136	11.46%	54.00	1.62	5.90	1.304	80.49%
14	OnSite	290.00	20.88	15.00	3.360	16.09%	5.80	0.17	0.29	0.064	36.83%
15	OnSite	See Note 6	NA	1.40	0.314	NA	See Note 6	NA	0.43	0.095	NA
17	Source	3,800.00	273.60	820.00	183.680	67.13%	1,100.00	33.00	550.00	121.550	368.33%
18	OnSite	See Note 6	NA	170.00	38.080	NA	See Note 6	NA	33.00	7.293	NA
21	Source	220.00	15.84	6.20	1.389	8.77%	95.00	2.85	3.60	0.796	27.92%
27	OnSite	See Note 6	NA	5.60	1.254	NA	See Note 6	NA	3.40	0.751	NA
33	OnSite	2,000.00	144.00	1.30	0.291	0.20%	160.00	4.80	0.13	0.029	0.60%
37	OffSite	720.00	51.84	4.60	1.030	1.99%	ND <10	NA	ND <0.1	NA	NA
48	OffSite	350.00	25.20	ND <0.03	NA	NA	ND <1	NA	ND <0.1	NA	NA
57	OffSite	ND <0.3	NA	ND <0.03	NA	NA	ND <1	NA	ND <0.1	NA	NA
61	OffSite	1,900.00	136.80	0.59	0.132	0.10%	13.00	0.39	ND <0.1	NA	NA

### NOTES:

- Predicted soil gas concentrations obtained using gas constants from Henry's Law (HL).  
 $\text{gas concentration (ppmv)} = \text{HL} * \text{water concentration (ug/l)}$   
 HL gas constant for TCE      0.072  
 HL gas constant for TCA      0.030
- Soil gas concentrations (ppmv) were calculated from laboratory data using the following conversion  
 (Albuquerque conditions, P = 621 mm Hg; T = 20 deg. Centigrade)  
 $C \text{ (ppmv)} = 0.224 * C \text{ (ug/l)} \text{ (TCE)}$   
 $C \text{ (ppmv)} = 0.221 * C \text{ (ug/l)} \text{ (TCA)}$
- Onsite location indicates Monitor Well is on Sparton Property.
- Offsite location indicates Monitor Well is not on Sparton Property.
- Source location indicates Monitor Well is on Sparton Property in the vicinity of the original source.
- Groundwater data not available.

# SPARTON TECHNOLOGY, INC.

## Monitor Well Vapor Sampling

**Introduction:** This test procedure was initiated to collect vadose zone soil gas data immediately above the water table. Several UFZ wells screened across the water table were selected for the test, see attachment 1 for all UFZ wells elevation data. Initially 21 wells were selected for testing with two in reserve pending analytical results, MW-7, 13, 14, 15, 17, 21, 33, 36, 37, 47, 48, 52, 53, 57, 58, 61, also recovery wells MW-18, 24, and 27, and wells in reserve MW-51 and 63. MW-16, in the source area was rejected as the water level elevation was above the top of the well screen. Recovery well MW-24 in the source area was substituted for MW-16. As analytical data became available other wells were rejected. The final count was 13 wells sampled, MW-7, 13, 14, 15, 17, 18, 21, 27, 33, 37, 48, 57 and MW-61 with 2 samples rejected as invalid, MW-24 and MW-25, see text.

**Procedure:** Calibrate PID at the start of each day. Test and/or calibrate PID between wells. Unlock and open well, take an initial PID reading, determine water level elevation and casing air volume. Pull dedicated sampling equipment and install test plug. Install approximately 3 feet of vinyl tubing to test plug via 1/8 in. brass hose barb and a Parker Quick-Connect fitting. The other end of the vinyl tubing was run through the pressure wall of the Xitech sampler and connected to the vacuum line via a brass hose barb. The rest of the purging apparatus was connected as illustrated on the attached drawing, see photographs also. The end of the air discharge line was taped to the sampling port of the PID and this was inserted and sealed with tape into a 50 gal plastic bag. The plastic bag was inserted into a 32 gal steel drum to approximately measure evacuated air volume. The portable vacuum pump was started and PID (ppm TCE), flowrate (SCFH), and vacuum (in. of Hg) readings were taken see field notes in attachment 2. When at least 3 casing volumes of air were purged and some semblance of stability achieved for PID readings the vinyl sampling tube was pinched near point 3, the sample tube was disconnected from the vacuum line at point 3, see illustration. The sample tube was then connected to a SKC tedlar bag, the crimp in the vinyl tubing was released, the tedlar valve was opened and the sample bag was sealed inside the Xitech Box. Xitech vacuum pump turned on and well vapor sample drawn into the bag. When the bag was full the vacuum pump was turned off, Xitech vent valve opened allowing access to sample bag. The tedlar bag valve was closed, sample tube disconnected, tedlar bag was labeled and placed in a cooler, see photographs. All equipment was disconnected. The test plug and brass hose barb fittings were decontaminated via an Alconox wash and DI water rinse. Vinyl sample tube was disposed after each use.

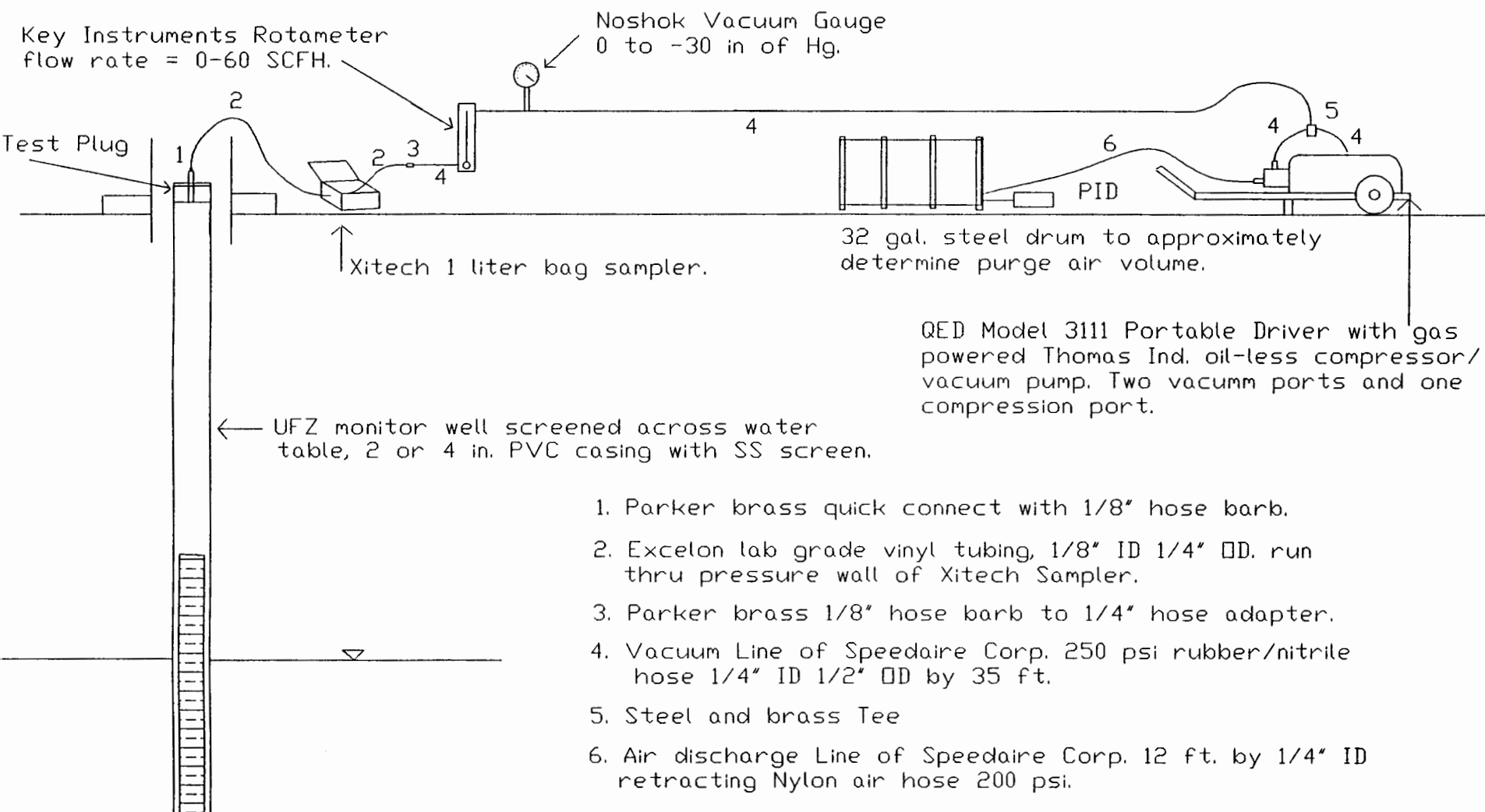
**Results:** See enclosed tables and data summaries.

## SPARTON TECHNOLOGY, INC.

Equipment Illustration For  
Monitor Well Vapor Sampling

April 10, 1996

Not to Scale



**TABLE 1**  
Summary of Sampling Data and TCE Gas Concentration

Well No.	Date Sampled	Elev top of scrn	WLE	PID* ppm TCE	Vacuum in of Hg	Flowrate SCFH	TCE mg/m3
MW-7	04/10/96	4981.30	4977.82	2.2	14.2	47	0.25
MW-13	04/10/96	4983.25	4975.26	2.3	12.9	58	14
MW-14	04/12/96	4980.41	4972.39	2.5	11.5	45	15
MW-15	04/11/96	4987.49	DRY	1.0	14.0	55	1.4
MW-17	04/10/96	4982.28	4979.20	96.5	12.0	59	820
MW-18	04/10/96	4977.58	4967.81	39.3	13.0	70	170
MW-21	04/12/96	4983.86	4978.84	0.0	9.5	39	6.2
MW-24	04/12/96	4980.30	4973.30	4.3	16.5	10	NS
MW-25	04/12/96	4981.30	4975.36	2.9	9.0	7.5	NS
MW-27	04/11/96	4978.50	4972.59	1.1	7.0	36	5.6
MW-33	04/11/96	4981.29	4973.42	0.0	11.5	68	1.3
MW-37	04/15/96	4976.66	4969.70	0.0	15.5	48	4.6
MW-48	04/15/96	4976.31	4967.65	0.3	12.0	36	<0.03
MW-57	04/15/96	4977.54	4967.12	0.3	15.0	14	<0.03
MW-61	04/12/96	4975.98	4967.47	0.3	11.5	46	0.59

\*PID reading at sampling time.



## Summary of Data During Monitor Well Gas Sampling

Day 1 04/10/96

MW-7	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	1	47.6	14.2
	Maximum	2.3	47.6	14.2
	Average	1.9	47.6	14.2
	Final	2.2	47.6	14.2

MW-13	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	1.5	58	12.9
	Maximum	3	58	12.9
	Average	2.4	58	12.9
	Final	2.3	58	12.9

MW-17	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	25	59	12
	Maximum	99.5	63	13.2
	Average	96.3	59	12
	Final	99.5	59	12

MW-18	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0.9	62	11
	Maximum	42.7	70	13.5
	Average	33.1	66.7	12.3
	Final	39.3	70	13

Day 2 04/11/96

MW-33	Readings	PID ppm TCE	Flowrate SCFH	Vacuum Hg In
	Minimum	0	68	11
	Maximum	0.5	73	12.5
	Average	0.3	69.7	11.7
	Final	0	68	11.5

MW-15	Readings	PID ppm TCE	Flowrate SCFH	Vacuum Hg In
	Minimum	0.1	55	14.5
	Maximum	1.2	58	15
	Average	0.8	55.8	14.6
	Final	1	55	14.5

MW-27	Readings	PID ppm TCE	Honda Driver		Briggs & Stratton Driver	
			Flowrate SCFH	Vacuum Hg In	Flowrate SCFH	Vacuum Hg In
	Minimum	1.5	52	12.2	36	7
	Maximum	7.7	62	15	40	9
	Average	4.0	60	14	37	8
	Final	6.5	62	15	36	7

Comment QED portable driver failed on this well switched from Honda powered to a Briggs and Stratton powered driver with same model pump for rest of sampling.

Day 3 04/12/96

MW-21	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0.0	39	9.5
	Maximum	0.0	39	9.5
	Average	0.0	39	9.5
	Final	0.0	39	9.5

MW-14	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0.1	38	9.5
	Maximum	3.2	45	11.5
	Average	1.9	41.6	10.6
	Final	2.5	45	11.5

MW-24	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	1.5	10	12
	Maximum	9.9	30	16
	Average	5.0	18.3	14.3
	Final	4.3	10	16

Comment This sample was rejected as the water was drawn above the top of the screen. WLE after sampling = 4980.86 vs. WLE prior to sampling = 4973.30 with Top Scrn = 4980.30.

MW-61	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0	43	10.5
	Maximum	2.4	46	11.5
	Average	0.4	45	11
	Final	0.3	46	11.5

MW-25	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	1.7	7.5	7
	Maximum	11.9	7.5	7
	Average	5.5	7.5	7
	Final	2.9	7.5	7

Comment This sample was rejected as the water was drawn above the top of the screen. WLE after sampling = 4981.850.86 vs. WLE prior to sampling = 4975.36 with Top Scrn = 4981.30.

Day 4 04/15/96

MW-37	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0.0	48	14
	Maximum	0.1	48	15.5
	Average	0.0	48	14.9
	Final	0.0	48	15.5

MW-48	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0	26	10
	Maximum	1.2	36	15.2
	Average	0.2	35	12
	Final	0.3	36	12

MW-57	Readings	PID	Flowrate	Vacuum
		ppm TCE	SCFH	Hg In
	Minimum	0	10	12
	Maximum	1.3	14	15.1
	Average	0.3	13.0	14.2
	Final	2.3	14	15

# Attachment 1

# American Environmental Network, Inc.

Soil Vapor Sampling of MW-7,13,17,18  
Smpld. 4-10-96  
Rec. 4-17-96

AEN I.D. 604338

April 15, 1996

Sparton Technology Inc.  
4901 Rockaway Blvd SE  
Rio Rancho, NM 87124-4469

Project Name/Number: SVS-2Q96 41096-AIR

Attention: John Wakefield

On 04/10/96, American Environmental Network (NM), Inc., (ADHS License No. AZ0015) (formerly ATI-NM), received a request to analyze air samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.



Kimberly D. McNeill  
Project Manager



H. Mitchell Rubenstein, Ph.D.  
Laboratory Manager

MR:jt

Enclosure

OGC-003831

*American Environmental Network, Inc.*

CLIENT : SPARTON TECHNOLOGY INC. DATE RECEIVED : 04/10/96  
PROJECT # : 41096-AIR  
PROJECT NAME : SVS-2Q96 REPORT DATE : 04/15/96

AEN ID: 604338

AEN #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-7 2.2PPM	AIR	04/10/96
02	MW-13 2.3PPM	AIR	04/10/96
03	MW-17 96.5PPM	AIR	04/10/96
04	MW-18 39.3PPM	AIR	04/10/96

---TOTALS---

<u>MATRIX</u>	<u>#SAMPLES</u>
AIR	4

AEN STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

GAS CHROMATOGRAPHY RESULTS

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 CLIENT : SPARTON TECHNOLOGY INC. AEN I.D.: 604338  
 PROJECT # : 41096-AIR  
 PROJECT NAME : SVS-2Q96

SAMPLE ID. #	CLIENT I.D.	MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	DIL. FACTOR
01	MW-7 2.2PPM	AIR	04/10/96	NA	04/11/96	1
02	MW-13 2.3PPM	AIR	04/10/96	NA	04/11/96	1
03	MW-17 96.5PPM	AIR	04/10/96	NA	04/10/96	100
PARAMETER			UNITS	01	02	03
BENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
BROMODICHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
BROMOFORM			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
BROMOMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<10
CARBON TETRACHLORIDE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
CHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
CHLOROETHANE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
CHLOROFORM			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
CHLOROMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<10
DIBROMOCHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
1,2-DIBROMOETHANE (EDB)			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
1,2-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
1,3-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
1,4-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
1,1-DICHLOROETHANE			MG/M <sup>3</sup>	<0.03	<0.03	<3.0
1,2-DICHLOROETHANE (EDC)			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
1,1-DICHLOROETHENE			MG/M <sup>3</sup>	0.03	1.9 D(10)	100
CIS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
TRANS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.10	<0.10	<10
1,2-DICHLOROPROPANE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
CIS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
TRANS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
ETHYLBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
METHYL-t-BUTYL ETHER			MG/M <sup>3</sup>	<0.25	<0.25	<25
METHYLENE CHLORIDE			MG/M <sup>3</sup>	<0.20	<0.20	<20
1,1,2,2-TETRACHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02	5.3
TETRACHLOROETHENE			MG/M <sup>3</sup>	<0.05	0.05	25
TOLUENE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
1,1,1-TRICHLOROETHANE			MG/M <sup>3</sup>	<0.10	5.9 D(10)	550 D(500)
1,1,2-TRICHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
TRICHLOROETHENE			MG/M <sup>3</sup>	0.25	14 D(10)	820 D(500)
TRICHLOROFLUOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<2.0
VINYL CHLORIDE			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
TOTAL XYLENES			MG/M <sup>3</sup>	<0.05	<0.05	<5.0
SURROGATES:						
BROMOCHLOROMETHANE (%)				96	87	87
TRIFLUOROTOLUENE (%)				97	85	93

D(10)=DILUTED 10X, ANALYZED 04/10/96

D(500)=DILUTED 500X, ANALYZED 04/12/96



GAS CHROMATOGRAPHY RESULTS

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 CLIENT : SPARTON TECHNOLOGY INC. AEN I.D.: 604338  
 PROJECT # : 41096-AIR  
 PROJECT NAME : SVS-2Q96

SAMPLE ID. #	CLIENT I.D.	MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	DIL. FACTOR
04	MW-18 39.3PPM	AIR	04/10/96	NA	04/11/96	100
PARAMETER			UNITS	04		
BENZENE			MG/M <sup>3</sup>	<5.0		
BROMODICHLOROMETHANE			MG/M <sup>3</sup>	<2.0		
BROMOFORM			MG/M <sup>3</sup>	<5.0		
BROMOMETHANE			MG/M <sup>3</sup>	<10		
CARBON TETRACHLORIDE			MG/M <sup>3</sup>	<2.0		
CHLOROBENZENE			MG/M <sup>3</sup>	<5.0		
CHLOROETHANE			MG/M <sup>3</sup>	<5.0		
CHLOROFORM			MG/M <sup>3</sup>	<5.0		
CHLOROMETHANE			MG/M <sup>3</sup>	<10		
DIBROMOCHLOROMETHANE			MG/M <sup>3</sup>	<2.0		
1,2-DIBROMOETHANE (EDB)			MG/M <sup>3</sup>	<2.0		
1,2-DICHLOROBENZENE			MG/M <sup>3</sup>	<5.0		
1,3-DICHLOROBENZENE			MG/M <sup>3</sup>	<5.0		
1,4-DICHLOROBENZENE			MG/M <sup>3</sup>	<5.0		
1,1-DICHLOROETHANE			MG/M <sup>3</sup>	<3.0		
1,2-DICHLOROETHANE (EDC)			MG/M <sup>3</sup>	<5.0		
1,1-DICHLOROETHENE			MG/M <sup>3</sup>	33		
CIS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<2.0		
TRANS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<10		
1,2-DICHLOROPROPANE			MG/M <sup>3</sup>	<2.0		
CIS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<2.0		
TRANS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<2.0		
ETHYLBENZENE			MG/M <sup>3</sup>	<5.0		
METHYL-t-BUTYL ETHER			MG/M <sup>3</sup>	<25		
METHYLENE CHLORIDE			MG/M <sup>3</sup>	<20		
1,1,2,2-TETRACHLOROETHANE			MG/M <sup>3</sup>	<2.0		
TETRACHLOROETHENE			MG/M <sup>3</sup>	<5.0		
TOLUENE			MG/M <sup>3</sup>	<5.0		
1,1,1-TRICHLOROETHANE			MG/M <sup>3</sup>	33		
1,1,2-TRICHLOROETHANE			MG/M <sup>3</sup>	<2.0		
TRICHLOROETHENE			MG/M <sup>3</sup>	170		
TRICHLOROFLUOROMETHANE			MG/M <sup>3</sup>	<2.0		
VINYL CHLORIDE			MG/M <sup>3</sup>	<5.0		
TOTAL XYLENES			MG/M <sup>3</sup>	<5.0		
SURROGATES:						
BROMOCHLOROMETHANE (%)				87		
TRIFLUOROTOLUENE (%)				98		

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604338
BLANK I.D.	: 041196	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 41096-AIR	DATE ANALYZED	: 04/11/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	96
TRIFLUOROTOLUENE (%)	98

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604338
BLANK I.D.	: 041096	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 41096-AIR	DATE ANALYZED	: 04/10/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	85
TRIFLUOROTOLUENE (%)	96

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604338
BLANK I.D.	: 041296	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 41096-AIR	DATE ANALYZED	: 04/12/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	89
TRIFLUOROTOLUENE (%)	94

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604338
BLANK I.D.	: 040996	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 41096-AIR	DATE ANALYZED	: 04/09/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	94
TRIFLUOROTOLUENE (%)	97

GAS CHROMATOGRAPHY - QUALITY CONTROL

MSMSD

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 MSMSD # : 040996 AEN I.D. : 604338  
 CLIENT : SPARTON TECHNOLOGY INC. DATE EXTRACTED : NA  
 PROJECT # : 41096-AIR DATE ANALYZED : 04/09/96  
 PROJECT NAME : SVS-2Q96 SAMPLE MATRIX : AIR  
 REF. I.D. : 040996 UNITS : MG/M<sup>3</sup>

PARAMETER	SAMPLE RESULT	CONC SPIKE	SPIKED SAMPLE	% REC	DUP SPIKE	DUP % REC	RPD
BENZENE	<0.05	1.00	1.05	105	0.94	94	11
CHLOROBENZENE	<0.05	1.00	1.04	104	1.05	105	1
1,1-DICHLOROETHENE	<0.02	1.00	0.75	75	0.77	77	3
TOLUENE	<0.05	1.00	1.04	104	0.96	96	8
TRICHLOROETHENE	<0.03	1.00	1.00	100	1.04	104	4

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

# CHAIN OF CUSTODY

ATILAB I.D. 604338

DATE: 4-10-96 PAGE 1 OF 1

Analytical Technologies, Inc., Albuquerque, NM  
San Diego • Phoenix • Seattle • Pensacola • Ft. Collins • Portland • Albuquerque

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ADDRESS: 4901 Rockaway Blvd SE  
Rio Rancho NM 87124-4407  
PID TCE room

SAMPLE ID	DATE	TIME	MATRIX	LAB ID
MW-7	2.24pm	4-10-96	Air	-01
MW-13	2.03pm	4-10-96	Air	-02
MW-17	9.05pm	4-10-96	Air	-03
MW-18	3.73pm	4-10-96	Air	-04

OGC-003840

## ANALYSIS REQUEST

ANALYSIS REQUEST	NUMBER OF CONTAINERS
Petroleum Hydrocarbons (418.1)	
(MOD 8015) Gas/Diesel	
Diesel/Gasoline/BTXE/MTBE (MOD 8015/8020)	
BTXE/MTBE (8020)	
Chlorinated Hydrocarbons (501/8010)	X
Aromatic Hydrocarbons (502/8020)	X
SDWA Volatiles (502.1/503.1, 502.2 Reg. & Unreg.)	X
Pesticides/PCB (608/8080)	
Herbicides (615/8150)	
Base/Neutral/Acid Compounds GC/MS (625/8270)	
Volatile Organics GC/MS (624/8240)	
Polynuclear Aromatics (610/8310)	
SDWA Primary Standards - Arizona	
SDWA Secondary Standards - Arizona	
SDWA Primary Standards - Federal	
SDWA Secondary Standards - Federal	
The 13 Priority Pollutant Metals	
RCRA Metals by Total Digestion	
RCRA Metals by TCLP (1311)	

## PROJECT INFORMATION

PROJ. NO.: 892-5300-410916-Air	NO. CONTAINERS: 4
PROJ. NAME: SVS-20916	CUSTODY SEALS: Y/DNA
P.O. NO.:	RECEIVED INTACT: Y
SHIPPED VIA: Delivered	RECEIVED COLD: 1/A

## PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24hr ☐ 48hr ☒ 72hr ☐ 1 WEEK (NORMAL) ☐ 2 WEEK  
Comments: Need preliminary data faxed to TMW at 892-5300 Note PID Readings. Also for the Pierce Smelter 214-770-1549

## SAMPLED & RELINQUISHED BY: 1. RELINQUISHED BY: 2. RELINQUISHED BY: 3.

Signature: John M. Whitefield	Signature:	Signature:	Signature:
Printed Name: John M. Whitefield	Printed Name:	Printed Name:	Printed Name:
Company: STI	Company:	Company:	Company:
Phone: 892-5300	Time:	Time:	Time:
Date: 4-10-96	Date:	Date:	Date:
Signature: [Signature]	Signature:	Signature:	Signature:
Printed Name: [Name]	Printed Name:	Printed Name:	Printed Name:
Company: [Company]	Company:	Company:	Company:
Time: [Time]	Time:	Time:	Time:
Date: [Date]	Date:	Date:	Date:

# American Environmental Network, Inc.

Soil Vapor Sampling of MW-33,15,27  
Smpld: 4-11-96  
Rec: 4-17-96

AEN I.D. 604346

April 15, 1996

Sparton Technology Inc.  
4901 Rockaway Blvd SE  
Albuquerque, NM 87124-4469

Project Name/Number: SVS-2Q96 041196-SV

Attention: John Wakefield

On 04/11/96, American Environmental Network (NM), Inc., (ADHS License No. AZ0015) (formerly ATI-NM), received a request to analyze air samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.

Kimberly D. McNeill  
Project Manager

H. Mitchell Rubenstein, Ph.D.  
Laboratory Manager

MR:jt

Enclosure



*American Environmental Network, Inc.*

CLIENT : SPARTON TECHNOLOGY INC. DATE RECEIVED : 04/11/96  
PROJECT # : 041196-SV  
PROJECT NAME : SVS-2Q96 REPORT DATE : 04/15/96

AEN ID: 604346

AEN #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-33 0.0	AIR	04/11/96
02	MW-15 1.0	AIR	04/11/96
03	MW-27 1.1	AIR	04/11/96

---TOTALS---

<u>MATRIX</u>	<u>#SAMPLES</u>
AIR	3

AEN STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

## GAS CHROMATOGRAPHY RESULTS

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 CLIENT : SPARTON TECHNOLOGY INC. AEN I.D.: 604346  
 PROJECT # : 041196-SV  
 PROJECT NAME : SVS-2Q96

SAMPLE ID. #	CLIENT I.D.	MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	DIL. FACTOR
01	MW-33 0.0	AIR	04/11/96	NA	04/11/96	1
02	MW-15 1.0	AIR	04/11/96	NA	04/11/96	1
03	MW-27 1.1	AIR	04/11/96	NA	04/11/96	1
PARAMETER			UNITS	01	02	03
BENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMODICHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.05
BROMOFORM			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMOMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
CARBON TETRACHLORIDE			MG/M <sup>3</sup>	<0.02	<0.02	<0.05
CHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROETHANE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROFORM			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
DIBROMOCHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.05
1,2-DIBROMOETHANE (EDB)			MG/M <sup>3</sup>	<0.02	<0.02	<0.05
1,2-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,3-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,4-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHANE			MG/M <sup>3</sup>	<0.03	<0.03	<0.03
1,2-DICHLOROETHANE (EDC)			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHENE			MG/M <sup>3</sup>	0.07	0.08	1.0
CIS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRANS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
1,2-DICHLOROPROPANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
CIS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRANS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
ETHYLBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
METHYL-t-BUTYL ETHER			MG/M <sup>3</sup>	<0.25	<0.25	<0.25
METHYLENE CHLORIDE			MG/M <sup>3</sup>	<0.20	<0.20	<0.20
1,1,2,2-TETRACHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TETRACHLOROETHENE			MG/M <sup>3</sup>	<0.05	<0.05	0.06
TOLUENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1,1-TRICHLOROETHANE			MG/M <sup>3</sup>	0.13	0.43	3.4 D(10)
1,1,2-TRICHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRICHLOROETHENE			MG/M <sup>3</sup>	1.3	1.4	5.6 D(10)
TRICHLOROFLUOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
VINYL CHLORIDE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
TOTAL XYLENES			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
SURROGATES:						
BROMOCHLOROMETHANE (%)				88	82	91
TRIFLUOROTOLUENE (%)				85	95	95

D(10)=DILUTED 10X, ANALYZED 04/12/96

## GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604346
BLANK I.D.	: 040996	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041196-SV	DATE ANALYZED	: 04/09/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

## SURROGATES:

BROMOCHLOROMETHANE (%)	94
TRIFLUOROTOLUENE (%)	97

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604346
BLANK I.D.	: 041196	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041196-SV	DATE ANALYZED	: 04/11/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	96
TRIFLUOROTOLUENE (%)	98

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604346
BLANK I.D.	: 041296	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041196-SV	DATE ANALYZED	: 04/12/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	89
TRIFLUOROTOLUENE (%)	94

GAS CHROMATOGRAPHY - QUALITY CONTROL

MSMSD

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
MSMSD # : 040996 AEN I.D. : 604346  
CLIENT : SPARTON TECHNOLOGY INC. DATE EXTRACTED : NA  
PROJECT # : 041196-SV DATE ANALYZED : 04/09/96  
PROJECT NAME : SVS-2Q96 SAMPLE MATRIX : AIR  
REF. I.D. : 040996 UNITS : MG/M<sup>3</sup>

PARAMETER	SAMPLE RESULT	CONC SPIKE	SPIKED SAMPLE	% REC	DUP SPIKE	DUP % REC	RPD
BENZENE	<0.05	1.00	1.05	105	0.94	94	11
CHLOROBENZENE	<0.05	1.00	1.04	104	1.05	105	1
1,1-DICHLOROETHENE	<0.02	1.00	0.75	75	0.77	77	3
TOLUENE	<0.05	1.00	1.04	104	0.96	96	8
TRICHLOROETHENE	<0.03	1.00	1.00	100	1.04	104	4

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$

# CHAIN OF CUSTODY

Analytical Technologies, Inc., Albuquerque, NM  
San Diego • Phoenix • Seattle • Pensacola • Ft. Collins • Portland • Albuquerque

ATI LAB I.D.

DATE: 4-11-96 PAGE 1 OF 1

604346

PROJECT MANAGER: John W. Wakefield

COMPANY: Spartan Technology Inc.  
ADDRESS: 9621 Coors Rd NW  
Albuquerque NM 87114  
PHONE: 505-892-5300  
FAX: 505-872-5515

BILL TO: "  
COMPANY: "  
ADDRESS: 4901 Rockaway Blvd SE  
Albuquerque NM 87124-4469

SAMPLE ID	DATE	TIME	MATRIX	LAB ID
14W-33	4-11-96	09:20	Air	-01
14W-15	4-11-96	10:35	Air	-02
14W-27	4-11-96	13:01	Air	-03

OGC-003848

ANALYSIS REQUEST									
Petroleum Hydrocarbons (418.1)									
(MOD 8015) Gas/Diesel									
Diesel/Gasoline/BTXE/MTBE (MOD 8015/8020)									
BTXE/MTBE (8020)									
Chlorinated Hydrocarbons (601/8010)	X								
Aromatic Hydrocarbons (602/8020)	X								
SDWA Volatiles (502.1/503.1), 502.2 Reg. & Unreg.									
Pesticides/PCB (608/8080)									
Herbicides (615/8150)									
Base/Neutral/Acid Compounds GC/MS (625/8270)									
Volatile Organics GC/MS (624/8240)									
Polynuclear Aromatics (610/8310)									
SDWA Primary Standards - Arizona									
SDWA Secondary Standards - Arizona									
SDWA Primary Standards - Federal									
SDWA Secondary Standards - Federal									
The 13 Priority Pollutant Metals									
RCRA Metals by Total Digestion									
RCRA Metals by TCLP (1311)									
NUMBER OF CONTAINERS	1	1	1						

PROJECT INFORMATION

PROJ. NO.: 0-41196-5V

PROJ. NAME: SVS-2096

P.O. NO.:

SHIPPED VIA: Delivered

SAMPLE RECEIPT

NO. CONTAINERS: 3

CUSTODY SEALS: CDA/NA

RECEIVED INTACT: Y

RECEIVED COLD: -

PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS

(RUSH) ☐ 24hr ☐ 48hr ☒ 72hr ☐ 1 WEEK (NORMAL) ☐ 2 WEEK

Comments: Need preliminary data forwarded to 892-5515 and to P. Chandler at 214 770-1549

SAMPLED & RELINQUISHED BY: 1. RELINQUISHED BY: 2. HELINQUISHED BY: 3.

Signature: [Signature] Time: 4-11-96 Signature: Signature: Signature:

Printed Name: John W. Wakefield Printed Name: Printed Name: Printed Name:

Company: STI Company: Company: Company:

Phone: 892-5300

RECEIVED BY: 1. RECEIVED BY: 2. RECEIVED BY: 3.

Signature: Signature: Signature: Signature:

Printed Name: Printed Name: Printed Name: Printed Name:

Company: Company: Company: Company:

Signature: [Signature] Time: 4-11-96 Signature: [Signature] Time: 4-11-96 Signature: [Signature] Time: 4-11-96

Printed Name: John W. Wakefield Printed Name: Printed Name: Printed Name:

Company: STI Company: Company: Company:

Phone: 892-5300

RECEIVED BY: 1. RECEIVED BY: 2. RECEIVED BY: 3.

Signature: Signature: Signature: Signature:

Printed Name: Printed Name: Printed Name: Printed Name:

Company: Company: Company: Company:

# American Environmental Network, Inc.

Soil Vapor Sampling of Monitor Wells.  
MW-21, 14, G1 Sampled: 4-12-96 Rec: 4-25-96

AEN I.D. 604356

April 16, 1996

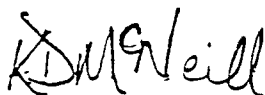
Sparton Technology Inc.  
4901 Rockaway Blvd SE  
Rio Rancho, NM 87124-4469

Project Name/Number: SVS-2Q96 041296

Attention: John Wakefield

On 04/12/96, American Environmental Network (NM), Inc., (ADHS License No. AZ0015) (formerly ATI-NM), received a request to analyze air samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.



Kimberly D. McNeill  
Project Manager



H. Mitchell Rubenstein, Ph.D.  
Laboratory Manager

MR:jt

Enclosure



CLIENT : SPARTON TECHNOLOGY INC. DATE RECEIVED : 04/12/96  
PROJECT # : 041296  
PROJECT NAME : SVS-2Q96 REPORT DATE : 04/16/96

AEN ID: 604356

AEN #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-21 0.0	AIR	04/12/96
02	MW-14 2.5	AIR	04/12/96
03	MW-61 0.3	AIR	04/12/96

---TOTALS---

<u>MATRIX</u>	<u>#SAMPLES</u>
AIR	3

AEN STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.

GAS CHROMATOGRAPHY RESULTS

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 CLIENT : SPARTON TECHNOLOGY INC. AEN I.D.: 604356  
 PROJECT # : 041296  
 PROJECT NAME : SVS-2Q96

SAMPLE ID. #	CLIENT I.D.	MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	DIL. FACTOR
01	MW-21 0.0	AIR	04/12/96	NA	04/13/96	1
02	MW-14 2.5	AIR	04/12/96	NA	04/12/96	1
03	MW-61 0.3	AIR	04/12/96	NA	04/12/96	1

PARAMETER	UNITS	01	02	03
BENZENE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10	<0.10	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10	<0.10	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
1,2-DICHLOROETHANE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,3-DICHLOROETHANE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,4-DICHLOROETHANE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03	<0.03	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	0.84	0.93	0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02	0.02	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10	<0.10	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25	<0.25	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20	<0.20	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	0.13	0.14	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	3.6 D(10)	0.29	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	6.2 D(10)	15 D(25)	0.59
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02	<0.02	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05	<0.05	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05	<0.05	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	92	100	89
TRIFLUOROTOLUENE (%)	96	81	91

D(10)=DILUTED 10X, ANALYZED 04/13/96

D(25)=DILUTED 25X, ANALYZED 04/13/96

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604356
BLANK I.D.	: 041296	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041296	DATE ANALYZED	: 04/12/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	89
TRIFLUOROTOLUENE (%)	94

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604356
BLANK I.D.	: 041296B	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041296	DATE ANALYZED	: 04/13/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	99
TRIFLUOROTOLUENE (%)	100

GAS CHROMATOGRAPHY - QUALITY CONTROL

MSMSD

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
MSMSD # : 041596 AEN I.D. : 604356  
CLIENT : SPARTON TECHNOLOGY INC. DATE EXTRACTED : NA  
PROJECT # : 041296 DATE ANALYZED : 04/15/96  
PROJECT NAME : SVS-2Q96 SAMPLE MATRIX : AIR  
REF. I.D. : 041596 UNITS : MG/M<sup>3</sup>

PARAMETER	SAMPLE RESULT	CONC SPIKE	SPIKED SAMPLE	% REC	DUP SPIKE	DUP % REC	RPD
BENZENE	<0.05	1.00	1.04	104	0.87	87	18
CHLOROBENZENE	<0.05	1.00	1.05	105	0.95	95	10
1,1-DICHLOROETHENE	<0.02	1.00	0.81	81	0.69	69	16
TOLUENE	<0.05	1.00	1.05	105	0.88	88	18
TRICHLOROETHENE	<0.03	1.00	1.05	105	0.94	94	11

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$



# American Environmental Network, Inc.

Vapor Sampling of Mon. b. Wells.  
mw - 37, 48, 57 Sampled 4-15-96  
Rec. 4-25-96

AEN I.D. 604358

April 19, 1996

Sparton Technology Inc.  
4901 Rockaway Blvd SE  
Rio Rancho, NM 87124

Project Name/Number: SVS-2Q96 041596

Attention: John Wakefield

On 04/15/96, American Environmental Network (NM), Inc., (ADHS License No. AZ0015) (formerly ATI-NM), received a request to analyze aqueous samples. The samples were analyzed with EPA methodology or equivalent methods. The results of these analyses and the quality control data, which follow each set of analyses, are enclosed.

If you have any questions or comments, please do not hesitate to contact us at (505) 344-3777.



Kimberly D. McNeill  
Project Manager



H. Mitchell Rubenstein, Ph.D.  
Laboratory Manager

MR:jt

Enclosure

*American Environmental Network, Inc.*

CLIENT : SPARTON TECHNOLOGY INC. DATE RECEIVED : 04/15/96  
PROJECT # : 041596  
PROJECT NAME : SVS-2Q96 REPORT DATE : 04/19/96

AEN ID: 604358

AEN #	CLIENT DESCRIPTION	MATRIX	DATE COLLECTED
01	MW-37	AQUEOUS	04/15/96
02	MW-48	AQUEOUS	04/15/96
03	MW-57	AQUEOUS	04/15/96

---TOTALS---

<u>MATRIX</u>	<u>#SAMPLES</u>
AQUEOUS	3

OGC-003857

AEN STANDARD DISPOSAL PRACTICE

The samples from this project will be disposed of in thirty (30) days from the date of this report. If an extended storage period is required, please contact our sample control department before the scheduled disposal date.



## GAS CHROMATOGRAPHY RESULTS

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
 CLIENT : SPARTON TECHNOLOGY INC. AEN I.D.: 604358  
 PROJECT # : 041596  
 PROJECT NAME : SVS-2Q96

SAMPLE ID. #	CLIENT I.D.	MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	DIL. FACTOR
01	MW-37	AIR	04/15/96	NA	04/15/96	1
02	MW-48	AIR	04/15/96	NA	04/16/96	1
03	MW-57	AIR	04/15/96	NA	04/15/96	1
PARAMETER			UNITS	01	02	03
BENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMODICHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
BROMOFORM			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
BROMOMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
CARBON TETRACHLORIDE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
CHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROETHANE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROFORM			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
CHLOROMETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
DIBROMOCHLOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
1,2-DIBROMOETHANE (EDB)			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
1,2-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,3-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,4-DICHLOROBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHANE			MG/M <sup>3</sup>	<0.03	<0.03	<0.03
1,2-DICHLOROETHANE (EDC)			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1-DICHLOROETHENE			MG/M <sup>3</sup>	0.066	<0.02	<0.02
CIS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRANS-1,2-DICHLOROETHENE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
1,2-DICHLOROPROPANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
CIS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRANS-1,3-DICHLOROPROPENE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
ETHYLBENZENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
METHYL-t-BUTYL ETHER			MG/M <sup>3</sup>	<0.25	<0.25	<0.25
METHYLENE CHLORIDE			MG/M <sup>3</sup>	<0.20	<0.20	<0.20
1,1,2,2-TETRACHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02 D(1)	<0.02
TETRACHLOROETHENE			MG/M <sup>3</sup>	0.13	<0.05	<0.05
TOLUENE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
1,1,1-TRICHLOROETHANE			MG/M <sup>3</sup>	<0.10	<0.10	<0.10
1,1,2-TRICHLOROETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
TRICHLOROETHENE			MG/M <sup>3</sup>	4.6 D(10)	<0.03	<0.03
TRICHLOROFLUOROMETHANE			MG/M <sup>3</sup>	<0.02	<0.02	<0.02
VINYL CHLORIDE			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
TOTAL XYLENES			MG/M <sup>3</sup>	<0.05	<0.05	<0.05
SURROGATES:						
BROMOCHLOROMETHANE (%)				93	97	92
TRIFLUOROTOLUENE (%)				97	98	104

D(1)=DILUTED 1X, ANALYZED 04/15/96

D(10)=DILUTED 10X, ANALYZED 04/16/96

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604358
BLANK I.D.	: 041696	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041596	DATE ANALYZED	: 04/16/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLOROBENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLOROBENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	98
TRIFLUOROTOLUENE (%)	101

GAS CHROMATOGRAPHY RESULTS - QUALITY CONTROL

TEST	: EPA 8010/8020	AEN I.D.	: 604358
BLANK I.D.	: 041596	MATRIX	: AIR
CLIENT	: SPARTON TECHNOLOGY INC.	DATE EXTRACTED	: NA
PROJECT #	: 041596	DATE ANALYZED	: 04/15/96
PROJECT NAME	: SVS-2Q96	DIL. FACTOR	: 1

PARAMETER	UNITS	
BENZENE	MG/M <sup>3</sup>	<0.05
BROMODICHLOROMETHANE	MG/M <sup>3</sup>	<0.02
BROMOFORM	MG/M <sup>3</sup>	<0.05
BROMOMETHANE	MG/M <sup>3</sup>	<0.10
CARBON TETRACHLORIDE	MG/M <sup>3</sup>	<0.02
CHLORO BENZENE	MG/M <sup>3</sup>	<0.05
CHLOROETHANE	MG/M <sup>3</sup>	<0.05
CHLOROFORM	MG/M <sup>3</sup>	<0.05
CHLOROMETHANE	MG/M <sup>3</sup>	<0.10
DIBROMOCHLOROMETHANE	MG/M <sup>3</sup>	<0.02
1,2-DIBROMOETHANE (EDB)	MG/M <sup>3</sup>	<0.02
1,2-DICHLORO BENZENE	MG/M <sup>3</sup>	<0.05
1,3-DICHLORO BENZENE	MG/M <sup>3</sup>	<0.05
1,4-DICHLORO BENZENE	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHANE	MG/M <sup>3</sup>	<0.03
1,2-DICHLOROETHANE (EDC)	MG/M <sup>3</sup>	<0.05
1,1-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
CIS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.02
TRANS-1,2-DICHLOROETHENE	MG/M <sup>3</sup>	<0.10
1,2-DICHLOROPROPANE	MG/M <sup>3</sup>	<0.02
CIS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
TRANS-1,3-DICHLOROPROPENE	MG/M <sup>3</sup>	<0.02
ETHYLBENZENE	MG/M <sup>3</sup>	<0.05
METHYL-t-BUTYL ETHER	MG/M <sup>3</sup>	<0.25
METHYLENE CHLORIDE	MG/M <sup>3</sup>	<0.20
1,1,2,2-TETRACHLOROETHANE	MG/M <sup>3</sup>	<0.02
TETRACHLOROETHENE	MG/M <sup>3</sup>	<0.05
TOLUENE	MG/M <sup>3</sup>	<0.05
1,1,1-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.10
1,1,2-TRICHLOROETHANE	MG/M <sup>3</sup>	<0.02
TRICHLOROETHENE	MG/M <sup>3</sup>	<0.03
TRICHLOROFLUOROMETHANE	MG/M <sup>3</sup>	<0.02
VINYL CHLORIDE	MG/M <sup>3</sup>	<0.05
TOTAL XYLENES	MG/M <sup>3</sup>	<0.05

SURROGATES:

BROMOCHLOROMETHANE (%)	106
TRIFLUOROTOLUENE (%)	104

GAS CHROMATOGRAPHY - QUALITY CONTROL

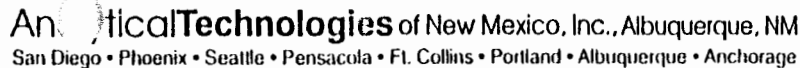
MSMSD

TEST : PURGEABLE HALOCARBONS/AROMATICS (EPA 8010/8020)  
MSMSD # : 041596 AEN I.D. : 604358  
CLIENT : SPARTON TECHNOLOGY INC. DATE EXTRACTED : NA  
PROJECT # : 041596 DATE ANALYZED : 04/15/96  
PROJECT NAME : SVS-2Q96 SAMPLE MATRIX : AIR  
REF. I.D. : 041596 UNITS : MG/M<sup>3</sup>

PARAMETER	SAMPLE RESULT	CONC SPIKE	SPIKED SAMPLE	% REC	DUP SPIKE	DUP % REC	RPD
BENZENE	<0.05	1.00	1.04	104	0.87	87	18
CHLOROBENZENE	<0.05	1.00	1.05	105	0.95	95	10
1,1-DICHLOROETHENE	<0.02	1.00	0.81	81	0.69	69	16
TOLUENE	<0.05	1.00	1.05	105	0.88	88	18
TRICHLOROETHENE	<0.03	1.00	1.05	105	0.94	94	11

$$\% \text{ Recovery} = \frac{(\text{Spike Sample Result} - \text{Sample Result})}{\text{Spike Concentration}} \times 100$$

$$\text{RPD (Relative Percent Difference)} = \frac{(\text{Sample Result} - \text{Duplicate Result})}{\text{Average Result}} \times 100$$



DATE: 4-15-96 PAGE: 1 OF 1

604358

PLEASE FILL THIS FORM IN COMPLETELY.

[illegible]

PROJECT INFORMATION		PRIOR AUTHORIZATION IS REQUIRED FOR RUSH PROJECTS		RELINQUISHED BY: 1.		RELINQUISHED BY: 2.	
PROJ. NO.: 041596		(RUSH) <input type="checkbox"/> 24hr <input type="checkbox"/> 48hr <input checked="" type="checkbox"/> 72hr <input type="checkbox"/> 1 WEEK (NORMAL) <input type="checkbox"/> 12 WEEK		Signature: [Signature] Time: 1609		Signature: [Signature] Time:	
PROJ. NAME: SVS-2096		CERTIFICATION REQUIRED: <input type="checkbox"/> NM <input type="checkbox"/> OTHER		Printed Name: [Signature] Date: 4-15-96		Printed Name: [Signature] Date:	
P.O. NO.:		METHANOL PRESERVATION <input type="checkbox"/>		Company: STL		Company:	
SHIPPED VIA: Delivered		COMMENTS: Fox. Puckers to DMW 892-5515		RECEIVED BY: 1.		RECEIVED BY: (LAB) 2.	
SAMPLE RECEIPT				Signature: [Signature] Time:		Signature: [Signature] Time:	
NO. CONTAINERS: 3				Printed Name: [Signature] Date:		Printed Name: [Signature] Date: 4-15-96	
CUSTODY SEALS: [Signature] NA				Company:		Analytical Technologies of New Mexico	
RECEIVED INTACT: Y							
BLUE ICE/ACE							

# SPARTON TECHNOLOGY, INC.

Date: 4-26-96  
To: File  
From: J. Wakefield

Re: WLE vs. Top Screen Elevation  
Page: 1 of 2  
File: SOILVAPAR.WQ1

## ONSITE WELLS

Well No.	Flow Zone	Case Dia	Elev top of scrn	WLE 04/24/95	Scr Ele - WLE 4/95	WLE 02/09/96	Scr Ele - WLE 2/9
MW-7	UFZ	2	4981.30	4978.39	2.91	4977.99	3.31
MW-9	UFZ	2	4981.61	4974.58	7.03	4973.99	7.62
MW-12	UFZ	4	4978.58	4974.25	4.33	4973.75	4.83
MW-13	UFZ	2	4983.25	4975.97	7.28	4975.34	7.91
MW-14	UFZ	2	4980.41	4972.85	7.56	4972.72	7.69
MW-15	UFZ	2	4987.49	4974.45	13.04	DRY	
MW-16	UFZ	2	4979.50	4979.90	-0.40	4979.70	-0.20
MW-17	UFZ	2	4982.28	4980.04	2.24	4979.69	2.59
MW-21	UFZ	2	4983.86	4979.85	4.01	4979.68	4.18
MW-22	UFZ	2	4976.06	4978.87	-2.81	4978.64	-2.58
MW-33	UFZ	2	4981.29	4973.99	7.30	4973.61	7.68

## PRODUCTION WELLS

Well No.	Flow Zone	Case Dia	Top of Scr Elev	Pump WL 03/28/96	Scr Ele - WLE 3/96
PW-1	UFZ	10	4984.54	4965.04	19.50
MW-18	UFZ	4	4977.58	4969.32	8.26
MW-23	UFZ	2	4976.51	4976.42	0.09
MW-24	UFZ	2	4980.30	4975.56	4.74
MW-25	UFZ	2	4981.30	4977.23	4.07
MW-26	UFZ	2	4972.71	4966.88	5.83
MW-27	UFZ	2	4978.50	4972.73	5.77
MW-28	UFZ	2	4977.69	4972.20	5.49

## OFFSITE WELLS

Well No.	Flow Zone	Case Dia	Top of Scr Elev	WLE 04/24/95	Scr Ele - WLE 4/95	WLE 01/17/96	Scr Ele - WLE 1/9
PZ-1	UFZ	2	4961.52	4960.87	0.65	4959.34	2.18
MW-34	UFZ	2	4977.99	4975.36	2.63	4974.88	3.11
MW-35	UFZ	2	4979.30	4973.08	6.22	4972.66	6.64
MW-36	UFZ	2	4977.05	4971.82	5.23	4971.52	5.53
MW-37	UFZ	2	4976.66	4970.57	6.09	4970.24	6.42
MW-47	UFZ	4	4975.83	4969.30	6.53	4968.83	7.00
MW-48	UFZ	4	4976.31	4968.68	7.63	4968.26	8.05
MW-50	UFZ	4	4976.51	4963.44	13.07	4962.28	14.23
MW-51	UFZ	2	4983.86	4981.26	2.60	4980.96	2.90
MW-52	UFZ	4	4975.01	4966.53	8.48	4965.85	9.16
MW-53	UFZ	4	4974.44	4968.00	6.44	4967.52	6.92
MW-54	UFZ		4980.64	4968.62	12.02	4967.97	12.67
MW-57	UFZ	4	4977.54	4968.26	9.28	4967.67	9.87
MW-58	UFZ	4	4974.89	4968.40	6.49	4967.98	6.91
MW-61	UFZ	4	4975.98	4968.40	7.58	4967.87	8.11
MW-62	UFZ	2	4980.00	4969.96	10.04	4969.91	10.09
MW-63	UFZ	2	4982.74	4979.29	3.45	4977.75	4.99

**APPENDIX 3**

**MODELED IMPACT TO NEW MEXICO UTILITIES WELL  
(PARADISE HILLS)**

Draft Final CMS - Sparton  
May 6, 1996

OGC-003865



In order to determine if the TCE plume from the facility will reach the Paradise Hills (New Mexico Utility) well, a groundwater computer model was run looking at the plume movement over a 200 to 300 year period. The computer model was based on a Department of Energy semianalytical model named AT123 (Analytical Transient, One, Two, or Three-Dimensional). The model allows the user to specify both aquifer and source parameters

The model was run under two scenarios. The first scenario assumed that a 10,000 microgram per liter (ug/l) source remains constant throughout the entire time frame modeled. The second scenario assumes that the source is removed after 20 years.

Four major assumptions were made for running the model. These assumptions took a very conservative view of the depositional environment and groundwater flow characteristics of the area. It was assumed that (1) a constant gradient of 0.002 ft/ft is present toward the Paradise Hills (New Mexico Utility) well (though this doesn't agree with the USGS Regional Model), (2) the Paradise Hills (New Mexico Utility) well is withdrawing groundwater from the shallow, uppermost portion of the aquifer (when it actually is much deeper), (3) no retardation of the chemical constituents in the plume exists, and (4) no degradation of the chemical constituents in the plume is taking place.

The aquifer input parameters from the RFI were as follows:

Hydraulic Conductivity = 32.1 feet per day

Hydraulic gradient = 0.002

Effective porosity = 0.25

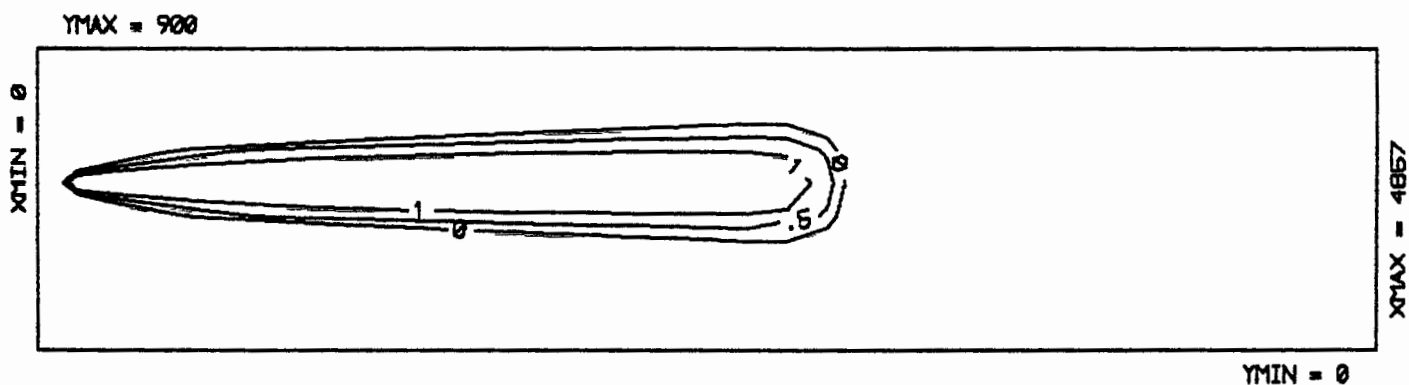
The model presents the log of the concentrations. For example, a plume contour of 0 is equal to  $10^0$  or 1 ug/l or the .5 contour is equal to  $10^{-5}$  or 3.16 ug/l.

To calibrate the model, the dispersive effects of the groundwater flow regime were varied until the horizontal boundary of the plume were similar to those presented in the RFI. In all cases, the vertical dispersion was at least one order of magnitude less than the horizontal dispersion.

To calibrate the model, it was initially run for a 30 year period with dispersion in the transverse (x-axis) and lateral (y-axis) directions being equal to one. This essentially means that dispersion plays no role in movement of the plume. The plume generated by the model is shown on Figure 1. This run gave a long narrow plume. Additional computer runs were made varying the dispersion in both the transverse and lateral directions until a plume with similar dimensions to the plume presented in the RFI was observed. Figure 2 shows the best fit generated by the groundwater model. The numbers used for transverse and lateral dispersion were then input into the model to forecast plume movement in the future.

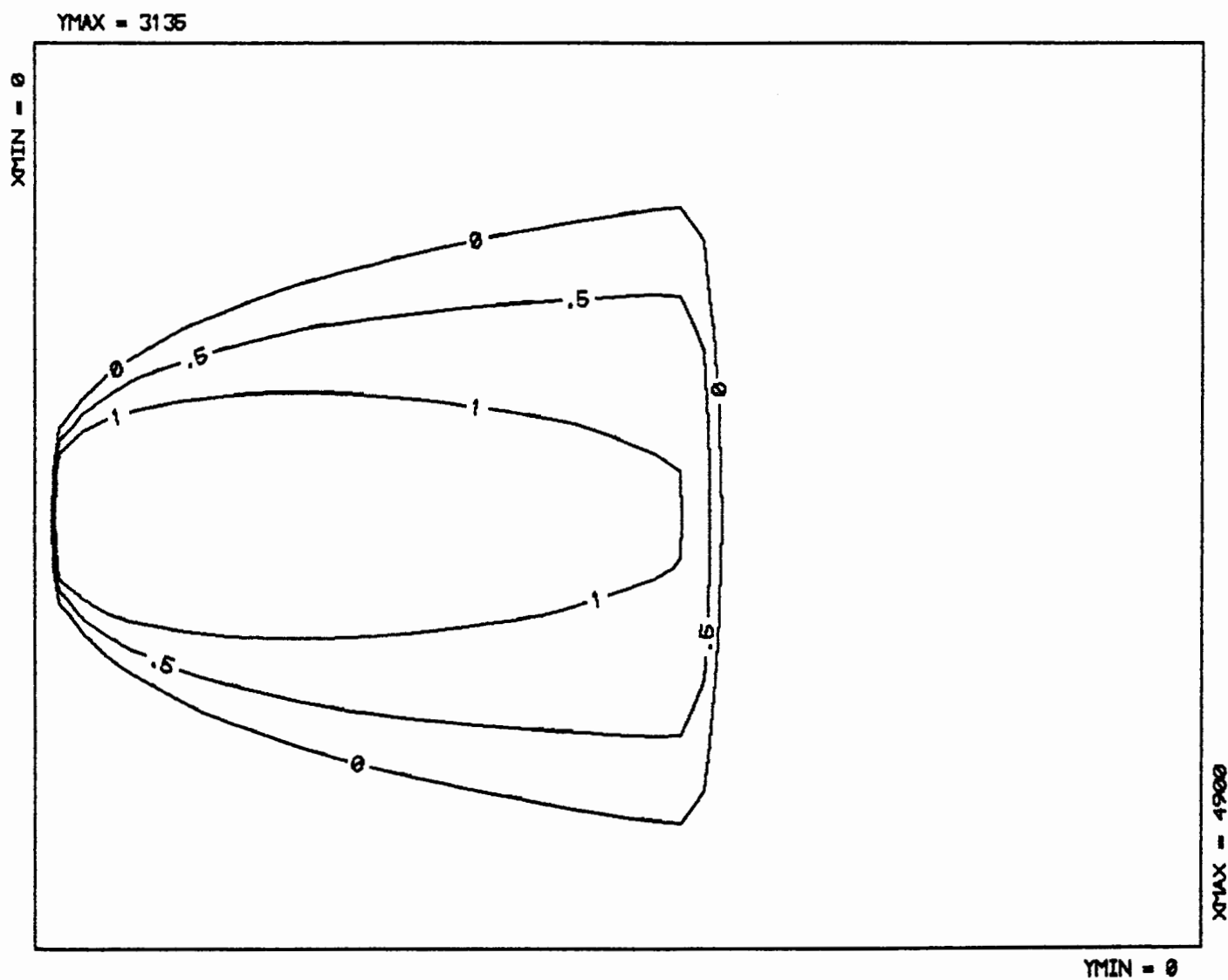
Figures 3 through 7 show the distances the plume (for 1 ug/l and 3.16 ug/l) should move for the next 50 to 300 years with a continual input source of 10,000 ug/l. The plume appears to reach equilibrium with a maximum downgradient extent (for the 3.16 ug/l contour) of about 9,500 feet after 150 years. This is about 5,000 short of the Paradise Hills (New Mexico Utility) well.

Figures 8 through 11 show the movement of the plume after the source is removed. For these computer runs, it was assumed that the 10,000 ug/l source was removed after an input period of 20 years. Several observations were noted from this computer run. First, between 100 and 150 years the maximum concentration in the plume is less than 3.16 ug/l. Second, after 100 years, the width of the plume remains fairly constant while the length of the plume begins shrinking. Figure 10 indicates that the 1 ug/l portion of the plume reaches the Paradise Hills (New Mexico Utility) well after 150 years.



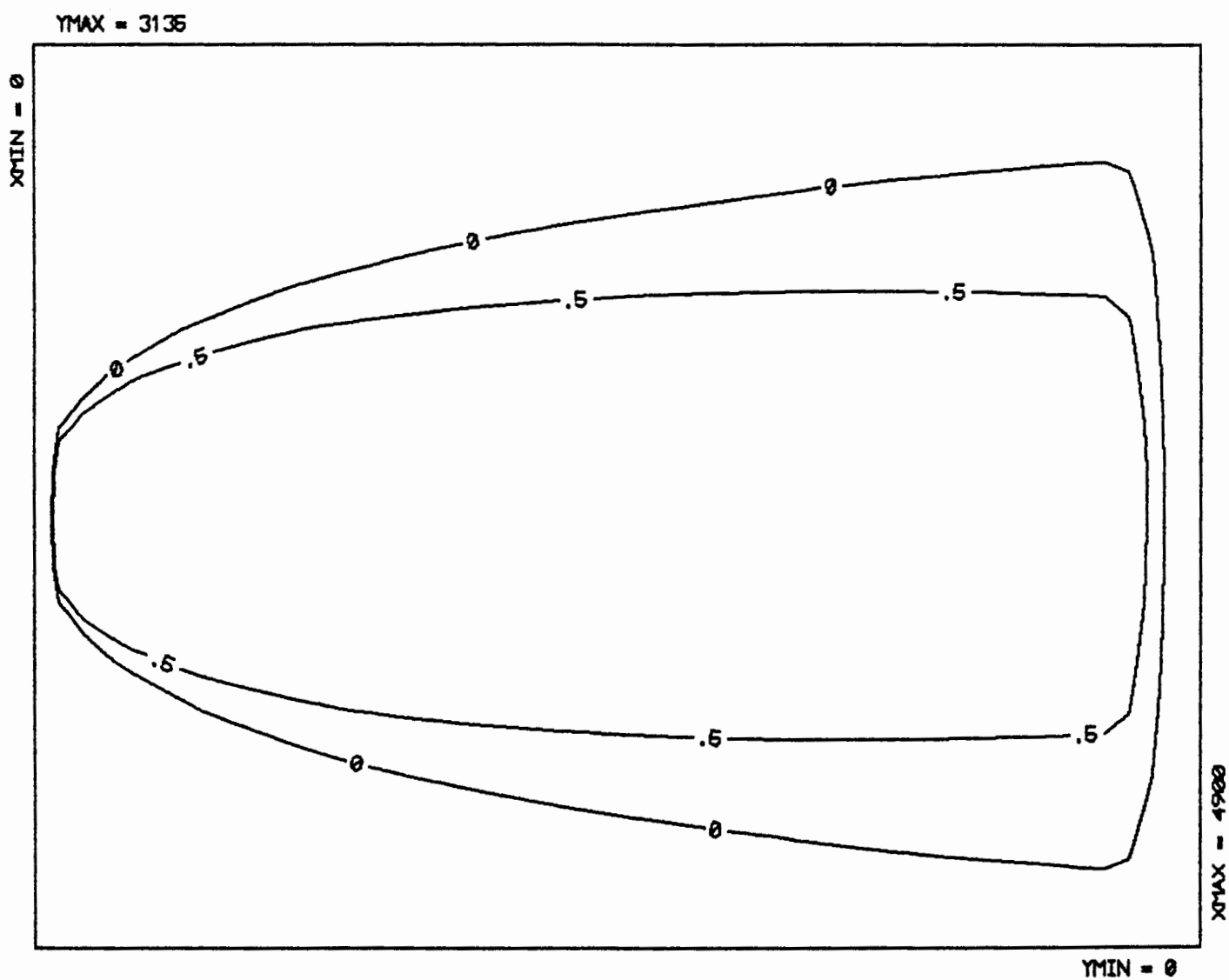
SPARTON PLUME - NO DISPERSION

FIGURE 1

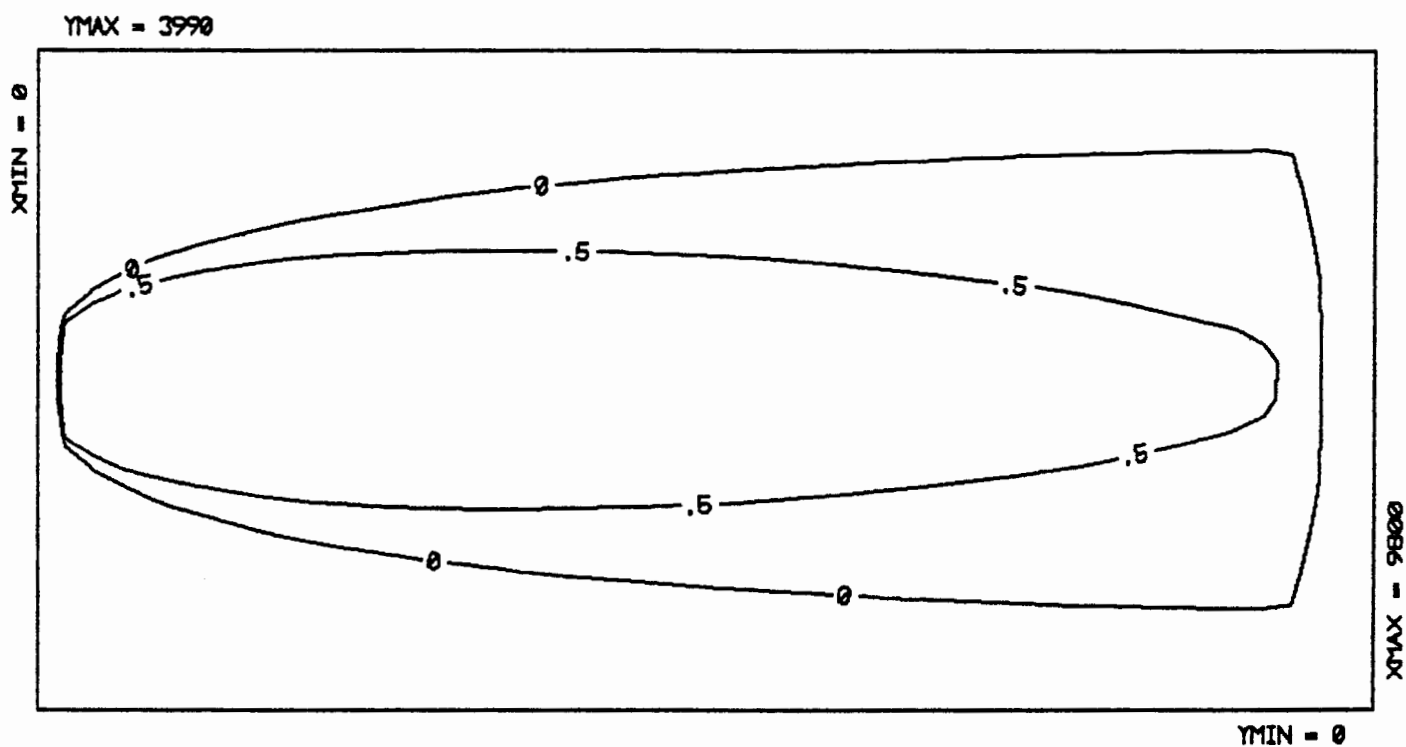


CALIBRATION - DISP.(X) = .55; DISP.(Y) = 45

FIGURE 2

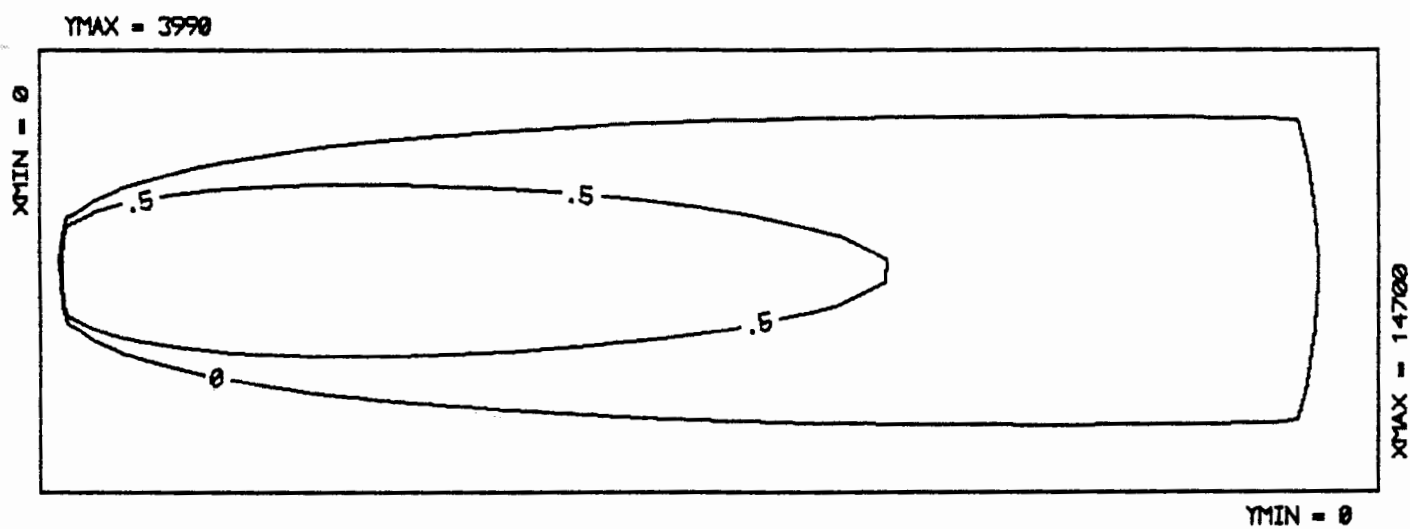


SPARTON PLUME - CONTINUAL SOURCE - 50 YRS.



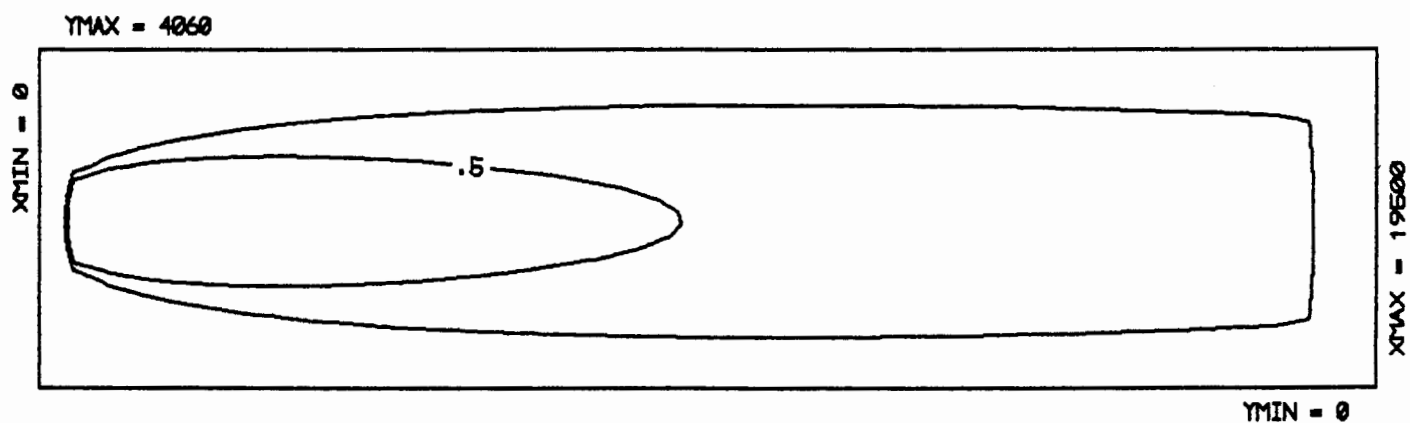
SPARTON PLUME - CONTINUAL SOURCE - 100 YRS.

FIGURE 4



SPARTON PLUME - CONTINUAL SOURCE - 150 YRS.

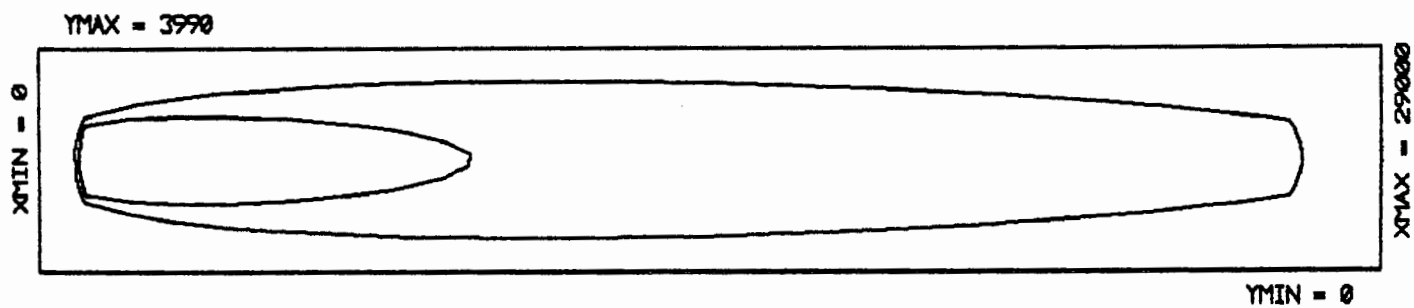
FIGURE 5



SPARTON PLUME - CONTINUAL SOURCE - 200 YRS.

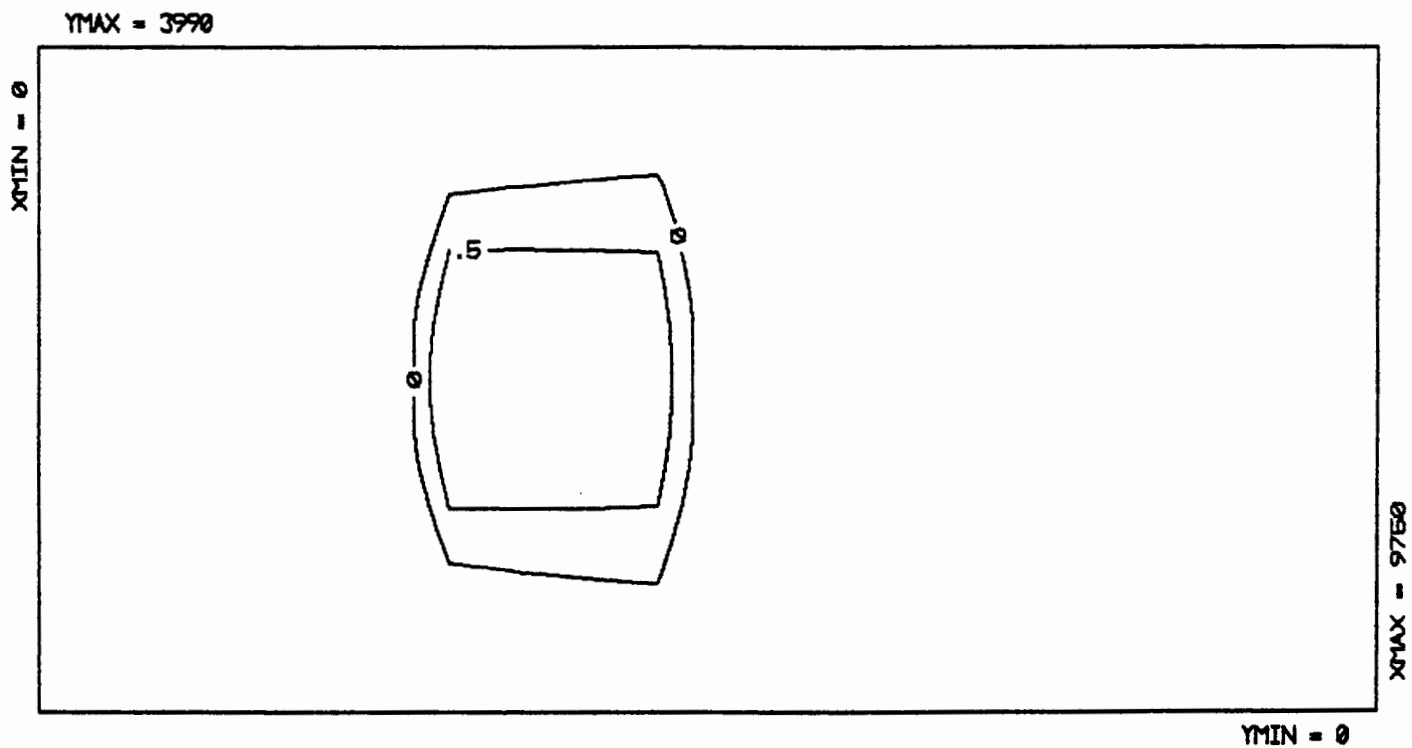
FIGURE 6





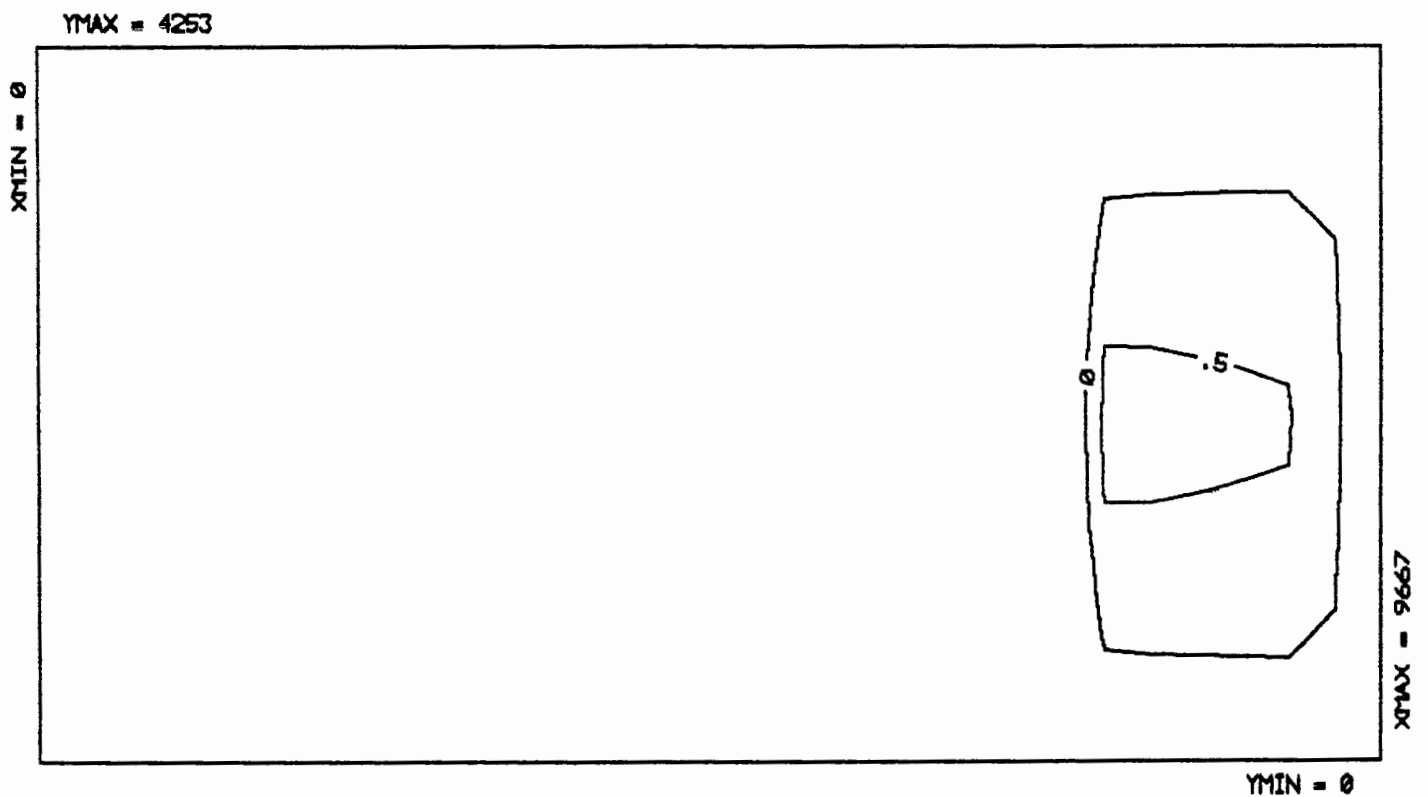
SPARTON PLUME - CONTINUAL SOURCE - 300 YRS.

FIGURE 7



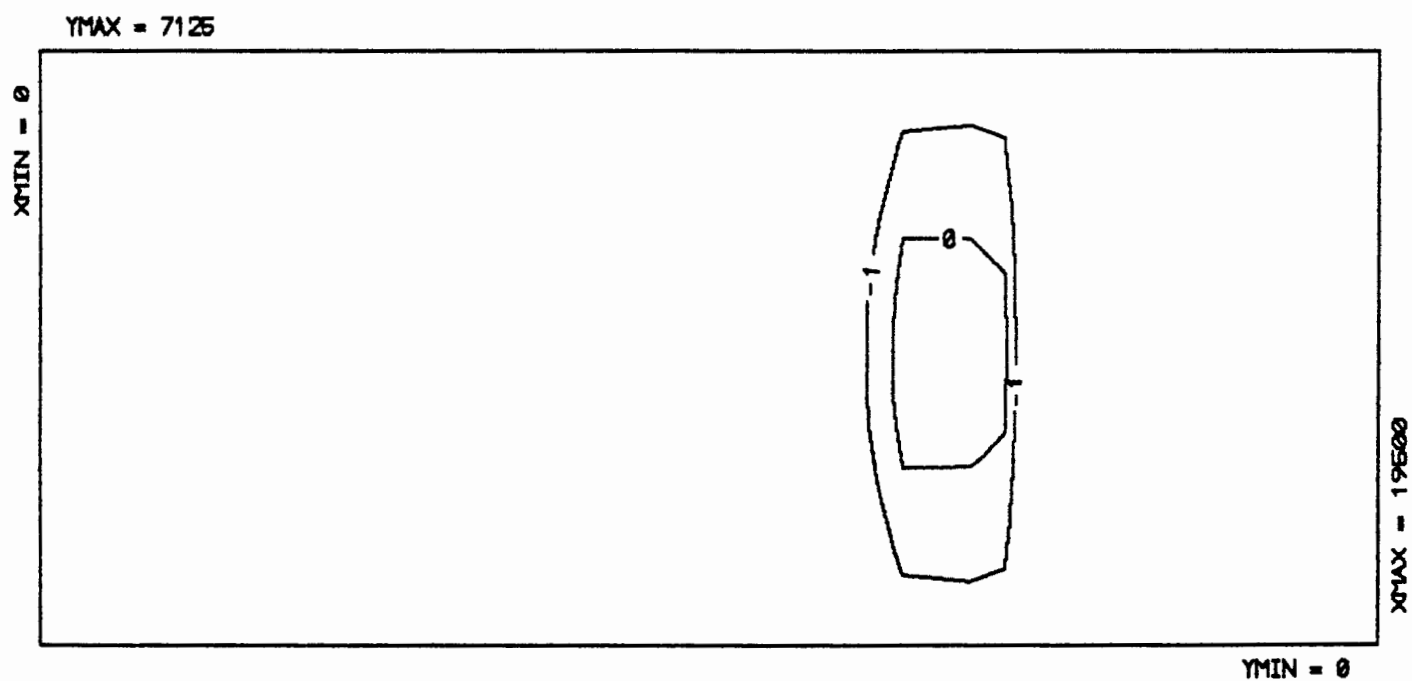
SPARTON PLUME - SOURCE STOPPED - 50 YRS.

FIGURE 8



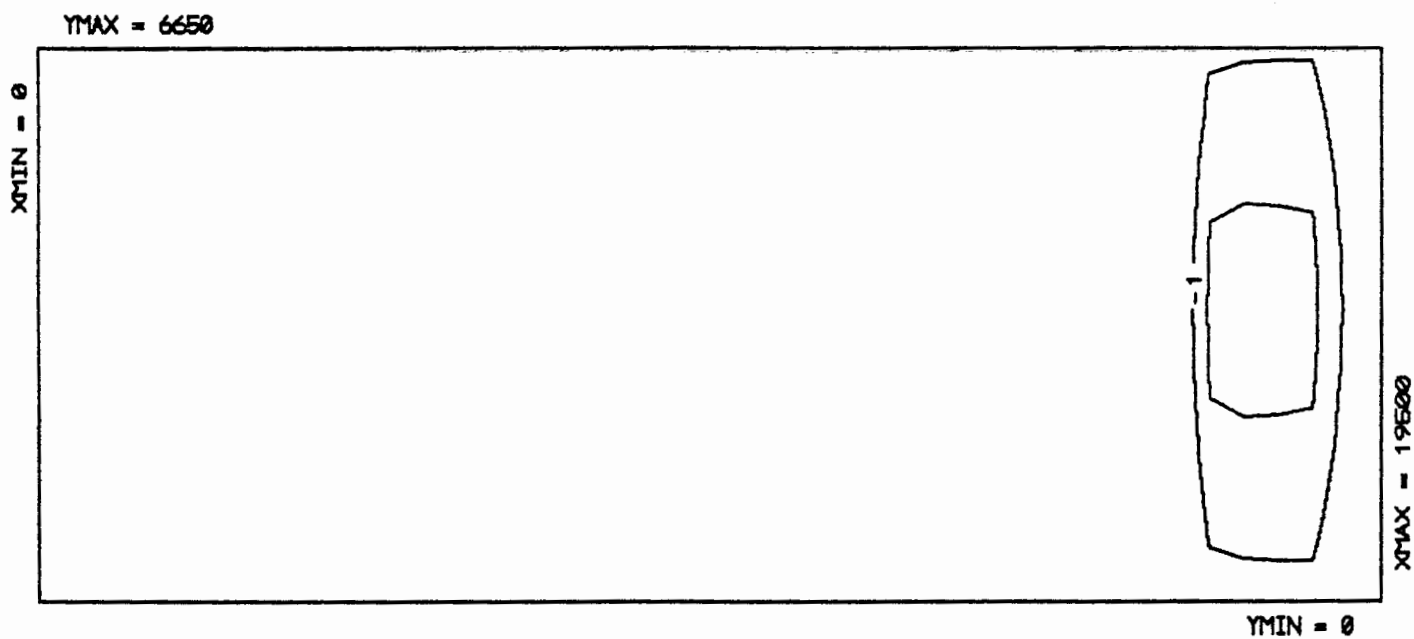
SPARTON PLUME - SOURCE STOPPED - 100 YRS.

FIGURE 9



SPARTON PLUME - SOURCE STOPPED - 150 YRS.

FIGURE 10



SPARTON PLUME - SOURCE STOPPED - 200 YRS.

## **APPENDIX 4**

### **REMEDIAL TECHNOLOGIES SCREENING MATRIX AND REFERENCE GUIDE**

**Draft Final CMS - Spanton  
May 6, 1996**

OGC-003879

# REMEDIATION TECHNOLOGIES SCREENING MATRIX

Reference Guide

Version I

A Joint Project  
of the

U.S. Environmental Protection Agency  
Office of Solid Waste and Emergency Response  
Technology Innovation Office  
Washington, DC 20460

and

U.S. Air Force  
Environics Directorate  
Armstrong Laboratory  
Tyndall Air Force Base, FL 32403

July 1993

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## Reference Guide: Remediation Technologies Screening Matrix

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### NOTICE

Preparation of the *Remediation Technologies Screening Matrix Reference Guide* has been funded by the United States Environmental Protection Agency (EPA) under contract number 68-W2-0004. The document is the result of a joint project by EPA and the U.S. Air Force and is intended to be used in conjunction with the *Remediation Technologies Screening Matrix* developed under the same project. Both documents were developed with extensive input from professionals in the field and have been subjected to administrative review by the sponsoring agencies. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.



## FOREWORD

The development of the *Remediation Technologies Screening Matrix* and accompanying *Reference Guide* was jointly sponsored by the U.S. Air Force and the U.S. Environmental Protection Agency (EPA). Both the Air Force and EPA are committed to encouraging further development and use of innovative technologies that offer efficient and cost-effective alternatives for site remediation.

The *Matrix* and *Reference Guide* support this effort by summarizing the strengths and limitations of innovative, as well as conventional, technologies for the remediation of soils, sediments, sludges; groundwater; and air emissions/off-gases. They provide information that will assist Air Force and EPA site project managers responsible for screening technologies for potential use at their sites.

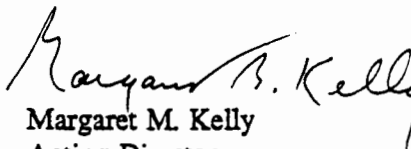
The *Matrix* and *Reference Guide* were developed with extensive input from professionals in the field. More than 30 technical experts—site remediation technology researchers, technology developers, and technology users from Federal agencies, State governments, universities, and the private sector—participated in the process. This included attending a two-day workshop at Tyndall Air Force Base, Florida, in March 1993, to identify appropriate technologies and processes to be included in the *Matrix* and to evaluate them based on the participants' collective experience and expertise.

The Air Force and EPA gratefully acknowledge the significant contribution these professionals, who are listed at the end of Chapter 1, have made to this important project.

The selection and use of innovative technologies to clean up hazardous waste sites is increasing rapidly and new technologies continue to emerge. The Air Force and EPA plan to issue periodic updates of the *Matrix* and *Reference Guide* to help site project managers keep pace with the ever changing range of technology options available.



Col. Neil J. Lamb  
Director, Environics Directorate  
Armstrong Laboratory  
Tyndall Air Force Base



Margaret M. Kelly  
Acting Director  
Technology Innovation Office  
U.S. Environmental Protection Agency

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## Reference Guide: Remediation Technologies Screening Matrix

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## Reference Guide: Remediation Technologies Screening Matrix

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## CHAPTER 1: INTRODUCTION

This *Reference Guide* provides additional information to increase the usability of the *Remediation Technologies Screening Matrix*. Together, the *Reference Guide* and *Matrix* can help site remediation project managers narrow the field of remediation alternatives and identify potentially applicable technologies for more detailed assessment and evaluation prior to remedy selection. In addition, the documents can be used to guide the selection of focused technology field demonstrations and specific technologies to highlight in subsequent technical data sheets, design manuals, and cost studies.

The *Reference Guide* and *Matrix* are intended as **general references only**. Additional information to support identification of potentially applicable technologies can be obtained by consulting published references, contacting technology experts, and conducting treatability studies. **The *Matrix* and *Reference Guide* are not designed to be used as the sole basis for remedy selection.**

Most of the technologies and processes included are innovative. Most have been developed to full-scale—commercial units are available or are expected shortly. However, many have had limited full-scale application, and comprehensive cost and performance data may not be available. In addition, site-specific factors—such as geology, depth to contamination, particle size, organic content, pH, moisture content, and soil-solvent reactions—may be critical in determining the potential effectiveness of a technology. In addition, Federal, State, and local laws may affect the applicability of technologies at some sites.

Depending on site-specific requirements, more than one technology or process may be needed to achieve remediation goals at a site. Many of the remedial technologies in the *Matrix* and *Reference Guide* may be used in combination with others in “treatment trains” to accomplish site cleanup. For example, “treatment trains” may be used to reduce the volume of contaminated material, to prevent the release of volatile contaminants during excavation and mixing, or to address multiple contaminants within the same matrix. Following are examples of “treatment trains” that have been selected for use at Superfund sites:

- Soil washing, followed by bioremediation, incineration, or solidification/stabilization of soil fines;
- Thermal desorption, followed by incineration, solidification/stabilization, or dehalogenation to treat PCBs;
- Soil vapor extraction, followed by various processes to remove semivolatile organics;
- Solvent extraction, followed by solidification/stabilization, soil washing, or incineration of extracted contaminants and solvents; and
- Bioremediation, followed by solidification/stabilization of inorganics.

Forty-eight technologies—including *in situ* and *ex situ* biological, thermal, and physical/chemical processes—have been chosen for inclusion in the *Matrix* and *Reference Guide* (see Table 1). In addition to treatment technologies, processes designed to be used primarily for containment, waste separation,

and enhanced recovery have been included to provide a broad range of remedial options. The *Matrix* and *Reference Guide* do not include every technology option available. Many other innovative technologies have been developed. Depending on site-specific conditions, some of these may provide additional options for site project managers. As a general rule, technologies included in the *Matrix* are commercially available or are likely to be within a year.

The technologies in the *Matrix* are evaluated against 13 factors that address specific cost, performance, technical, developmental, and institutional issues (see Table 2). These screening factors were chosen to assist site project managers identify applicable technologies for media and contaminants of concern at their sites.

It is important to recognize that information about innovative technologies is rapidly evolving. After using the *Matrix* and *Reference Guide* to identify potentially applicable technologies, it is essential that site project managers consult qualified professionals, who can evaluate each in light of the most up-to-date information and site-specific conditions prior to remedy selection.

### **Participation of Technical Experts**

The *Matrix* and *Reference Guide* were developed with extensive input from technical experts. They included professionals representing all segments of the remediation community—site remediation technology researchers, technology developers, and technology users from Federal agencies, State governments, universities, and the private sector (see Table 3).

More than 30 experts participated in an intensive workshop, March 2-3, 1993, at Tyndall Air Force Base, Florida. Based on their collective experience and expertise, they selected appropriate technologies and processes to be included in the *Matrix*, identified the contaminant groups addressed by each technology, and developed the list of factors against which the technologies are evaluated.

Workshop participants then separated into three small groups and focused on the technologies in their individual areas of specialization—biological processes, thermal processes, physical/chemical processes—to develop the ratings for each of the technologies shown on the *Matrix*. Each technical expert had the opportunity to review draft documents independently and provide written comments as well.

In light of the rapidly growing range of innovative technologies, workshop participants identified a number of full- and pilot-scale technologies, in addition to those in the *Matrix*, that may provide additional options for project managers to consider, depending on site-specific conditions. Among the full-scale technologies are air-phase resin adsorption, reverse osmosis/ultra membrane filtration, kerfing, cavitation/oxidation, melting/smelting, and high-temperature halogenated reduction. At the pilot and bench scale are molten salt, molten metal, electrokinetics, fungal remediation, solar soil detoxification, biocurtains, and electron beam technology. As these technologies are applied in the field and more information about them becomes available, they may be included in future editions of the *Remediation Technologies Screening Matrix* and *Reference Guide*.

### **Contents**

This chapter describes the development and limitations of the *Matrix* and *Reference Guide*. It also contains definitions for each of the technologies and processes rated in the *Matrix* (see Table 1). The

13 factors applied to technologies in the *Matrix* are defined in Table 2. The participation of technical experts in developing the *Matrix* and *Reference Guide* also is described in this chapter, and all participants are listed in Table 3.

Chapter 2 describes the system used to evaluate technologies, including an explanation of each possible rating (see Table 4).

Chapter 3 provides information about each of the technologies and processes evaluated in the *Matrix*. Included is a discussion of the contaminant groups treated by the technology and other issues that should be considered in determining its potential applicability and effectiveness. The ratings for each technology are presented and supplemental information is provided, as needed. For example, factors that could limit the suitability and effectiveness of each technology are discussed.

Two Appendices provide additional information. Appendix A contains a list of reference materials, including field demonstration reports and case studies, that site project managers may wish to consult for more detailed information about various technologies. Appendix B lists examples of contaminants included in each contaminant group used in the *Matrix*.

TABLE 1: DEFINITION OF MATRIX TECHNOLOGIES/PROCESSES

*Soils, Sediments, Sludges*

Technology	Status	Description
<i>In Situ Biological Processes</i>		
Biodegradation	Full-scale/ Innovative	The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance <i>in situ</i> biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from subsurface materials.
Bioventing	Full-scale/ Innovative	Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation. The system also may include the injection of contaminated gases, using the soil system for remediation.
<i>In Situ Physical/Chemical Processes</i>		
Soil Vapor Extraction	Full-scale/ Innovative	Vacuum is applied through extraction wells to create a pressure gradient that induces gas-phase volatiles to diffuse through soil to extraction wells. The process includes a system for handling off-gases. This technology also is known as <i>in situ</i> soil venting, <i>in situ</i> volatilization, enhanced volatilization, or soil vacuum extraction.
Soil Flushing	Pilot-scale/ Innovative	Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and captured/treated/removed.
Solidification/Stabilization	Full-scale/ Conventional	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).
Pneumatic Fracturing	Pilot-scale/ Innovative	Pressurized air is injected beneath the surface to develop cracks in low permeability and over-consolidated sediments, opening new passageways that increase the effectiveness of many <i>in situ</i> processes and enhance extraction efficiencies.
<i>In Situ Thermal Processes</i>		
<i>In Situ</i> Vitriification	Pilot-scale/ Innovative	Electrodes for applying electricity, or joule heating, are used to melt contaminated soils and sludges, producing a glass and crystalline structure with very low leaching characteristics.
Thermally Enhanced Soil Vapor Extraction	Full-scale/ Innovative	Steam/hot air injection or electric radio frequency heating is used to increase the mobility of volatiles and facilitate extraction. The process includes a system for handling off-gases.



**Reference Guide: Remediation Technologies Screening Matrix**

Technology	Status	Description
<i>Ex Situ Biological Processes (assuming excavation)</i>		
Slurry Phase Biological Treatment	Full-scale/ Innovative	An aqueous slurry is created by combining soil or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Nutrients, oxygen, and pH in the bioreactor may be controlled to enhance biodegradation. Upon completion of the process, the slurry is dewatered and the treated soil is disposed.
Controlled Solid Phase Biological Treatment	Full-scale/ Innovative	Excavated soils are mixed with soil amendments and placed in above-ground enclosures that have leachate collection systems and some form of aeration. Processes include prepared treatment beds, biotreatment cells, soil piles, and composting. Moisture, heat, nutrients, oxygen, and pH may be controlled to enhance biodegradation.
Landfarming	Full-scale/ Conventional	Contaminated soils are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste.
<i>Ex Situ Physical/Chemical Processes (assuming excavation)</i>		
Soil Washing	Full-scale/ Innovative	Contaminants sorbed onto soil particles are separated from soil in an aqueous-based system. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals.
Solidification/Stabilization	Full-scale/ Conventional	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization).
Dehalogenation (Glycolate)	Full-scale/ Innovative	An alkaline polyethylene glycolate (APEG) reagent is used to dehalogenate halogenated aromatic compounds in a batch reactor. Potassium polyethylene glycolate (KPEG) is the most common APEG reagent. Contaminated soils and the reagent are mixed and heated in a treatment vessel. In the APEG process, the reaction causes the polyethylene glycol to replace halogen molecules and render the compound non-hazardous. For example, the reaction between chlorinated organics and KPEG causes replacement of a chlorine molecule and results in a reduction in toxicity.
Dehalogenation (BCD)	Full-scale/ Innovative	Contaminated soil is screened, processed with a crusher and pug mill, and mixed with sodium bicarbonate. The mixture is heated in a rotary reactor to decompose and partially volatilize the contaminants.
Solvent Extraction (Chemical Extraction)	Full-scale/ Innovative	Waste and solvent are mixed in an extractor, dissolving the organic contaminant into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated for treatment and further use.

## Reference Guide: Remediation Technologies Screening Matrix

Technology	Status	Description
Chemical Reduction/Oxidation	Full-scale/ Innovative	Reduction/oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The reducing/oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide.
Soil Vapor Extraction	Full-scale/ Innovative	A vacuum is applied to a network of above-ground piping to encourage volatilization of organics from the excavated media. The process includes a system for handling off-gases.
<i>Ex Situ Thermal Processes (assuming excavation)</i>		
Low-Temperature Thermal Desorption	Full-scale/ Innovative	Wastes are heated to 200°-600°F (93°-315°C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.
High-Temperature Thermal Desorption	Full-scale/ Innovative	Wastes are heated to 600°-1,000°F (315°-538°C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system.
Vitrification	Full-scale/ Innovative	Contaminated soils and sludges are melted at high temperature to form a glass and crystalline structure with very low leaching characteristics.
Incineration	Full-scale/ Conventional	High temperatures, 1,600°- 2,200°F (871°-1,204°C), are used to volatilize and combust (in the presence of oxygen) organic constituents in hazardous wastes.
Pyrolysis	Pilot-scale/ Innovative	Chemical decomposition is induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash.
<i>Other Processes</i>		
Natural Attenuation	Conventional	Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels. Sampling and sample analysis throughout the process are required.
Excavation and Off-Site Disposal	Conventional	Contaminated material is removed and transported to permitted off-site treatment and disposal facilities. Pre-treatment may be required.

## Reference Guide: Remediation Technologies Screening Matrix

### Groundwater

Technology	Status	Description
<i>In Situ Biological Processes</i>		
Oxygen Enhancement with Hydrogen Peroxide	Full-scale/ Innovative	A dilute solution of hydrogen peroxide is circulated throughout a contaminated groundwater zone to increase the oxygen content of groundwater and enhance the rate of aerobic degradation of organic contaminants by naturally occurring microbes.
Co-Metabolic Processes	Pilot-scale/ Innovative	Water containing dissolved methane and oxygen is injected into groundwater to enhance methanotrophic biological degradation.
Nitrate Enhancement	Pilot-scale/ Innovative	Solubilized nitrate is circulated throughout groundwater contamination zones to provide electron acceptors for biological activity and enhance the rate of degradation of organic contaminants by naturally occurring microbes.
Oxygen Enhancement with Air Sparging	Full-scale/ Innovative	Air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes.
<i>In Situ Physical/Chemical Processes</i>		
Slurry Walls	Full-scale/ Conventional	These subsurface barriers consist of a vertically excavated trench filled with a slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and forms a filter cake to reduce groundwater flow.
Passive Treatment Walls	Pilot-scale/ Innovative	A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the plume to passively move through the wall. The halogenated compounds are degraded by reactions with a mixture of porous media and a metal catalyst.
Hot Water or Steam Flushing/Stripping	Pilot-scale/ Innovative	Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated. This variety of processes includes Contained Recovery of Oily Waste (CROW), Steam Injection and Vacuum Extraction (SIVE), <i>In Situ</i> Steam Enhanced Extraction (ISEE), and Steam Enhanced Recovery Process (SERP).
Hydrofracturing (enhancement)	Pilot-scale/ Innovative	Injection of pressurized water through wells cracks low permeability and over-consolidated sediments. Cracks are filled with porous media that serve as avenues for bioremediation or improve pumping efficiency.
Air Sparging	Full-scale/ Innovative	Air is injected into saturated matrices creating an underground air stripper that removes contaminants through volatilization.
Directional Wells (enhancement)	Full-scale/ Innovative	Drilling techniques are used to position wells horizontally, or at an angle, in order to reach contaminants not accessible via direct vertical drilling.

## Reference Guide: Remediation Technologies Screening Matrix

Technology	Status	Description
Dual Phase Extraction	Full-scale/ Innovative	A high vacuum system is applied to simultaneously remove liquid and gas from low permeability or heterogeneous formations.
Vacuum Vapor Extraction	Pilot-scale/ Innovative	Air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, some of the volatile organic compounds in the contaminated groundwater are transferred from the water to air bubbles which rise and are collected at the top of the well by vapor extraction. The partially treated groundwater is never brought to the surface; it is forced into the unsaturated zone, and the process is repeated. Contaminant concentrations gradually are reduced with each repetition of the process.
Free Product Recovery	Full-scale/ Conventional	Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (e.g., pumping) or a passive collection system.
<i>Ex Situ Biological Processes (assuming pumping)</i>		
Bioreactors	Full-scale/ Innovative	Contaminants in extracted groundwater are put into contact with microorganisms through attached or suspended biological systems. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces new cells. In attached systems, such as rotating biological contactors and trickling filters, microorganisms are established on an inert support matrix to aerobically degrade groundwater contaminants.
<i>Ex Situ Physical/Chemical Processes (assuming pumping)</i>		
Air Stripping	Full-scale/ Conventional	Volatile organics are partitioned from groundwater by increasing the surface area of the contaminated water exposed to air. Aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration.
Carbon Adsorption (Liquid Phase)	Full-scale/ Conventional	Groundwater is pumped through a series of canisters containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required.
UV Oxidation	Full-scale/ Innovative	Ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows into a treatment tank. An ozone destruction unit is used to treat off-gases from the treatment tank.
<i>Other Processes</i>		
Natural Attenuation	Conventional	Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels. Sampling and sample analysis throughout the process are required.

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**Reference Guide: Remediation Technologies Screening Matrix**

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***Air Emissions/Off-Gas Treatment Processes***

Technology	Status	Description
Carbon Adsorption (Vapor Phase)	Full-scale/ Conventional	Carbon, processed into hard granules or pellets, is used to capture molecules of gas-phase pollutants. The granulated activated carbon (GAC) may be contained in a packed bed through which contaminated emissions/off-gases flow. When the carbon has been saturated with contaminants, it can be regenerated in place, removed and regenerated at an off-site facility, or disposed.
Catalytic Oxidation (non-halogenated)	Full-scale/ Conventional	Trace organics in contaminated air streams are destroyed at lower temperatures, 842°F (450°C), than conventional combustion by passing the air/VOC mixture through a catalyst designed for non-halogenated compounds.
Catalytic Oxidation (halogenated)	Full-scale/ Conventional	Trace organics in contaminated air streams are destroyed at lower temperatures, 842°F (450°C), than conventional combustion by passing the air/VOC mixture through a catalyst designed for halogenated compounds.
Biofiltration	Full-scale/ Innovative	Vapor-phase organic contaminants are pumped through a soil bed and sorb to the soil surface where they are degraded by microorganisms in the soil. Specific strains of bacteria may be introduced into the filter and optimal conditions provided to preferentially degrade specific compounds.
Thermal Oxidation	Full-scale/ Conventional	Organic contaminants are destroyed in a high temperature 1,832°F (1,000°C) combustor.

**Reference Guide: Remediation Technologies Screening Matrix**

**TABLE 2: DEFINITION OF SCREENING FACTORS**

Factor	Definition
Overall Cost	Design, construction, and operation and maintenance (O&M) costs of the core process that defines each technology, exclusive of mobilization, demobilization, and pre- and post-treatment costs. (For <i>ex situ</i> soil, sediment, and sludge technologies, it is assumed that excavation costs average \$50/ton (\$55.00/metric ton). For <i>ex situ</i> groundwater technologies, it is assumed that pumping costs average \$0.25/1,000 gallons (\$0.07/1,000 liters).)
Capital or O&M Intensive?	Is this technology capital (Cap)-intensive, with significant costs for design and construction; O&M-intensive, with significant costs for labor, operation, maintenance, and repair; both; or neither?
Commercial Availability	Number of vendors that can design, construct, and maintain the technology.
Typically Part of a Treatment Train?	Is additional treatment necessary, after the use of this technology, to clean up the contaminated media? (Excludes treatment of off-gases.)
Residuals Produced (Solid, Liquid, Vapor)?	If use of the technology produces residuals that require management, are they solids, liquids, or vap.
Minimum Contaminant Concentration Achievable	Minimum contaminant concentration achievable by the technology, measured in milligrams per kilogram (mg/kg) for soil technologies, micrograms per liter (µg/L) for groundwater, and mg/kg and micrograms per kilogram (µg/kg) for air emissions/off-gases.
Addresses Toxicity, Mobility, or Volume?	What parameter(s) of the contaminated media — toxicity, mobility, or volume — is the technology primarily designed to address?
Long-Term Effectiveness/Permanence?	Does use of the technology maintain protection of human health and the environment, over time, after cleanup objectives have been met?
Time To Complete Cleanup	Time required to clean up a "standard" site using the technology. ("Standard" site is 20,000 tons (18,200 metric tons) for soil and 1 million gallons (3,785,000 liters) for groundwater.)
System Reliability/Maintainability	Degree of system reliability and level of maintenance required when using the technology.
Awareness of Remediation Consulting Community	Degree to which the technology is known to remediation consultants.
Regulatory/Permitting Acceptability	Degree to which use of the technology is acceptable to regulating and permitting agencies.
Community Acceptability	Degree to which use of the technology is acceptable to the public.

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**Reference Guide: Remediation Technologies Screening Matrix**

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## Reference Guide: Remediation Technologies Screening Matrix

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## CHAPTER 2: RATING SYSTEM

The purpose of the Rating System is to provide the framework and factors for screening the technologies included in the *Remediation Technologies Screening Matrix*.

The system is comprised of 13 factors that address specific cost, performance, technical, developmental, and institutional issues (see Table 2). The intention is to give site project managers an overview of a range of factors for use in identifying potentially applicable technologies and processes.

It is important to remember that the *Matrix* provides basic, representative information only. The impact of site-specific conditions cannot be reflected. For example, the cost of a technology may depend on the size of the cleanup and physical and chemical characteristics of the waste.

Five of the factors in the system pose performance-related questions. Answers to these questions are shown in the *Matrix* and are presented in Chapter 3 in the discussion of each technology or process.

The remaining eight factors—Overall Cost, Commercial Availability, Minimum Contaminant Concentration Achievable, Time To Complete Cleanup, System Reliability/Maintainability, Awareness of Remediation Consulting Community, Regulatory/Permitting Acceptability, and Community Acceptability—involve a comparative rating. Technologies are assigned one of four possible ratings: Better, Average, Worse, or Inadequate Information. Table 4, which begins on the next page, identifies the rating levels for these eight factors. The levels were defined by the technical experts who participated in the *Matrix* development workshop, based on their collective experience and expertise.

Three of the rating levels are differentiated in the *Matrix* by shape, as well as color, to facilitate black-and-white reproduction:

Better	= Square	= Blue
Average	= Circle	= White
Worse	= Triangle	= Yellow

The letter "I" indicates there is Inadequate Information with which to rate the technology or process; "NA" is used if the factor is Not Applicable to the technology or process. Ratings for individual technologies and processes are discussed in Chapter 3.

TABLE 4: DEFINITION OF RATING LEVELS

FACTORS AND DEFINITIONS	INADEQUATE INFORMATION (I)	WORSE (Triangle)	AVERAGE (Circle)	BETTER (Square)
<b>Overall Cost</b>  Design, construction, and operations and maintenance (O&M) costs of the core process that defines each technology, exclusive of mobilization, demobilization, and pre- and post-treatment. (For <i>ex situ</i> soil, sediment, and sludge technologies, it is assumed that excavation costs average \$50/ton (\$55.00/metric ton). For <i>ex situ</i> groundwater technologies, it is assumed that pumping costs average \$0.25/1,000 gallons (\$0.07/1,000 liters).)	There is insufficient information with which to rate the technology in this category.	More than \$300/ton (\$330/metric ton) for soils;  More than \$10/1,000 gal. (\$2.64/1,000 liters) for groundwater;  More than \$25/lb. (\$11.33/kg) for air emissions and off-gases	\$100-\$300/ton (\$110-\$330/metric ton);  \$3.00 -\$10.00/1,000 gal. (\$0.79-\$2.64/1,000 liters);  \$7-\$25/lb. (\$3.17-\$11.33/kg)	Less than \$100/ton (\$110/metric ton);  Less than \$3.00/1,000 gal. (\$0.79/1,000 liters);  Less than \$7/lb. (\$3.17/kg)
<b>Commercial Availability</b>  Number of vendors that can design, construct, and maintain the technology.	There is insufficient information with which to rate the technology in this category.	Less than 2 vendors	2-4 vendors	More than 4 vendors
<b>Minimum Contaminant Concentration Achievable</b>  Minimum contaminant concentration level achievable by the technology, measured in milligrams per kilogram for soil technologies, micrograms per liter for groundwater, and milligrams per kilogram and micrograms per kilogram for air emissions and off-gases.	There is insufficient information with which to rate the technology in this category.	More than 50 mg/kg;  More than 100 µg/L;  More than 250 mg/kg	5-50 mg/kg;  5-100 µg/L;  250 mg/kg-250 µg/kg, but detectable	Less than 5 mg/kg;  Less than 5 µg/L;  Not detectable

**Reference Guide: Remediation Technologies Screening Matrix**

<b>FACTORS AND DEFINITIONS</b>	<b>INADEQUATE INFORMATION (I)</b>	<b>WORSE (Triangle)</b>	<b>AVERAGE (Circle)</b>	<b>BETTER (Square)</b>
<b>Time To Complete Cleanup</b>  Time required to clean up a "standard" site using the technology. (The "standard" site is 20,000 tons (18,200 metric tons) for soils and 1 million gallons (3,785,000 liters) for groundwater. Chapter 3 contains a more detailed definition.)	There is insufficient information with which to rate the technology in this category.	More than 3 years for <i>in situ</i> soil technologies;  More than 1 year for <i>ex situ</i> soil technologies;  More than 10 years for groundwater technologies	1-3 years;  0.5-1 year;  3-10 years	Less than 1 year  Less than 0.5 years  Less than 3 years
<b>System Reliability/Maintainability</b>  The degree of system reliability and level of maintenance required when using the technology.	There is insufficient information with which to rate the technology in this category.	Low reliability and high maintenance	Average reliability and average maintenance	High reliability and low maintenance
<b>Awareness of Remediation Consulting Community</b>  Degree to which the technology is known to remediation consultants.	There is insufficient information with which to rate the technology in this category.	Generally unknown; little information available in technical literature	Moderately known; some information available in technical literature	Generally known; information readily available in technical literature

## Reference Guide: Remediation Technologies Screening Matrix

FACTORS AND DEFINITIONS	INADEQUATE INFORMATION (I)	WORSE (Triangle)	AVERAGE (Circle)	BETTER (Square)
<b>Regulatory/Permitting Acceptability</b>  Degree to which use of the technology is acceptable to the regulatory and permitting community.	There is insufficient information with which to rate the technology in this category.	Below average	Average	Above average
<b>Community Acceptability</b>  Degree to which use of the technology is acceptable to the public.	There is insufficient information with which to rate the technology in this category.	Serious public involvement is likely and the outcome is uncertain.	Public involvement usually occurs, but the technology is generally accepted.	Minimal opposition from the community is likely.

## CHAPTER 3: TECHNOLOGY RATINGS

This chapter provides information about each of the technologies and processes evaluated in the *Matrix*. Included is a discussion of the contaminant groups treated by the technology and other issues that should be considered in determining its potential applicability and effectiveness. The ratings on the *Matrix* for each technology are presented in this chapter, and supplemental information is provided, as needed. For example, factors that could limit the suitability and effectiveness of each technology are discussed.

### Conventions

The following conventions were used in preparing the *Remediation Technologies Screening Matrix*:

1. Contaminants identified in the *Matrix* are grouped as follows: (1) halogenated volatiles; (2) halogenated semivolatiles; (3) non-halogenated volatiles; (4) non-halogenated semivolatiles; (5) fuel hydrocarbons; (6) pesticides; and (7) inorganics. These groupings were developed based on a review of EPA's *Technology Screening Guide for Treatment of Soils and Sludges* and *Superfund Treatability Clearing House Abstracts* and with guidance from the technical experts who participated in the development of the *Matrix*. Appendix B contains a list of selected contaminants in each group.
2. While all contaminant groups to which the technology or process is applicable are indicated on the *Matrix*, each technology is evaluated based on the contaminant group(s) that it is primarily designed to treat. If appropriate, additional information on the technology's performance against other contaminants is noted.
3. "Standard" site profiles were developed to provide a baseline for rating the soil and groundwater technologies consistently against the "Time To Complete Cleanup" factor. A calculation of the time required to clean up the "standard" site is shown in the text only when the technology's processing rate was generally known. No "standard" was developed for air emissions/off-gas technologies, because cleanup time is dependent on the primary technology or process they support. Air emissions/off-gas treatment technologies are not rated against the "Time To Complete Cleanup" factor.
  - The "standard" for soil is a normalized site of 1 acre, 10 feet deep (.41 hectare, 3.04 meters deep). Site volume is 20,000 tons (18,200 metric tons).
  - The "standard" for groundwater is a normalized site of 1 acre, 10 feet deep (.41 hectare, 3.04 meters deep) with an average porosity of 30% and a shallow aquifer. Site volume is 1,000,000 gallons (3,785,000 liters).
4. For *ex situ* soil, sediment, and sludge technologies, the ratings in the Overall Cost category include an assumption that excavation costs average \$50/ton (\$55.00/metric ton). For *ex situ* groundwater technologies, it is assumed that pumping costs average \$0.25/1,000 gallons (\$0.07/1,000 liters).

The discussion of each technology and process included in the *Matrix* begins on page 21.

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## Reference Guide: Remediation Technologies Screening Matrix

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## Soils, Sediments, Sludges

### **IN SITU BIODEGRADATION:**

The activity of naturally occurring microbes is stimulated by circulating water-based solutions through contaminated soils to enhance *in situ* biological degradation of organic contaminants. Nutrients, oxygen, or other amendments may be used to enhance biodegradation and contaminant desorption from subsurface materials. Generally, the process includes above-ground treatment and conditioning of the infiltration water with nutrients and an oxygen (or other electron acceptor) source. **In situ biodegradation is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- Extensive treatability studies and site characterization may be necessary.
- The circulation of water-based solutions through the soil may increase contaminant mobility and necessitate use of an above-ground system for treating water prior to re-injection or disposal.
- The injection of microorganisms into the subsurface is not recommended. Naturally occurring organisms are generally adapted to the contaminants present.
- Preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones.
- The system should be used only where groundwater is near the surface and where the groundwater underlying the contaminated soils is contaminated.
- The system should not be used for clay, highly layered, or heterogeneous subsurface environments due to oxygen (or other electron acceptor) transfer limitations.
- Bioremediation may not be applicable at sites where there are high concentrations of heavy metals, highly chlorinated organics, or inorganic salts.

Target contaminants for *in situ* biodegradation are non-halogenated volatile and semivolatile organics and fuel hydrocarbons (groups 3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be treated, but the process may be less effective and may only be applicable to some compounds within these contaminant groups.

- |                                                                                                                                                                                                                 |                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1. Overall Cost                                                                                                                                                                                                 | Rating: Average |
| 2. Capital (Cap) or O&M Intensive?                                                                                                                                                                              | O&M             |
| <p>Various quantities of nutrients or other amendments must be obtained and circulated through contaminated soils, and their concentrations and effects on contaminant degradation rates must be monitored.</p> |                 |
| 3. Commercial Availability:                                                                                                                                                                                     | Rating: Better  |
| 4. Typically Part of a Treatment Train?                                                                                                                                                                         | No              |
| 5. Residuals Produced (Solid, Liquid, Vapor)?                                                                                                                                                                   | None            |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable:****Rating: Average**

*In situ* soil biodegradation systems are capable of transforming contaminants into non-hazardous substances. However, the extent of contaminant degradation depends on a variety of parameters, such as the specific contaminants present and their concentrations, and adequate electron acceptors.

**7. Addresses Toxicity, Mobility, or Volume?****Toxicity****8. Long-Term Effectiveness/Permanence?****Yes**

*In situ* biodegradation can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup:****Rating: Worse**

Remediation times are often 4-6 years, depending mainly on the degradation rates of specific contaminants. Less than one year may be required to cleanup some contaminants with relatively short half-lives, but higher molecular weight compounds have much longer half-lives and thus take longer to degrade.

**10. System Reliability/Maintainability:****Rating: Worse****11. Awareness of the Remediation Consulting Community:****Rating: Average****12. Regulatory/Permitting Acceptability:****Rating: Worse**

There is a risk of increasing contaminant mobility and leaching of contaminants into the groundwater. Regulators often do not accept the addition of nutrients and other amendments to contaminated soils. *In situ* biodegradation has been selected for remedial and emergency response actions at only a few Superfund sites.

**13. Community Acceptability:****Rating: Better**

Communities generally prefer technologies that result in contaminant destruction and that do not require excavation.

## BIOVENTING:

Oxygen is delivered to contaminated unsaturated soils by forced air movement (either extraction or injection of air) to increase oxygen concentrations and stimulate biodegradation. The system also may include the injection of contaminated gases, using the soil system for remediation. Unlike soil vapor extraction, bioventing employs much lower air flow rates that provide only the amount of oxygen necessary for biodegradation while minimizing volatilization and release of contaminants to the atmosphere. The advantages of gas-phase (as opposed to liquid phase) introduction of oxygen into soils are that gases diffuse more rapidly than liquids into less permeable subsurface formations and much less gas is required to deliver oxygen at levels needed to stimulate biological degradation of contaminants. **Bioventing is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- Tests should be conducted to determine soil gas permeability.
- Bioventing is not recommended where there is a high water table (within several feet of the surface), saturated soil lenses, or impermeable soils. Areas with a high water table can be successfully treated by combining bioventing with a dewatering process.
- Vapors can build up in building basements within the radius of influence of air injection wells. This can be alleviated by extracting air near the structure of concern.
- Low soil moisture content may limit biodegradation and the effectiveness of bioventing, which tends to dry out the soils.
- Monitoring of off-gases at the soil surface may be required.
- Aerobic biodegradation of chlorinated compounds is not very effective unless there is a co-metabolite present.

Bioventing is primarily designed to treat non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be treated, but the process may be less effective and may only be applicable to some compounds within these contaminant groups.

### 1. Overall Cost

**Rating: Better**

Costs for operating a bioventing system typically are \$15 per yard<sup>3</sup> (\$19.50 per meter<sup>3</sup>). This technology does not require expensive equipment and can be left unattended for long periods of time. Relatively few personnel are involved in the operation and maintenance of a bioventing system. Typically, quarterly maintenance monitoring is conducted.

### 2. Capital (Cap) or O&M Intensive?

**Neither**

### 3. Commercial Availability:

**Rating: Better**

Bioventing is becoming more commonplace, and most of the hardware components are readily available.

### 4. Typically Part of a Treatment Train?

**No**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**5. Residuals Produced (Solid, Liquid, Vapor)?** **None**

**6. Minimum Contaminant Concentration Achievable.** **Rating: Better**

Bioventing is capable of completely transforming contaminants into non-hazardous substances. One of the advantages of bioventing is its ability to biodegrade the non-volatile organics that other vapor extraction technologies that rely on volatilization cannot address.

**7. Addresses Toxicity, Mobility, or Volume?** **Totally**

**8. Long-Term Effectiveness/Permanence?** **Yes**

Bioventing can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup:** **Rating: Average**

As with all biological technologies, the time required to remediate a site using bioventing is highly dependent upon the specific soil and chemical properties of the contaminated media. The Air Force considers three years as the typical time required for cleaning up most sites.

**10. System Reliability/Maintainability:** **Rating: Better**

Generally, downtime is minimal and repair parts are readily available.

**11. Awareness of the Remediation Consulting Community:** **Rating: Average**

Although relatively new, bioventing is receiving increased exposure to the remediation consulting community, particularly its use in conjunction with soil vapor extraction. The Air Force is sponsoring bioventing demonstrations at more than 100 sites.

**12. Regulatory/Permitting Acceptability:** **Rating: Average**

**13. Community Acceptability:** **Rating: Better**

The public generally prefers destruction technologies that do not require excavation. In addition, bioventing can eliminate the risks of volatilization of contaminants into the atmosphere.

## SOIL VAPOR EXTRACTION (SVE):

Vacuum is applied through extraction wells to create a pressure gradient that induces volatiles to diffuse through the soil to extraction wells. The process includes a system for handling off-gases. This process also is known as *in situ* soil venting, *in situ* volatilization, enhanced volatilization, or soil vacuum extraction. *In situ* SVE is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- High humic content of soil inhibits contaminant volatilization.
- Heterogeneous soil conditions may result in inconsistent removal rates.
- Low soil permeability limits subsurface air flow rates and reduces process efficiency.

The target contaminant groups for *in situ* SVE are halogenated and non-halogenated volatile organic compounds, and fuel hydrocarbons (1, 3, and 5). The technology is applicable only to volatile compounds with a Henry's law constant greater than 0.01 or a vapor pressure greater than 0.5 units. *In situ* SVE generally applies only to the vadose zone. Treatment of the saturated zone is only possible by artificially lowering the water table. Since SVE is an *in situ* remedy and all contaminants are under vacuum until treatment, the possibility of release is greatly reduced.

- |                                                                                                                                                 |                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1. Overall Cost</b>                                                                                                                          | <b>Rating: Better</b>  |
| Data indicates the overall cost for <i>in situ</i> SVE is typically under \$50/ton, excluding treatment of off-gases and collected groundwater. |                        |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                                   | <b>O&amp;M</b>         |
| <b>3. Commercial Availability</b>                                                                                                               | <b>Rating: Better</b>  |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                                  | <b>No</b>              |
| While SVE is considered a stand-alone technology, it also can be used as part of treatment trains to address semivolatiles.                     |                        |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                             | <b>Rating: Liquid</b>  |
| <b>6. Minimum Contaminant Concentration Achievable</b>                                                                                          | <b>Rating: Average</b> |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>                                                                                  | <b>Rating: Volume</b>  |

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## Reference Guide: Remediation Technologies Screening Matrix

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### 8. Long-Term Effectiveness/Permanence?

Yes

Assuming the characteristics of the treated soil allow for the effective use of *in situ* SVE, the remediation of the targeted contaminants is permanent.

### 9. Time To Complete Cleanup

Rating: Average

The time required to remediate a site using *in situ* SVE is highly dependent upon the specific soil and chemical properties of the contaminated media. The "standard" site of 20,000 tons (18,200 metric tons) of contaminated media generally would require 12-36 months.

### 10. System Reliability/Maintainability

Rating: Better

Generally, most of the hardware components are readily available. Typical *in situ* SVE systems can be left unattended for long periods of time. The technology has been successfully operated during severe weather conditions.

### 11. Awareness of Remediation Consulting Community

Rating: Better

### 12. Regulatory/Permitting Acceptability

Rating: Better

*In situ* SVE has been used at many Superfund and other hazardous waste sites.

### 14. Community Acceptability

Rating: Better

## SOIL FLUSHING:

Water, or water containing an additive to enhance contaminant solubility, is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater. The process includes extraction of the groundwater and capture/treatment/removal of the leached contaminants before the groundwater is re-circulated. Soil flushing is a pilot-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The technology is applicable only to sites with favorable hydrology, where flushed contaminants and soil flushing fluid can be contained and recaptured.
- Low permeable soils are difficult to treat.
- Surfactants can adhere to soil and reduce effective soil porosity.
- Solvent reactions with soil can reduce contaminant mobility.

The target contaminant groups for soil flushing are halogenated and non-halogenated volatile organic compounds, and inorganics (1, 3, and 7). The technology can be used to treat halogenated and non-halogenated semivolatile organic compounds, fuels, and pesticides (2, 4, 5, and 6), but it may be less effective and may only be applicable to some compounds in these contaminant groups. The addition of compatible surfactants may be used to increase the solubility of some compounds effectively. The technology offers the potential for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils. Soil flushing does introduce potential toxins (e.g., the flushing solution) into the soil, which also may alter the physical/chemical properties of the soil system.

- |                                                                                                                                                                                                                                                                                        |                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 1. Overall Cost                                                                                                                                                                                                                                                                        | Rating: Inadequate Information |
| 2. Capital (Cap) or O&M Intensive?                                                                                                                                                                                                                                                     | O&M                            |
| 3. Commercial Availability                                                                                                                                                                                                                                                             | Rating: Better                 |
| 4. Typically Part of a Treatment Train?                                                                                                                                                                                                                                                | No                             |
| <p>Soil flushing can be used as a stand-alone technology for some applications and is capable of reducing contaminant concentrations in the soil to acceptable levels. However, it also can be used in combination with other technologies, such as <i>in situ</i> bioremediation.</p> |                                |
| 5. Residuals Produced (Solid, Liquid, Vapor)                                                                                                                                                                                                                                           | Rating: Liquid                 |
| <p>It is important to ensure that the site has favorable hydrology so that flushed contaminants and soil flushing fluid can be contained and recaptured.</p>                                                                                                                           |                                |
| 6. Minimum Contaminant Concentration Achievable                                                                                                                                                                                                                                        | Rating: Worse                  |
| 7. Addresses Toxicity (T), Mobility (M), or Volume (V)?                                                                                                                                                                                                                                | Rating: Volume                 |

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**Reference Guide: Remediation Technologies Screening Matrix**

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<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Worse</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Average</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Average</b>
<b>12. Regulatory/Permitting Acceptability</b>	<b>Rating: Worse</b>
<b>13. Community Acceptability</b>	<b>Rating: Average</b>



## ***IN SITU* SOLIDIFICATION/STABILIZATION:**

Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). *In situ* solidification/stabilization is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Depth of contaminants.
- Environmental conditions may affect ability to maintain immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with variations of this process. Treatability studies may be required.

The target contaminant group for *in situ* solidification/stabilization is inorganics (7). The technology has limited effectiveness against halogenated and non-halogenated semivolatile organic compounds, and pesticides (2, 4, and 6). However, systems designed to be more effective in treating organics are being developed and tested. *In situ* solidification/stabilization is relatively simple, uses readily available equipment, and has high throughput rates compared to other technologies.

- |                                                |                       |
|------------------------------------------------|-----------------------|
| <b>1. Overall Cost</b>                         | <b>Rating: Better</b> |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>  | <b>Capital</b>        |
| <b>3. Commercial Availability</b>              | <b>Rating: Better</b> |
| <b>4. Typically Part of a Treatment Train?</b> | <b>No</b>             |
- In situ* solidification/stabilization is generally considered a stand-alone technology.
- |                                                      |              |
|------------------------------------------------------|--------------|
| <b>5. Residuals Produced (Solid, Liquid, Vapor)?</b> | <b>Solid</b> |
|------------------------------------------------------|--------------|
- Depending on the original contaminants and the chemical reactions that take place in the *in situ* solidification/stabilization process, the resultant stabilized mass may still have to be treated as a hazardous waste.
- |                                                                |                               |
|----------------------------------------------------------------|-------------------------------|
| <b>6. Minimum Contaminant Concentration Achievable</b>         | <b>Rating: Not Applicable</b> |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b> | <b>Mobility</b>               |
- In situ* solidification/stabilization processes have demonstrated the capability to reduce the mobility of contaminated waste by greater than 95%.
- |                                               |                               |
|-----------------------------------------------|-------------------------------|
| <b>8. Long-Term Effectiveness/Permanence?</b> | <b>Inadequate Information</b> |
| <b>9. Time To Complete Cleanup</b>            | <b>Rating: Better</b>         |

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**Reference Guide: Remediation Technologies Screening Matrix**

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<b>10. System Reliability/Maintainability</b>	<b>Rating: Better</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Average</b>
<b>12. Regulatory/Permitting Acceptability</b>	<b>Rating: Average</b>
<b>13. Community Acceptability</b>	<b>Rating: Average</b>

## PNEUMATIC FRACTURING:

Pressurized air is injected beneath the surface to develop cracks in low permeability and over-consolidated sediments. These new passageways increase the effectiveness of many *in situ* processes and enhance extraction efficiencies. Pneumatic fracturing is a pilot-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The technology should not be used in areas of high seismic activity.
- Investigation of possible underground utilities, structures, or trapped free product is required.
- The potential exists to open new pathways for the unwanted spread of contaminants (e.g., dense non-aqueous phase liquids).

Pneumatic fracturing is applicable to the complete range of contaminant groups (1-7) with no particular target group. The technology is used primarily to fracture clays and bedrock, but has applications in aerating sand. Normal operation employs a two-person crew, making 25 - 40 fractures per day with a fracture radius of 15-20 feet (4.6-6.1 meters) to a depth of 50-100 feet (15.2-30.5 meters).

### 1. Overall Cost

Rating: Better

The normal cost range for pneumatic fracturing is \$5-\$10/ton (\$5.50-\$11.00/metric ton).

### 2. Capital (Cap) or O&M Intensive?

Neither

### 3. Commercial Availability

Rating: Worse

The technology is currently available from only one vendor. Pneumatic fracturing was tested with hot gas injection and extraction in EPA's SITE Demonstration Program in 1992. Results are expected to be published in mid-1993. A phase II demonstration is planned for 1993.

### 4. Typically Part of a Treatment Train?

Yes

Pneumatic fracturing is an enhancement technology, designed to increase the efficiency of other *in situ* technologies in difficult soil conditions. The technology is most commonly integrated with vapor extraction, bioremediation, thermal treatment, or soil flushing.

### 5. Residuals Produced (Solid, Liquid, Vapor)

None

### 6. Minimum Contaminant Concentration Achievable

Rating: Not Applicable

### 7. Addresses Toxicity (T), Mobility (M), or Volume (V)?

Mobility

Pneumatic fracturing is designed to increase the mobility through difficult soil conditions. The passageways enhance extraction efficiencies and increase contact between contaminants and soil amendments.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

For longer remediation programs, refracturing efforts may be required at 6-12 month intervals.

**9. Time To Complete Cleanup****Rating: Not Applicable**

Pneumatic fracturing is designed to enhance the efficiency of other technologies.

**10. System Reliability/Maintainability****Rating: Better****11. Awareness of Remediation Consulting Community****Rating: Worse**

The technology has been demonstrated in the field, including the one under EPA's SITE program. In addition, numerous bench-scale and theoretical studies have been published.

**12. Regulatory/Permitting Acceptability****Rating: Inadequate Information****13. Community Acceptability****Rating: Inadequate Information**

## **IN SITU VITRIFICATION:**

Electrodes for applying electricity, or joule heating, are used to melt contaminated soils and sludges, producing a glass and crystalline structure with very low leaching characteristics. *In situ* vitrification is currently in pilot-scale development. Most of the current work is being sponsored by the Department of Energy (DOE).

The following factors may limit the applicability and effectiveness of the process:

- The process requires homogeneity of the media.
- *In situ* vitrification is only effective to a maximum depth of approximately 30 feet (9 meters).
- Organic and inorganic off-gases must be controlled.
- *In situ* vitrification is limited to operations in the vadose zone.

While *in situ* vitrification is used primarily to encapsulate non-volatile inorganic elements (7), temperatures of approximately 3000°F (1600°C) achieved in the process destroy organic contaminants (1-6) by pyrolysis. The vitrified mass resists leaching for geologic time periods. A vacuum hood placed over the treated area collects off-gases, which are treated before release. The entire process is conducted under a vacuum, greatly reducing the possibility of contaminant release. The high voltage used in the *in situ* vitrification process, as well as control of the off-gases, present some health and safety risks. Recent operational problems involving a sudden gas release at a large-scale test pose some additional technical concerns.

### **1. Overall Cost**

**Rating: Worse**

The cost of *in situ* vitrification has been estimated to be approximately \$790/ton (\$870/metric ton). *In situ* vitrification is a relatively complex, high-energy technology requiring a high degree of skill and training.

### **2. Capital (Cap) or O&M Intensive?**

**Both**

### **3. Commercial Availability**

**Rating: Worse**

Only one vendor, Battelle Memorial Institute, is licensed at this time by the DOE to perform *in situ* vitrification. Geosafe Corporation, primarily owned by Battelle, holds the exclusive sublicense to perform *in situ* vitrification commercially.

### **4. Typically Part of a Treatment Train?**

**No**

*In situ* vitrification is normally considered a stand-alone technology.

### **5. Residuals Produced (Solid, Liquid, Vapor)**

**Liquid**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Not Applicable**

*In situ* vitrification is designed to encapsulate target contaminants rather than reduce contaminant concentration levels. However, destruction of the organic contaminants present in the treated media does occur because of temperatures achieved in the process.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Mobility**

*In situ* vitrification is designed to reduce the mobility of the contaminated wastes within the media. The vitrified mass has high resistance to leaching and has strength properties better than those of concrete. The monolith formed has hydration properties similar to those of obsidian, which hydrates at rates of less than 1 millimeter/10,000 years.

**8. Long-Term Effectiveness/Permanence?****Yes**

Studies indicate that the glass and crystalline product of *in situ* vitrification permanently immobilizes hazardous inorganics and will retain its physical and chemical integrity for geologic time periods.

**9. Time To Complete Cleanup****Rating: Better**

The time to complete cleanup of a 20,000-ton (18,200-metric ton) site using *in situ* vitrification would be approximately 7 months.

**10. System Reliability/Maintainability****Rating: Worse**

During a recent large-scale test, a sudden gas release pressurized the containment hood and splattered molten soil on the stainless steel hood.

**11. Awareness of Remediation Consulting Community****Rating: Average**

*In situ* vitrification has been used in 22 pilot-scale and 10 large-scale tests on media contaminated with inorganics, organics, and/or radioactive wastes. However, dissemination of technical information outside of DOE, Battelle, and Geosafe has been limited to date.

**12. Regulatory/Permitting Acceptability****Rating: Worse****13. Community Acceptability****Rating: Worse**

## THERMALLY ENHANCED SVE:

This process uses steam/hot-air injection or electric/radio frequency heating to increase the mobility of volatiles and facilitate extraction. The process includes a system for handling off-gases. **Thermally enhanced SVE is a full-scale technology.** It is designed to treat halogenated and non-halogenated semivolatile organic compounds (2 and 4). Some thermally enhanced SVE technologies also are effective in treating some pesticides (6), depending on the temperatures achieved by the system. The technology can also be used to treat some halogenated and non-halogenated volatile organic compounds and fuels (1, 3, and 5), but effectiveness may be limited.

The following factors may limit the applicability and effectiveness of the process:

- Debris or other large objects buried in the media can cause operating difficulties.
- Use of the technology is limited to a 5° slope or less.
- Performance against certain contaminants varies depending upon the process selected because of the maximum temperature achieved.
- The soil structure at the site may be modified depending upon the process selected.

The thermally enhanced SVE processes used by each vendor are notably different and should be investigated individually for more detailed information. Since thermally enhanced SVE is an *in situ* remedy and all contaminants are under a vacuum during operation, the possibility of contaminant release is greatly reduced.

- |                                                                                                                                                                                                 |                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1. Overall Cost</b>                                                                                                                                                                          | <b>Rating: Average</b> |
| Available data indicates the overall cost for thermally enhanced SVE systems is approximately \$50-\$75/ton (\$55-\$82/metric ton), excluding treatment of off-gases and collected groundwater. |                        |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                                                                                   | <b>Both</b>            |
| <b>3. Commercial Availability</b>                                                                                                                                                               | <b>Rating: Average</b> |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                                                                                  | <b>No</b>              |
| Thermally enhanced SVE is most commonly used as a stand-alone technology.                                                                                                                       |                        |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                                                                             | <b>Liquid</b>          |
| <b>6. Minimum Contaminant Concentration Achievable</b>                                                                                                                                          | <b>Rating: Average</b> |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>                                                                                                                                  | <b>Volume</b>          |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

Assuming the soil characteristics allow for the effective use of thermally enhanced SVE, the remediation of the target contaminants is permanent.

**9. Time To Complete Cleanup****Rating: Better**

As with SVE, remediation projects using thermally enhanced SVE systems are highly dependent upon the specific soil and chemical properties of the contaminated media. The "standard" site consisting of 20,000 tons (18,200 metric tons) of contaminated media would require approximately 9 months.

**10. System Reliability/Maintainability****Rating: Average****11. Awareness of Remediation Consulting Community****Rating: Average**

Although thermally enhanced SVE systems have only seen limited use to date, the concept of soil vapor extraction, which is its basis, is well recognized.

**12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Average**



## SLURRY PHASE BIOLOGICAL TREATMENT:

An aqueous slurry is created by combining soil or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Nutrients, oxygen, and pH in the bioreactor are controlled to enhance biodegradation. Upon completion of the process, the slurry is dewatered and the treated soil is disposed. Slurry phase biological treatment is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- A slurry phase process is much more complex than a controlled solid phase system.
- Excavation of contaminated soils is required.
- Sizing of materials prior to putting them in the hopper can be difficult and expensive. Non-homogeneous soils can create serious materials handling problems.
- Contaminant loading rates can be slow, depending on the compounds to be treated.
- Dewatering soil fines after treatment and prior to ultimate disposal is part of the process and is very expensive.
- An acceptable method for disposing of wastewaters is required.
- Slurry phase biological treatment systems are still under design to include a broader spectrum of contaminants.

Slurry-phase biological treatment is primarily designed to treat non-halogenated volatile organics and fuel hydrocarbons (3 and 5). Halogenated volatiles and semivolatiles, non-halogenated semivolatiles, and pesticides (1, 2, 4, and 6) also can be treated, but the process may be less effective and may only be applicable to some compounds within these contaminant groups. Many chlorinated organics and pesticides are not very biodegradable and this technology would not be very applicable. Aerobic co-metabolism using methanotrophic bacteria and phenol-degrading bacteria can degrade TCE and the lower chlorinated aliphatics, but do not work well for PCE and higher chlorinated compounds. Anaerobic reductive dechlorination is being investigated to treat the higher chlorinated compounds. Higher ringed polynuclear aromatic (PNA) compounds (greater than 5 rings) are very difficult to degrade.

### 1. Overall Cost

**Rating: Average**

Costs are highly dependant on the extent of preparation required for contaminated material prior to slurrying, the need for post-treatment (such as dewatering), and the need for addition of air emission control equipment.

### 2. Capital (Cap) or O&M Intensive?

**Both**

### 3. Commercial Availability:

**Rating: Average**

Commercial-scale units that are complete cleanup systems are in operation. Most of the advances in this technology are related to the development of materials handling equipment and nutrient formulations.

### 4. Typically Part of a Treatment Train?

**No**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**5. Residuals Produced (Solid, Liquid, Vapor)?** **None**

**6. Minimum Contaminant Concentration Achievable:** **Rating: Average**

This is highly dependent upon the biodegradability of the contaminants, which is affected by the mix of contaminants in the matrix, initial concentrations, and matrix desorption characteristics.

**7. Addresses Toxicity, Mobility, or Volume?** **Toxicity**

**8. Long-Term Effectiveness/Permanence?** **Yes**

Slurry phase biodegradation can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup:** **Rating: Average**

Slurry phase biological treatment is relatively rapid compared to other biological treatment processes, particularly for contaminated clays. However, as with other biological technologies, this is highly dependent upon the specific soil and chemical properties of the contaminated media. This technology is particularly applicable where the quantity of material containing recalcitrant compounds is small, and time to complete remediation is a high priority.

**10. System Reliability/Maintainability:** **Rating: Average**

**11. Awareness of the Remediation Consulting Community:** **Rating: Average**

A substantial amount of information is available on slurry phase bioremediation in the published literature and from vendors.

**12. Regulatory/Permitting Acceptability:** **Rating: Better**

The technology has been selected to treat soils and sludges at one Superfund site and has been selected to treat the fines from soil washing at four Superfund sites.

**13. Community Acceptability:** **Rating: Average**

Communities generally prefer technologies that do not require excavation, although this technology usually meets with little opposition because it destroys contaminants.

## CONTROLLED SOLID PHASE BIOLOGICAL TREATMENT:

Excavated soils are mixed with soil amendments and placed in above-ground enclosures that include leachate collection systems and some form of aeration. Controlled solid phase processes include prepared treatment beds, biotreatment cells, soil piles, and composting. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation. Controlled solid phase biological treatment is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- A large amount of space is required.
- Excavation of contaminated soils is required.
- Treatability testing should be conducted to determine the biodegradability of contaminants and appropriate oxygenation and nutrient loading rates.
- Solid phase processes have questionable effectiveness for halogenated compounds and may not be very effective in degrading transformation products of explosives.
- These processes require more time to complete cleanup than slurry phase processes.

Solid-phase biological treatment is most effective in treating non-halogenated volatile organics and fuel hydrocarbons (3 and 5). Halogenated volatiles and semivolatiles, non-halogenated semivolatiles, and pesticides (1, 2, 4, and 6) also can be treated, but the process may be less effective and may only be applicable to some compounds within these contaminant groups.

### 1. Overall Cost Rating: Better

Costs are dependent on the contaminant, procedure to be used, need for additional pre- and post-treatment, and need for air emission control equipment. Controlled solid phase processes are relatively simple and require few personnel for operation and maintenance.

### 2. Capital (Cap) or O&M Intensive? Neither

### 3. Commercial Availability: Rating: Better

### 4. Typically Part of a Treatment Train? No

### 5. Residuals Produced (Solid, Liquid, Vapor)? None

### 6. Minimum Contaminant Concentration Achievable: Rating: Average

As with other biological treatments, under proper conditions controlled solid phase processes can transform contaminants into non-hazardous substances. However, the extent of biodegradation is highly dependent on the initial concentrations of the the contaminants and their biodegradability, the properties of the contaminated matrix, and the particular treatment system selected.

### 7. Addresses Toxicity, Mobility, or Volume? Toxicity

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence? Yes**

Controlled solid phase biodegradation can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup: Rating: Average**

Time to complete cleanup for these systems is primarily a function of the degradation rates of the contaminants being treated. A prepared bed system is mainly limited by available space and the size and cost of the treatment beds.

**10. System Reliability/Maintainability: Rating: Better**

Solid phase systems are relatively simple systems that are easy to operate and maintain.

**11. Awareness of the Remediation Consulting Community: Rating: Better****12. Regulatory/Permitting Acceptability: Rating: Better**

Tanks or containers must meet RCRA standards, including requirements for secondary containment. NPDES permits are required for wastewater disposal.

**13. Community Acceptability: Rating: Average**

Communities generally prefer technologies that do not require excavation; however, this technology usually meets with little opposition due to its low cost and destruction of contaminants.

## LANDFARMING:

Contaminated soils are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste. Although landfarming usually requires excavation of contaminated soils, surface-contaminated soils may sometimes be treated in place without excavation. Landfarming systems are increasingly incorporating liners and other methods to control leaching of contaminants. **Landfarming is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- A large amount of space is required.
- Excavation of contaminated soils usually is required.
- Conditions advantageous for biological degradation of contaminants are largely uncontrolled, which increases the length of time to complete remediation, particularly for recalcitrant compounds.
- Reduction of contaminant concentrations may be caused more by volatilization than biodegradation.

Landfarming is most effective in treating non-halogenated volatile organics and fuel hydrocarbons (3 and 5). Halogenated volatiles and semivolatiles, non-halogenated semivolatiles, and pesticides (1, 2, 4, and 6) also can be treated, but the process may only be applicable to some compounds in these groups.

### 1. Overall Cost

Rating: Better

Landfarming is a very simple process and does not require control of moisture, oxygen, pH, or other parameters. Most of the system operations, such as tilling, can be done by relatively unskilled personnel.

### 2. Capital (Cap) or O&M Intensive?

Neither

### 3. Commercial Availability:

Rating: Better

Numerous full-scale operations have been used, particularly by the petroleum industry.

### 4. Typically Part of a Treatment Train?

No

### 5. Residuals Produced (Solid, Liquid, Vapor)?

None

### 6. Minimum Contaminant Concentration Achievable:

Rating: Average

As with other biological treatments, under proper conditions, landfarming can transform contaminants into non-hazardous substances. However, removal efficiencies are a function of contaminant type and concentrations, soil type, temperature, moisture, waste loading rates, application frequency, aeration, volatilization, and other factors.

### 7. Addresses Toxicity, Mobility, or Volume?

Toxicity

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

Landfarming can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup:****Rating: Worse**

This is primarily a function of the degradation rates of the contaminants being treated.

**10. System Reliability/Maintainability:****Rating: Better**

These systems require regular tilling to aerate the soil and periodic chemical analyses of waste constituents in the soil. Potential for failure is minimal unless there is excessive rainfall or degradation rates are not achieved.

**11. Awareness of the Remediation Consulting Community:****Rating: Better**

Numerous full-scale landfarming applications have been operated over the last ten years.

**12. Regulatory/Permitting Acceptability:****Rating: Average**

The acceptability of this technology varies by State. Permitting of landfarm operations is becoming more difficult.

**13. Community Acceptability:****Rating: Average**

Communities generally prefer technologies that do not require excavation; however, this technology usually meets with little opposition due to its low cost and destruction of contaminants.

## SOIL WASHING:

Contaminants sorbed onto soil particles are separated from soil in an aqueous-based system. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics or heavy metals. Soil washing is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Fine soil particles (silts, clays) are difficult to remove from washing fluid.
- Complex waste mixtures (e.g., metals with organics) make formulating washing fluid difficult.
- High humic content in soil inhibits desorption.

The target contaminant groups for soil flushing are halogenated and non-halogenated semivolatile organic compounds, fuel hydrocarbons, and inorganics (2, 4, 5, and 7). The technology can be used but may be less effective against halogenated and non-halogenated volatile organic compounds and pesticides (1, 3, and 6). The technology offers the potential for recovery of metals and can clean a wide range of organic and inorganic contaminants from coarse-grained soils. As an *ex situ* remedy, the excavation associated with soil washing poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

**1. Overall Cost** **Rating: Average**

Average cost for use of this technology, including excavation, is approximately \$120-\$200 per ton (\$132-\$220/metric ton), depending on the target waste quantity and concentration.

**2. Capital (Cap) or O&M Intensive?** **Both**

**3. Commercial Availability** **Rating: Average**

**4. Typically Part of a Treatment Train?** **Yes**

Soil washing is most commonly used in combination with the following technologies: bioremediation, incineration, and solidification/stabilization.

**5. Residuals Produced (Solid, Liquid, Vapor)** **Rating: Solid, Liquid**

Depending on the process used, the washing agent and soil fines are residuals that require further treatment.

**6. Minimum Contaminant Concentration Achievable** **Rating: Average**

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Volume**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

When contaminated fines have been separated, coarse-grain soil can usually be returned clean to the site. It should stay clean unless re-contaminated.

**9. Time To Complete Cleanup****Rating: Better**

The time to complete cleanup of the "standard" 20,000-ton (18,200-metric ton) site using soil washing would be less than 3 months.

**10. System Reliability/Maintainability****Rating: Average****11. Awareness of Remediation Consulting Community****Rating: Average****12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Better**



## SOLIDIFICATION/STABILIZATION:

Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). *Ex situ* solidification/stabilization is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Environmental conditions may affect the long-term immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with different processes. Treatability studies may be required.

The target contaminant group for *ex situ* solidification/stabilization is inorganics (7). The technology has limited effectiveness against halogenated and non-halogenated semivolatile organic compounds and pesticides (2, 4, and 6). However, systems designed to be more effective against organic contaminants are being developed and tested. *Ex situ* solidification/stabilization is relatively simple, uses readily available equipment, and has high throughput rates compared to other technologies. As an *ex situ* remedy, the excavation associated with solidification/stabilization poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

### 1. Overall Cost

Rating: Better

*Ex situ* solidification/stabilization processes are among the most mature remediation technologies. Representative overall costs from more than a dozen vendors indicate an approximate cost of under \$100/ton (\$110/metric ton), including excavation.

### 2. Capital (Cap) or O&M Intensive?

Capital

### 3. Commercial Availability

Rating: Better

### 4. Typically Part of a Treatment Train?

No

*Ex situ* solidification/stabilization is generally considered a stand-alone technology. However, it is often used in combination with other technologies, such as solvent extraction, bioremediation, soil washing, and soil vapor extraction.

### 5. Residuals Produced (Solid, Liquid, Vapor)

Solid

Depending upon the original contaminants and the chemical reactions that take place in the *ex situ* solidification/stabilization process, the resultant stabilized mass may have to be handled as a hazardous waste.

### 6. Minimum Contaminant Concentration Achievable

Rating: Not Applicable

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**Reference Guide: Remediation Technologies Screening Matrix**

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**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Mobility**

*Ex situ* solidification/stabilization processes have demonstrated capability to reduce the mobility of contaminated waste by greater than 95%.

**8. Long-Term Effectiveness/Permanence?****Inadequate Information****9. Time To Complete Cleanup****Rating: Better**

Remediation of the "standard" site consisting of 20,000 tons (18,200 metric tons) would require less than 1 month.

**10. System Reliability/Maintainability****Rating: Better****11. Awareness of Remediation Consulting Community****Rating: Better****12. Regulatory/Permitting Acceptability****Rating: Average**

While CERCLA includes preference for treatment of contaminants, solidification/stabilization technologies generally face minimal difficulty in obtaining the necessary regulatory/permitting approvals and have been selected for use at many Superfund sites.

**13. Community Acceptability****Rating: Average**

Public resistance to most solidification/stabilization technologies has been minimal and the technology is normally accepted.

## **DEHALOGENATION (GLYCOLATE):**

An alkaline polyethylene glycolate (APEG) reagent is used to dehalogenate halogenated aromatic compounds in a batch reactor. Potassium Polyethylene Glycolate (KPEG) is the most common APEG reagent. Contaminated soils and the reagent are mixed and heated in a treatment vessel. In the APEG process, the reaction causes the polyethylene glycol to replace halogen molecules and render the compound non-hazardous. For example, the reaction between chlorinated organics and KPEG causes replacement of a chlorine molecule and results in a reduction in toxicity. **Dehalogenation (glycolate) is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- The technology is generally not cost effective for large waste volumes.
- Media water content above 20% requires excessive reagent volume.
- Concentrations of chlorinated organics greater than 5% require large volumes of reagent.
- The resultant soil has poor physical characteristics.

The target contaminant groups for glycolate dehalogenation are halogenated semivolatile organic compounds and pesticides (2 and 6). The technology can be used but may be less effective against selected halogenated volatile organic compounds (1). APEG dehalogenation is one of the few processes available other than incineration that has been successfully field tested in treating PCBs. The technology is amenable to small-scale applications. As an *ex situ* remedy, the excavation associated with dehalogenation (APEG/KPEG) poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

- |                                                                                                                                              |                        |
|----------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1. Overall Cost</b>                                                                                                                       | <b>Rating: Worse</b>   |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                                | <b>Both</b>            |
| <b>3. Commercial Availability</b>                                                                                                            | <b>Rating: Average</b> |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                               | <b>No</b>              |
| Dehalogenation (APEG/KPEG) is generally considered a stand-alone technology. However, it can be used in combination with other technologies. |                        |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                          | <b>Liquid</b>          |

Treatment of the wastewater generated by the process may include chemical oxidation, biodegradation, carbon adsorption, or precipitation.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Better**

Dehalogenation (glycolate) has been used to successfully treat contaminant concentrations of PCBs from less than 2 mg/kg to reportedly as high as 45,000 mg/kg.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Rating: Toxicity****8. Long-Term Effectiveness/Permanence?****Yes****9. Time To Complete Cleanup****Rating: Worse****10. System Reliability/Maintainability****Rating: Worse****11. Awareness of Remediation Consulting Community****Rating: Average****12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Average**

The technology has greater public acceptance than incineration.

## **DEHALOGENATION (BASE-CATALYZED DECOMPOSITION):**

Contaminated soil is screened, processed with a crusher and pug mill, and mixed with sodium bicarbonate. The mixture is heated at 630°F (333°C) in a rotary reactor to decompose and partially volatilize the contaminants. Dehalogenation (BCD) is a full-scale technology. However, it has had very limited use.

The following factors may limit the applicability and effectiveness of the process:

- If the influent matrix includes heavy metals and certain non-halogenated volatiles, they will not be destroyed by the process.
- High clay and moisture content will increase treatment costs.

The target contaminant groups for dehalogenation (BCD) are halogenated semivolatile organic compounds and pesticides (2 and 6). The technology can be used to treat halogenated volatile organic compounds (1), but may be less effective and applicable to only some compounds within this group. The dehalogenation (BCD) process was developed by EPA's Risk Reduction Engineering Laboratory (RREL), in cooperation with the Naval Civil Engineering Laboratory (NCEL), as a clean, inexpensive way to remediate soils and sediments contaminated with chlorinated organic compounds, especially PCBs. As an *ex situ* remedy, the excavation associated with dehalogenation (BCD) poses a potential health and safety risk to site workers, through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

- |                                                                                                                                        |                                       |
|----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| <b>1. Overall Cost</b>                                                                                                                 | <b>Rating: Inadequate Information</b> |
| Use of this technology has been so limited that no reliable data on cost are available.                                                |                                       |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                          | <b>Rating: Inadequate Information</b> |
| <b>3. Commercial Availability</b>                                                                                                      | <b>Rating: Worse</b>                  |
| As of November 1992, no U.S. vendors were licensed to use the technology.                                                              |                                       |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                         | <b>No</b>                             |
| Dehalogenation (BCD) is generally considered a stand-alone technology. However, it can be used in combination with other technologies. |                                       |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                    | <b>Vapor</b>                          |
| <b>6. Minimum Contaminant Concentration Achievable</b>                                                                                 | <b>Rating: Inadequate Information</b> |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>                                                                         | <b>Toxicity</b>                       |
| <b>8. Long-Term Effectiveness/Permanence?</b>                                                                                          | <b>Yes</b>                            |

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**Reference Guide: Remediation Technologies Screening Matrix**

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<b>9. Time To Complete Cleanup</b>	<b>Rating: Inadequate Information</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Inadequate Information</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Worse</b>
<b>12. Regulatory/Permitting Acceptability</b>	<b>Rating: Inadequate Information</b>
<b>13. Community Acceptability</b>	<b>Rating: Inadequate Information</b>

## **SOLVENT EXTRACTION:**

Waste and solvent are mixed in an extractor, dissolving into the solvent. The extracted organics and solvent are then placed in a separator, where the contaminants and solvent are separated for treatment and further use. Solvent extraction is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Organically bound metals can be extracted along with the target organic pollutants, which restricts handling of the residuals.
- The presence of detergents and emulsifiers can unfavorably influence the extraction performance.
- Traces of solvent may remain in the treated solids; the toxicity of the solvent is an important consideration.
- Solvent extraction is generally least effective on very high molecular weight organic and very hydrophilic substances.
- Some soil types and moisture content levels will adversely impact process performance.

The target contaminant groups for solvent extraction are halogenated and non-halogenated semivolatile organic compounds and pesticides (2, 4, and 6). The technology can be used to treat halogenated and non-halogenated volatile organic compounds, and fuels (1, 3, and 5), but it may be less effective and may be applicable to only some compounds in these groups. As an *ex situ* remedy, the excavation associated with solvent extraction poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

- |                                                |                        |
|------------------------------------------------|------------------------|
| <b>1. Overall Cost</b>                         | <b>Rating: Worse</b>   |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>  | <b>Both</b>            |
| <b>3. Commercial Availability</b>              | <b>Rating: Average</b> |
| <b>4. Typically Part of a Treatment Train?</b> | <b>Yes</b>             |

Solvent extraction is commonly used in combination with other technologies, such as solidification/stabilization, incineration, or soil washing, depending upon site-specific conditions. It also can be used as a stand-alone technology, in some instances.

- |                                                     |               |
|-----------------------------------------------------|---------------|
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b> | <b>Liquid</b> |
|-----------------------------------------------------|---------------|

Organically bound metals can be extracted along with the target organic contaminants, thereby creating residuals with special handling requirements. Traces of solvent may remain within the treated soil matrix, so the toxicity of the solvent is an important consideration.

- |                                                        |                        |
|--------------------------------------------------------|------------------------|
| <b>6. Minimum Contaminant Concentration Achievable</b> | <b>Rating: Average</b> |
|--------------------------------------------------------|------------------------|

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**Reference Guide: Remediation Technologies Screening Matrix**

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**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Volume**

Solvent extraction does not destroy wastes, but is a means of separating the contaminants, thereby reducing the volume of hazardous waste to be treated.

**8. Long-Term Effectiveness/Permanence?** **Yes**

The treated media is usually returned to the site after having met Best Demonstrated Available Technology (BDAT) and other standards.

**9. Time To Complete Cleanup** **Rating: Worse****10. System Reliability/Maintainability** **Rating: Average****11. Awareness of Remediation Consulting Community** **Rating: Average****12. Regulatory/Permitting Acceptability** **Rating: Average****13. Community Acceptability** **Rating: Average**

With enclosed systems and dust control measures during soil (feed) preparation, solvent extraction appears to pose little threat to the community.



## CHEMICAL REDUCTION/OXIDATION:

Reduction/oxidation chemically converts hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The reducing/oxidizing agents most commonly used for treatment of hazardous contaminants are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. A combination of these reagents, or combining them with ultraviolet (UV) oxidation, makes the process more effective. Chemical reduction/oxidation is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Incomplete oxidation or formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents used.
- The process is not cost effective for high contaminant concentrations due to the large amounts of oxidizing agent required.
- Oil and grease in the media should be minimized to optimize process efficiency.

The target contaminant group for chemical reduction/oxidation is inorganics (7). The technology can be used but may be less effective against non-halogenated volatile and semivolatile organic compounds, fuel hydrocarbons, and pesticides (3, 4, 5, and 6). As an *ex situ* remedy, the excavation associated with chemical reduction/oxidation poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

1. Overall Cost	Rating: Average
2. Capital (Cap) or O&M Intensive?	Neither
3. Commercial Availability	Rating: Better
4. Typically Part of a Treatment Train?	Yes
5. Residuals Produced (Solid, Liquid, Vapor)	Solid
6. Minimum Contaminant Concentration Achievable	Rating: Not Applicable
7. Addresses Toxicity (T), Mobility (M), or Volume (V)?	Toxicity, Mobility
Oxidation chemically converts inorganics to non-hazardous or less toxic compounds that are more stable, less mobile, or inert.	
8. Long-Term Effectiveness/Permanence?	Inadequate Information
9. Time To Complete Cleanup	Rating: Better
10. System Reliability/Maintainability	Rating: Better

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**Reference Guide: Remediation Technologies Screening Matrix**

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**11. Awareness of Remediation Consulting Community****Rating: Average**

Chemical reduction/oxidation is a well established technology used for disinfection of drinking water and wastewater, and is a common treatment for cyanide wastes. Enhanced systems are now being used more frequently to treat hazardous wastes in soils.

**12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Average**

## SOIL VAPOR EXTRACTION (SVE):

A vacuum is applied to a network of above-ground piping to encourage volatilization of organics from the excavated media. The process includes a system for handling off-gases. The process is very similar to *in situ* SVE. *Ex situ* SVE is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- High humic content of soil inhibits volatilization.
- The technology is incompatible with certain soil types.

The target contaminant groups for *ex situ* SVE are halogenated and non-halogenated volatile organic compounds (1 and 3). An advantage of the technology over its *in situ* counterpart is the increased number of passageways formed via the excavation process. However, as an *ex situ* remedy, the excavation associated with SVE poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

1. Overall Cost Rating: Better

The overall cost for *ex situ* SVE is under \$100/ton (\$110/metric ton), including the cost of excavation, but excluding treatment of off-gases and collected groundwater.

2. Capital (Cap) or O&M Intensive? Neither

3. Commercial Availability Rating: Better

4. Typically Part of a Treatment Train? No

5. Residuals Produced (Solid, Liquid, Vapor) Liquid

6. Minimum Contaminant Concentration Achievable Rating: Average

7. Addresses Toxicity (T), Mobility (M), or Volume (V)? Volume

8. Long-Term Effectiveness/Permanence? Yes

Assuming the characteristics of the treated soil allow for the effective use of *ex situ* SVE, the remediation of the targeted contaminants is permanent.

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## Reference Guide: Remediation Technologies Screening Matrix

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### 9. Time To Complete Cleanup

Rating: Average

The time required to remediate a site using *ex situ* SVE is highly dependent upon the specific soil and chemical properties of the contaminated media. Cleanup of the "standard" site consisting of 20,000 tons (18,200 metric tons) of contaminated media would require 12-36 months.

### 10. System Reliability/Maintainability

Rating: Better

Generally, most of the hardware components are relatively well developed with repair parts readily available to minimize downtime. Typical *ex situ* SVE systems can be left unattended for long periods of time.

### 11. Awareness of Remediation Consulting Community

Rating: Better

### 12. Regulatory/Permitting Acceptability

Rating: Average

### 13. Community Acceptability

Rating: Average

## LOW TEMPERATURE THERMAL DESORPTION:

Wastes are heated from 200°-600°F (93°-315°C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. Low temperature thermal desorption systems are physical separation processes and are not designed to destroy organics. The bed temperatures and residence times designed into these systems will volatilize selected contaminants, but typically not oxidize them. **Low temperature thermal desorption is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- There are specific feed size and materials handling requirements that can impact applicability or cost at specific sites.
- Dewatering may be necessary to achieve acceptable soil moisture content levels.
- Highly abrasive feed potentially can damage the processor unit.

The target contaminant groups for low temperature thermal desorption systems are halogenated and non-halogenated volatile organic compounds and fuels (1, 3, and 5). The technology can be used to treat halogenated and non-halogenated semivolatile organic compounds and pesticides (2, 4, and 6) but may be less effective. As an *ex situ* remedy, the excavation associated with low temperature thermal desorption poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

### 1. Overall Cost

Rating: Better

Approximate overall cost is less than \$100/ton (\$110/metric ton). Low temperature thermal desorption is relatively labor intensive. The skill and training level required for most of the operating personnel is minimal.

### 2. Capital (Cap) or O&M Intensive?

Both

### 3. Commercial Availability

Rating: Better

There are at least five vendors actively promoting the technology and most of the hardware components for low temperature thermal desorption systems are readily available off the shelf. The engineering and configuration of the systems are similarly refined, such that once a full-scale system is designed, little or no prototyping is required.

### 4. Typically Part of a Treatment Train?

Yes

Low temperature thermal desorption is frequently used in combination with incineration, solidification/stabilization, or dechlorination, depending upon site-specific conditions.

### 5. Residuals Produced (Solid, Liquid, Vapor)

Liquid

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Better**

The technology has proven it can produce a final contaminant concentration level below 5 mg/kg for the target contaminants identified.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Volume****8. Long-Term Effectiveness/Permanence?****Yes**

Treatment using low temperature thermal desorption is considered to be permanent.

**9. Time To Complete Cleanup****Rating: Better**

Cleanup of the "standard" site consisting of 20,000 tons (18,200 metric tons) would require less than 2 months.

**10. System Reliability/Maintainability****Rating: Average**

Daily maintenance checks are required for all thermal desorption technologies. Generally, most of the hardware components are relatively well developed with repair parts readily available to minimize downtime. Normal maintenance concerns include temperature control, waste feed system, dust and particulate collection, and fouling of the heat transfer surfaces with polymers.

**11. Awareness of Remediation Consulting Community****Rating: Better**

Low temperature thermal desorption systems have been demonstrated in the EPA SITE Demonstration Program.

**12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Average**

## HIGH TEMPERATURE THERMAL DESORPTION:

Wastes are heated to 600°-1,000°F (315°-538°C) to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. High temperature thermal desorption systems are physical separation processes and are not designed to destroy organics. Bed temperatures and typical residence times will cause selected contaminants to volatilize, but not oxidize. High temperature thermal desorption is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- There are specific feed size and materials handling requirements that can impact applicability or cost at specific sites.
- Dewatering may be necessary to achieve acceptable soil moisture content levels.
- Highly abrasive feed can potentially damage the processor unit.

High temperature thermal desorption systems have varying degrees of effectiveness against the full spectrum of organic contaminants. The target contaminants are halogenated and non-halogenated semivolatile organic compounds, and pesticides (2, 4, and 6). Halogenated and non-halogenated volatiles and fuels (1, 3, and 5) also may be treated, but treatment may be less effective. As an *ex situ* remedy, the excavation associated with high temperature thermal desorption poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations.

### 1. Overall Cost

Rating: Average

Approximate overall cost is between \$100 and \$300/ton (\$110 and \$330/metric ton).

### 2. Capital (Cap) or O&M Intensive?

Both

### 3. Commercial Availability

Rating: Better

There are at least five vendors actively promoting the technology and most of the hardware components for high temperature thermal desorption systems are readily available off the shelf. The engineering and configuration of the systems are similarly refined, such that once a full-scale system is designed, little or no prototyping is required.

### 4. Typically Part of a Treatment Train?

Yes

High temperature thermal desorption is frequently used in combination with incineration, solidification/stabilization, or dechlorination, depending upon site-specific conditions.

### 5. Residuals Produced (Solid, Liquid, Vapor)

Liquid

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Better**

The technology has proven it can produce a final contaminant concentration level below 5 mg/kg for the target contaminants identified.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Volume****8. Long-Term Effectiveness/Permanence?****Yes**

Treatment using high temperature thermal desorption is considered to be permanent.

**9. Time To Complete Cleanup****Rating: Better**

The time to complete cleanup of the "standard" 20,000-ton (18,200-metric ton) site using high temperature thermal desorption is just over 4 months.

**10. System Reliability/Maintainability****Rating: Average**

Daily maintenance checks are required for all thermal desorption technologies. Generally, most of the hardware components are relatively well developed with repair parts readily available to minimize downtime. Normal maintenance concerns include temperature control, waste feed system, dust and particulate collection, and fouling of the heat transfer surfaces with polymers.

**11. Awareness of Remediation Consulting Community****Rating: Average**

High temperature thermal desorption has been demonstrated in the EPA SITE Demonstration Program.

**12. Regulatory/Permitting Acceptability****Rating: Average****13. Community Acceptability****Rating: Average**



## VITRIFICATION:

Contaminated soils and sludges are melted at high temperature to form a glass and crystalline structure with very low leaching characteristics. Non-volatile inorganic elements are encapsulated in a vitreous slag while organic contaminants are destroyed by pyrolysis. *Ex situ* vitrification is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Organic and inorganic off-gases need to be controlled.
- Use or disposal of the resultant vitrified slag is required.
- Accessibility to a sufficient power supply is needed.

*Ex situ* vitrification is applicable to the full range of contaminant groups, but inorganics (7) is the target contaminant group. Metals are encapsulated in the vitrified mass, resisting leaching for geologic time periods. The excavation associated with *ex situ* vitrification poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations. The high energy required for the *ex situ* vitrification process also is a health and safety concern when using the technology.

### 1. Overall Cost

Rating: Worse

Approximate overall cost is \$700/ton (\$770/metric ton). *Ex situ* vitrification is a relatively complex, high-energy technology requiring a high degree of specialized skill and training.

### 2. Capital (Cap) or O&M Intensive?

Both

### 3. Commercial Availability

Rating: Average

Five vendors are known to be actively promoting their own proprietary *ex situ* vitrification technology processes.

### 4. Typically Part of a Treatment Train?

No

*Ex situ* vitrification is normally considered a stand-alone technology. However, its potential for use in treating the solid residuals from other technologies, such as incinerator ash, is receiving increasing attention.

### 5. Residuals Produced (Solid, Liquid, Vapor)

Liquid

### 6. Minimum Contaminant Concentration Achievable

Rating: Not Applicable

Vitrification is designed to encapsulate target contaminants, rather than reduce contaminant concentrations. However, destruction of the organic contaminants present in the treated media does occur because of temperatures achieved in the process.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Mobility**

*Ex situ* vitrification is most effective in reducing the mobility of the contaminated wastes within the media. The vitrified mass has high resistance to leaching and possess strength properties better than those of concrete. The monolith formed has hydration properties similar to those of obsidian, which hydrates at rates of less than 1 mm/10,000 years.

**8. Long-Term Effectiveness/Permanence?****Yes**

Studies indicate that the glass and crystalline product of *ex situ* vitrification permanently immobilizes hazardous inorganics and will retain its physical and chemical integrity for geologic time periods.

**9. Time To Complete Cleanup****Rating: Average****10. System Reliability/Maintainability****Rating: Average****11. Awareness of Remediation Consulting Community****Rating: Average****12. Regulatory/Permitting Acceptability****Rating: Worse****13. Community Acceptability****Rating: Worse**

## INCINERATION:

High temperatures, 1,600°-2,200°F (871°-1,204°C), are used to volatilize and combust (in the presence of oxygen) organic constituents in hazardous wastes. Four common incinerator designs are rotary kiln, liquid injection, fluidized bed, and infrared incinerators. The destruction and removal efficiency (DRE) for properly operated incinerators often exceeds the 99.99% requirement for hazardous waste and can be operated to meet the 99.9999% requirement for PCBs and dioxins. **All four incinerator types have been used successfully at full scale.**

The following factors may limit the applicability and effectiveness of the process:

- There are specific feed size and materials handling requirements that can impact applicability or cost at specific sites.
- The presence of volatile metals and salts may affect performance or incinerator life.
- Volatile metals, including lead and arsenic, leave the combustion unit with the flue gases or in bottom ash and may have to be removed prior to incineration.
- Metals can react with other elements in the feed stream, such as chlorine or sulfur, forming more volatile and toxic compounds than the original species.
- Sodium and potassium can attack the brick lining and form a sticky particulate that fouls heat transfer surfaces.

The target contaminant groups for incineration are all halogenated and non-halogenated semivolatile organic compounds and pesticides (2, 4, and 6). The technology also may be used to treat halogenated and non-halogenated volatile organics and fuels (1, 3, and 5) but may be less effective. As an *ex situ* remedy, the excavation associated with incineration poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations. If an off-site incinerator is used, the potential risk of transporting the hazardous waste through the community must be considered.

### 1. Overall Cost

Rating: Worse

Incineration costs are highly dependent upon the size of the contaminated site and the type of incinerator technology used. The cost to incinerate approximately 20,000 tons (18,200 metric tons) of contaminated media would be greater than \$300/ton (\$330/metric ton).

### 2. Capital (Cap) or O&M Intensive?

Both

The capital expenditures associated with incinerators is relatively high. Materials handling, control of bed temperatures and residence times, and system maintenance make the technology O&M-intensive as well.

### 3. Commercial Availability

Rating: Better

Incineration is one of the most mature remediation technologies and its use at Superfund sites is increasing. There are well over a dozen mobile, transportable, or off-site incinerator vendors, and as many or more incinerator manufacturers.

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**Reference Guide: Remediation Technologies Screening Matrix**

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- 4. Typically Part of a Treatment Train?** **No**

Incineration is normally considered a stand-alone technology. However, incineration can be used in combination with other technologies, such as soil washing, thermal desorption, and solvent extraction, depending upon site-specific conditions.

- 5. Residuals Produced (Solid, Liquid, Vapor)** **Liquid, Solid**

- 6. Minimum Contaminant Concentration Achievable** **Rating: Better**

The technology has proven it can produce a final contaminant concentration level below 5 mg/kg for the target contaminants identified.

- 7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Toxicity**

Incinerators primarily reduce toxicity by destroying the contaminants, but the process also accomplishes volume reduction.

- 8. Long-Term Effectiveness/Permanence?** **Yes**

The result of incineration is the destruction of organic wastes, permanently reducing the risk to human health and the environment.

- 9. Time To Complete Cleanup** **Rating: Better**

The time to complete cleanup of the "standard" 20,000-ton (18,200-metric ton) site using incineration would be less than 3 months.

- 10. System Reliability/Maintainability** **Rating: Average**

Daily maintenance checks are required for all incinerator designs. Generally, most of the hardware components are relatively well developed and repair parts are readily available to minimize downtime. Normal maintenance concerns include temperature control, waste feed system, dust and particulate collection, and fouling of the heat transfer surfaces.

- 11. Awareness of Remediation Consulting Community** **Rating: Better**

- 12. Regulatory/Permitting Acceptability** **Rating: Average**

Incineration, primarily off-site, has been selected or used as the remedial action at more than 150 Superfund sites. Incineration is subject to a series of technology-specific regulations, including the following federal requirements: CAA (Air Emissions), TSCA (PCB Treatment and Disposal), NEPA (HW Generation, Treatment, Storage and Disposal), NPDES (Discharge to Surface Waters), NCA (Noise), and RCRA (Emissions).

- 13. Community Acceptability** **Rating: Worse**

## **PYROLYSIS:**

Chemical decomposition is induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash. Pyrolysis is currently pilot scale.

The following factors may limit the applicability and effectiveness of the process:

- There are specific feed size and materials handling requirements that impact applicability or cost at specific sites.
- The technology requires a low soil moisture content.
- Highly abrasive feed can potentially damage the processor unit.

The target contaminant groups for pyrolysis are all halogenated and non-halogenated semivolatile organic compounds and pesticides (2, 4, and 6). The technology also may be used to treat halogenated and non-halogenated volatile organics and fuels (1, 3, and 5) but may be less effective. As an *ex situ* remedy, the excavation associated with pyrolysis poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, normally would be required during excavation operations.

**1. Overall Cost** **Rating: Worse**

Overall cost for remediating approximately 20,000 tons (18,200 metric tons) of contaminated media is expected to exceed \$300/ton (\$330/metric ton).

**2. Capital (Cap) or O&M Intensive?** **Both**

**3. Commercial Availability** **Rating: Worse**

Pyrolysis is in the early stages of development.

**4. Typically Part of a Treatment Train?** **No**

**5. Residuals Produced (Solid, Liquid, Vapor)** **Solid, Liquid**

**6. Minimum Contaminant Concentration Achievable** **Rating: Better**

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Toxicity**

Pyrolysis primarily reduces toxicity by destroying the contaminants.

**8. Long-Term Effectiveness/Permanence?** **Yes**

The result of pyrolysis is the destruction of the target contaminated wastes, which permanently reduces the risk to human health and the environment.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**9. Time To Complete Cleanup** **Rating: Better**

**10. System Reliability/Maintainability** **Rating: Inadequate Information**

**11. Awareness of Remediation Consulting Community** **Rating: Worse**

Pyrolysis is still relatively unknown due to its early stage of development.

**12. Regulatory/Permitting Acceptability** **Rating: Average**

**13. Community Acceptability** **Rating: Worse**

## NATURAL ATTENUATION:

Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels.

Natural attenuation is not a “technology” per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option requires modeling and evaluation of contaminant degradation rates to determine feasibility, and special approvals may be needed. In addition, sampling and sample analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives. It has been included in the *Matrix* and this *Guide* for completeness only.

Natural attenuation is not the same as “no action,” although it often is perceived as such. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires evaluation of a “no action” alternative, but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving. It has been selected at Superfund sites where, for example, PCBs are strongly sorbed to deep subsurface soils and are not migrating; where removal of dense non-aqueous phase liquids (DNAPLs) has been determined to be technically impracticable (Superfund is developing technical impracticability (TI) guidance); and where it has been determined that active remedial measures would be unable to significantly speed remediation time frames. Where contaminants are expected to remain in place over long periods of time, as in the first two examples, TI waivers must be obtained. In all cases, extensive site characterization is required.

The attitude toward natural attenuation varies among agencies. The Air Force carefully evaluates the potential for use of natural attenuation at its sites. However, EPA accepts its use only in certain special cases.

Natural attenuation involves no excavation or handling of contaminated materials. Therefore, site workers require no protective equipment and there is no risk to the community from excavation and transportation of contaminated materials. There are potential risks, however, from migration of contaminants to areas where groundwater is being used.

The following factors may limit the applicability and effectiveness of the process:

- Data must be collected to determine model input parameters.
- Although commercial services for evaluating natural attenuation are widely available, the quality of these services varies widely among the many potential suppliers. Highly skilled modelers are required.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation should be used only where there are no impacts on potential receptors.
- Contaminants may migrate before they are degraded.
- The site may have to be fenced and may not be available for re-use until contaminant levels are reduced.
- If free product exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.

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**Reference Guide: Remediation Technologies Screening Matrix**

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Target contaminants for natural attenuation are non-halogenated volatile and semivolatile organics and fuel hydrocarbons (groups 3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be allowed to naturally attenuate, but the process may be less effective and may only be applicable to some compounds within these contaminant groups.

**1. Overall Cost** **Rating: Better**

There are no capital or O&M costs associated with natural attenuation. However, there are costs for modeling contamination degradation rates to determine whether natural attenuation is a feasible remedial alternative, and there are costs for subsurface sampling and sample analysis (potentially extensive) to determine the extent of contamination and confirm contaminant degradation rates and cleanup status. Skilled labor hours are required to conduct the modeling, sampling, and analysis.

**2. Capital (Cap) or O&M Intensive?** **Neither**

**3. Commercial Availability:** **Rating: Better**

Many potential suppliers can perform the modeling, sampling, and sample analysis required for justifying and monitoring natural attenuation. However, the quality of services provided varies widely.

**4. Typically Part of a Treatment Train?** **No**

**5. Residuals Produced (Solid, Liquid, Vapor)?** **None**

**6. Minimum Contaminant Concentration Achievable:** **Rating: Inadequate Information**

The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen, nitrate).

**7. Addresses Toxicity, Mobility, or Volume?** **Toxicity**

**8. Long-Term Effectiveness/Permanence?** **Yes**

**9. Time To Complete Cleanup:** **Rating: Worse**

Natural attenuation does not involve active remedial measures. Subsurface environments are often oxygen limited in regards to the needs of microorganisms that can degrade organic contaminants. Without active measures to increase the oxygen supply (or supply of other electron acceptors), biodegradation can be slow.

**10. System Reliability/Maintainability:** **Rating: Better**

Natural attenuation requires no equipment to maintain.



**11. Awareness of the Remediation Consulting Community:**

**Rating: Average**

A large amount of information is available on subsurface processes that affect contaminant transport and transformation. In addition, subsurface transport and fate models are available to estimate times required for natural attenuation to attain cleanup goals. However, natural attenuation is considered a viable alternative only for a limited number of contaminated sites.

**12. Regulatory/Permitting Acceptability:**

**Rating: Worse**

Because it involves no active remedial measures, natural attenuation is not well accepted by the regulatory community. However, regulatory/permitting acceptance may be possible where alternative remedial options are technically or economically infeasible and where a very strong scientific case can be made predicting its success and protectiveness.

**13. Community Acceptability:**

**Rating: Worse**

The public generally prefers active remedial alternatives.

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**Reference Guide: Remediation Technologies Screening Matrix**

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## EXCAVATION AND OFF-SITE DISPOSAL:

Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pre-treatment of the contaminated media usually is required in order to meet land disposal restrictions. Excavation and off-site disposal is applicable to the complete range of contaminant groups (1-7) with no particular target group. Although excavation and off-site disposal alleviates the contaminant problem at the site, it does not treat the contaminants.

The following factors may limit the applicability and effectiveness of the process:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility will affect cost and may affect community acceptability.
- Depth and composition of the media requiring excavation must be considered.
- Applicable Land Ban Restrictions must be considered.

The type of contaminant and its concentration level will impact off-site disposal requirements. Most hazardous wastes must be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Excavation poses a potential health and safety risk to site workers through skin contact and air emissions. Personal protective equipment, at a level commensurate with the contaminants involved, is normally required during excavation operations. Additionally, transportation to the off-site facility introduces a potential risk to the community via accidental releases.

### 1. Overall Cost

Rating: Worse

Cost estimates for excavation and disposal range from \$272 to \$463/ton (\$300 to \$510/metric ton). These estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation.

### 2. Capital (Cap) or O&M Intensive?

Neither

No capital investment is required and once disposal is completed, no O&M costs are incurred.

### 3. Commercial Availability

Rating: Better

Several manufacturers produce heavy equipment and hazardous waste transport containers.

### 4. Typically Part of a Treatment Train?

No

Excavation and off-site disposal is considered a stand-alone remediation option. Excavation also is an integral first step in the use of many treatment technologies.

### 5. Residuals Produced (Solid, Liquid, Vapor)

Not Applicable

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Not Applicable**

This process does not treat the contaminants. However, some pre-treatment of the contaminated media usually is required before approval is granted for off-site disposal.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Mobility**

The mobility of the contaminated media is reduced. This is accomplished by moving the media from the unsecured site to a disposal facility that will physically contain it.

**8. Long-Term Effectiveness/Permanence?****No**

Since excavation and off-site disposal does not treat the contaminants, no long-term effectiveness or permanence is achieved without some other additional treatment.

**9. Time To Complete Cleanup****Rating: Better**

The excavation of 20,000 tons (18,200 metric tons) of contaminated soil would require about 2 months. Disposal of the contaminated media is dependant upon the availability of adequate containers to transport the hazardous waste to a RCRA permitted facility.

**10. System Reliability/Maintainability****Rating: Better**

Adequately maintained heavy earth moving equipment has a minimal probability of failure.

**11. Awareness of Remediation Consulting Community****Rating: Better**

Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in *ex situ* treatments. As a consequence, the remediation consulting community is very familiar with this remediation option.

**12. Regulatory/Permitting Acceptability****Rating: Worse**

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by the Resource Conservation and Recovery Act (RCRA) (40 CFR Parts 261-265), and the U.S. Department of Transportation regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

**13. Community Acceptability****Rating: Better**

## Groundwater

### **OXYGEN ENHANCEMENT WITH HYDROGEN PEROXIDE:**

A dilute solution of hydrogen peroxide is circulated throughout a contaminated groundwater zone to increase the oxygen content of groundwater and enhance the rate of aerobic degradation of organic contaminants by naturally occurring microbes. For best results, factors that must be considered include redox conditions, saturation rates, presence of nutrient trace elements, pH, temperature, and permeability of the subsurface materials. **Oxygen enhancement with hydrogen peroxide is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- A groundwater circulation system must be created so that contaminants do not escape from zones of active biodegradation.
- Where the subsurface is heterogeneous, it is very difficult to circulate the hydrogen peroxide solution throughout every portion of the contaminated zone. Higher permeability zones are cleaned up much faster because groundwater flow rates are greater.
- High iron content of subsurface materials can rapidly reduce concentrations of hydrogen peroxide.
- Amended hydrogen peroxide can be consumed very rapidly near the injection well, which creates two significant problems: biological growth can be limited to the region near the injection well, limiting adequate contamination/microorganism contact throughout the contaminated zone; and biofouling of wells can retard the input of nutrients.
- A surface treatment system, such as air stripping or carbon adsorption, may be required to treat extracted groundwater prior to re-injection or disposal.

Oxygen enhancement with hydrogen peroxide is primarily designed to treat non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be treated, but the process may be less effective and only applicable to some compounds within these groups.

- |                                                                                                                                  |                        |
|----------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1. Overall Cost</b>                                                                                                           | <b>Rating: Average</b> |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                    | <b>O&amp;M</b>         |
| O&M costs can be significant because a continuous source of hydrogen peroxide must be delivered to the contaminated groundwater. |                        |
| <b>3. Commercial Availability:</b>                                                                                               | <b>Rating: Better</b>  |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                   | <b>No</b>              |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)?</b>                                                                             | <b>None</b>            |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable: Rating: Better**

As with other biological treatments, under proper conditions, oxygen enhancement with hydrogen peroxide can completely transform contaminants into non-hazardous substances.

**7. Addresses Toxicity, Mobility, or Volume? Toxicity****8. Long-Term Effectiveness/Permanence? Yes**

Enhancement of biological degradation with hydrogen peroxide can permanently destroy selected organic contaminants.

**9. Time To Complete Cleanup: Rating: Average**

As with all biodegradation processes, remediation projects are highly dependent upon the specific soil and chemical properties of the contaminated media.

**10. System Reliability/Maintainability: Rating: Worse**

Maintenance of sufficient hydrogen peroxide concentrations to promote biological activity throughout contaminated zones has proven to be very difficult.

**11. Awareness of the Remediation Consulting Community: Rating: Better****12. Regulatory/Permitting Acceptability: Rating: Average****13. Community Acceptability: Rating: Better**

Communities generally prefer *in situ* remedies because the possibility of contaminant releases is greatly reduced. In addition, this technology can permanently destroy groundwater contaminants.

**CO-METABOLIC PROCESSES:**

Water containing dissolved methane and oxygen is injected into groundwater to enhance methanotrophic biological degradation. This class of microorganisms can degrade chlorinated solvents, such as vinyl chloride and TCE, by co-metabolism. Co-metabolism is one form of secondary substrate transformation in which enzymes produced for primary substrate oxidation are capable of degrading the secondary substrate fortuitously, even though the secondary substrates do not afford sufficient energy to sustain the microbial population. **Development of co-metabolic processes is at the pilot scale.**

While development of *ex situ* bioreactors for methanotrophic TCE biodegradation is progressing well, *in situ* application has not yet been demonstrated at a practical scale. A field demonstration project has been conducted at DOD's Moffett Naval Air Station and another is being conducted at DOE's Savannah River Site.

The following factors may limit the applicability and effectiveness of the process:

- This technology is still under development.
- Where the subsurface is heterogeneous, it is very difficult to circulate the methane solution throughout every portion of the contaminated zone. Higher permeability zones are cleaned up much faster because groundwater flow rates are greater.

Target contaminants for co-metabolic processes are halogenated volatile and semivolatile organics (1 and 2). Non-halogenated organics, fuel hydrocarbons, and pesticides (3, 4, 5, and 6) also can be treated, but the process may be less effective and only applicable to some compounds within these groups.

**1. Overall Cost** **Rating: Average**

**2. Capital (Cap) or O&M Intensive?** **O&M**

O&M costs can be significant because a continuous source of methane solution must be delivered to the contaminated groundwater.

**3. Commercial Availability:** **Rating: Worse**

The development of this technology is still at the pilot-scale level.

**4. Typically Part of a Treatment Train?** **No**

**5. Residuals Produced (Solid, Liquid, Vapor)?** **None**

**6. Minimum Contaminant Concentration Achievable:** **Rating: Better**

As with other biological treatments, this is highly dependent upon the biodegradability of the contaminants. Under proper conditions, co-metabolic processes can remove virtually all of selected contaminants.

**7. Addresses Toxicity, Mobility, or Volume?** **Toxicity**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

Co-metabolic biodegradation can permanently destroy selected contaminants.

**9. Time To Complete Cleanup:****Rating: Average****10. System Reliability/Maintainability:****Rating: Worse**

This technology has not yet been demonstrated to be effective at full commercial scale.

**11. Awareness of the Remediation Consulting Community:****Rating: Worse****12. Regulatory/Permitting Acceptability:****Rating: Inadequate Information****13. Community Acceptability:****Rating: Inadequate Information**



## NITRATE ENHANCEMENT:

Solubilized nitrate is circulated throughout groundwater contamination zones to provide electron acceptors for biological activity and enhance the rate of degradation of organic contaminants by naturally occurring microbes. Development of nitrate enhancement is still at the pilot scale.

The following factors may limit the applicability and effectiveness of the process:

- This technology has been found to be effective on only a narrow spectrum of contaminants to date.
- Where the subsurface is heterogeneous, it is very difficult to circulate the nitrate solution throughout every portion of the contaminated zone. Higher permeability zones will be cleaned up much faster because groundwater flow rates are greater.

Target contaminants for the process are non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5). Nitrate enhancement has primarily been used to remediate groundwater contaminated by BTEX. Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also should be treatable, but the process has had only limited use and the potential effectiveness and applicability to specific compounds in these groups is not known.

1. Overall Cost Rating: Better

The costs of supplying solubilized nitrate is less expensive than similar costs for hydrogen peroxide or methane solutions.

2. Capital (Cap) or O&M Intensive? Neither

3. Commercial Availability: Rating: Worse

4. Typically Part of a Treatment Train? No

5. Residuals Produced (Solid, Liquid, Vapor)? None

6. Minimum Contaminant Concentration Achievable: Rating: Better

As with other biological treatments, this is highly dependent upon the biodegradability of the contaminants. Under proper conditions, nitrate enhancement can remove virtually all of selected contaminants.

7. Addresses Toxicity, Mobility, or Volume? Toxicity

8. Long-Term Effectiveness/Permanence? Yes

Nitrate enhancement can permanently destroy selected contaminants.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**10. Time To Complete Cleanup:****Rating: Average**

As with other *in situ* biodegradation processes, the success of this technology is highly dependent upon soil and chemical properties.

**11. System Reliability/Maintainability:****Rating: Average****12. Regulatory/Permitting Acceptability:****Rating: Worse****13. Community Acceptability:****Rating: Worse**

Many states prohibit nitrate injection into groundwater because nitrate is regulated through Drinking Water Standards.

**14. Community Acceptability:****Rating: Average**

Communities generally prefer *in situ* remedies because the possibility of contaminant release is minimal, and they prefer technologies that permanently destroy contaminants.

## OXYGEN ENHANCEMENT WITH AIR SPARGING:

Air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of organic contaminants by naturally occurring microbes. Air sparging increases mixing in the saturated zone, which increases the contact between groundwater and soil. The ease and low cost of installing small-diameter air injection points allows considerable flexibility in the design and construction of a remediation system. **Oxygen enhancement with air sparging is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- A permeability differential, such as a clay layer, above the air injection zone can reduce the effectiveness of air sparging.
- Where vertical air flow is restricted due to the presence of less permeable strata, sparging can push contaminated groundwater away from the injection point. In these cases, a groundwater recovery system may be needed.
- Vapors may rise through the vadose zone and be released into the atmosphere.
- Since air sparging increases pressure in the vadose zone, vapors can build up in building basements, which are generally low pressure areas.

Oxygen enhancement with air sparging is primarily designed to treat non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be treated, but the process may be less effective and only applicable to some compounds within these groups.

### 1. Overall Cost

**Rating: Better**

The technology employs the same concepts as bioventing, except that air is injected below the water table to promote the remediation of groundwater.

### 2. Capital (Cap) or O&M Intensive?

**Neither**

Equipment is readily available and the process is simple to operate. It does not require maintaining concentrations of chemical solutions in the subsurface to provide adequate electron acceptors for biological activity.

### 3. Commercial Availability:

**Rating: Better**

### 4. Typically Part of a Treatment Train?

**No**

### 5. Residuals Produced (Solid, Liquid, Vapor)?

**None**

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## Reference Guide: Remediation Technologies Screening Matrix

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**6. Minimum Contaminant Concentration Achievable:**

**Rating: Better**

As with other biological treatments, this is highly dependent upon the biodegradability of the contaminants. Under proper conditions, air sparging can remove virtually all of selected contaminants.

**7. Addresses Toxicity, Mobility, or Volume?**

**Toxicity**

**8. Long-Term Effectiveness/Permanence?**

**Yes**

Air sparging can permanently destroy selected contaminants.

**9. Time To Complete Cleanup:**

**Rating: Average**

**10. System Reliability/Maintainability:**

**Rating: Better**

**11. Awareness of the Remediation Consulting Community:**

**Rating: Average**

Although oxygen enhancement with air sparging is relatively new, the related technology, bioventing, is rapidly receiving increased attention from remediation consultants.

**12. Regulatory/Permitting Acceptability:**

**Rating: Average**

**13. Community Acceptability:**

**Rating: Better**

Communities generally prefer *in situ* remedies because the possibility of contaminant release is minimal, and they prefer technologies that permanently destroy contaminants.

## **SLURRY WALLS (containment only):**

These subsurface barriers consist of a vertically excavated trench that is filled with a slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and forms a filter cake to reduce groundwater flow. Slurry walls often are used where the waste mass is too large for practical treatment and where soluble and mobile constituents pose an imminent threat to a source of drinking water. **Slurry walls are a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- The technology only contains the contaminants to a specific area.
- Soil-bentonite backfills are not able to withstand attack by strong acids, bases, salt solutions, and some organic chemicals.
- There is the potential for the slurry walls to degrade or deteriorate over time.

Slurry walls are applicable to the full range of contaminant groups (1-7), with no particular target group.

**1. Overall Cost** **Rating: Better**

**2. Capital (Cap) or O&M Intensive?** **Capital**

**3. Commercial Availability** **Rating: Better**

Slurry walls have been used for decades, so the equipment and methodology are readily available and well known. The process of designing the proper mix of wall materials to contain specific contaminants is relatively new, however.

**4. Typically Part of a Treatment Train?** **Not Applicable**

**5. Residuals Produced (Solid, Liquid, Vapor)** **Not Applicable**

**6. Minimum Contaminant Concentration Achievable** **Rating: Not Applicable**

The technology does not treat the contaminants. It is a containment system only.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Mobility**

Slurry walls are most effective in reducing the overall mobility of the contaminated media. The technology has demonstrated its effectiveness in containing greater than 95% of the contaminated groundwater.

**8. Long-Term Effectiveness/Permanence?** **Inadequate Information**

Slurry walls have been used for decades as long-term solutions for controlling seepage of uncontaminated water. In contaminated environments, however, their long-term effectiveness is very dependent on contaminant types and concentrations, and has not been proven.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**9. Time To Complete Cleanup****Rating: Better**

The only time involved in employing this technology is the excavation and backfilling of the trench, and some monitoring activities.

**10. System Reliability/Maintainability****Rating: Better****11. Awareness of Remediation Consulting Community****Rating: Better**

Slurry walls have been used for decades, so the methodology is well known.

**12. Regulatory/Permitting Acceptability****Rating: Worse****13. Community Acceptability****Rating: Average**

## **PASSIVE TREATMENT WALLS:**

A permeable reaction wall is installed across the flow path of a contaminant plume, allowing the plume to passively move through the wall. The halogenated compounds are degraded by reactions with a mixture of porous media and a metal catalyst. **Development of passive treatment walls is at the pilot scale.**

The following factors may limit the applicability and effectiveness of the process:

- The technology is applicable only in relatively shallow aquifers because the trench must be constructed down to the level of the bedrock or an impermeable clay.
- Passive treatment walls are often only effective for a short time because they lose their reactive capacity, requiring replacement of the reactive medium.

The target contaminant groups for passive treatment walls are halogenated volatile and semivolatile organic compounds, and inorganics (1, 2, and 7). The technology can be used, but may be less effective, in treating some non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5).

**1. Overall Cost** **Rating: Inadequate Information**

**2. Capital (Cap) or O&M Intensive?** **Capital**

**3. Commercial Availability** **Rating: Worse**

This technology currently is available from only one vendor, Envirometal Technologies (Canada).

**4. Typically Part of a Treatment Train?** **No**

**5. Residuals Produced (Solid, Liquid, Vapor)** **Solid**

**6. Minimum Contaminant Concentration Achievable** **Rating: Inadequate Information**

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Toxicity**

Passive treatment walls are most effective in reducing the overall toxicity of the contaminated media.

**8. Long-Term Effectiveness/Permanence?** **Inadequate Information**

Theoretically, passive treatment walls are a destructive technology capable of meeting or exceeding maximum concentration limits (MCLs) for drinking water. This would permanently reduce the risk to human health and the environment from the treated groundwater. However, there has been insufficient field data available to confirm its long-term effectiveness and permanence.

**9. Time To Complete Cleanup** **Rating: Worse**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**11. System Reliability/Maintainability****Rating: Inadequate Information**

The system requires consistent control of pH levels. When the pH level within the passive treatment wall rises, it reduces the reaction rate and can inhibit effectiveness of the wall.

**11. Awareness of Remediation Consulting Community****Rating: Worse**

Data has been developed by the U.S. Air Force, University of Waterloo, and Envirometal Technologies but has received limited dissemination in the technical literature to date.

**12. Regulatory/Permitting Acceptability****Rating: Inadequate Information****13. Community Acceptability****Rating: Inadequate Information**



## HOT WATER OR STEAM FLUSHING/STRIPPING:

Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated. This variety of processes includes Contained Recovery of Oily Waste (CROW), Steam Injection and Vacuum Extraction (SIVE), *In Situ* Steam Enhanced Extraction (ISEE), and Steam Enhanced Recovery Process (SERP). Hot water or steam flushing/stripping is a pilot-scale technology.

The following factor may limit the applicability and effectiveness of the process:

- Soil type will significantly impact process effectiveness.

The target contaminant groups for hot water or steam flushing/stripping are halogenated and non-halogenated semivolatile organic compounds and fuels (2, 4, and 5). The technology can be used to treat halogenated and non-halogenated volatile organic compounds (1 and 3), but may be less effective.

1. Overall Cost	Rating: Average
2. Capital (Cap) or O&M Intensive?	Capital
3. Commercial Availability	Rating: Average
Four vendors are promoting hot water or steam flushing/stripping processes. The CROW system appears to be the most developed of the four.	
4. Typically Part of a Treatment Train?	Yes
5. Residuals Produced (Solid, Liquid, Vapor)	Liquid, Vapor
6. Minimum Contaminant Concentration Achievable	Rating: Average
7. Addresses Toxicity (T), Mobility (M), or Volume (V)?	Volume
8. Long-Term Effectiveness/Permanence?	Yes
9. Time To Complete Cleanup	Rating: Better
10. System Reliability/Maintainability	Rating: Worse
11. Awareness of Remediation Consulting Community	Rating: Worse
12. Regulatory/Permitting Acceptability	Rating: Average
13. Community Acceptability	Rating: Average

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## Reference Guide: Remediation Technologies Screening Matrix

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## **HYDROFRACTURING (enhancement):**

Pressurized water is injected through injection wells to crack low permeability and over-consolidated sediments. Cracks are filled with porous media that serve as avenues for bioremediation or improved pumping efficiency. Hydrofracturing is a pilot-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The technology should not be used in areas of high seismic activity.
- Investigation of possible underground utilities, structures, or trapped free product is required.
- The potential exists to open new pathways for the unwanted spread of contaminants (e.g., DNAPLs).

Hydrofracturing is applicable to the complete range of contaminant groups (1-7) with no particular target group. The technology has seen widespread use in the water-well construction industry, but is relatively new at remediating hazardous waste sites.

- |                                                                                                                                                                                                                                               |                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 1. Overall Cost                                                                                                                                                                                                                               | Rating: Average                |
| 2. Capital (Cap) or O&M Intensive?                                                                                                                                                                                                            | Neither                        |
| 3. Commercial Availability                                                                                                                                                                                                                    | Rating: Inadequate Information |
| 4. Typically Part of a Treatment Train?                                                                                                                                                                                                       | Yes                            |
| <p>Hydrofracturing is an enhancement technology, designed to increase the efficiency of other <i>in situ</i> technologies in difficult subsurface conditions.</p>                                                                             |                                |
| 5. Residuals Produced (Solid, Liquid, Vapor)                                                                                                                                                                                                  | None                           |
| 6. Minimum Contaminant Concentration Achievable                                                                                                                                                                                               | Rating: Not Applicable         |
| 7. Addresses Toxicity (T), Mobility (M), or Volume (V)?                                                                                                                                                                                       | Mobility                       |
| <p>Hydrofracturing is designed to increase the mobility through difficult soil conditions. The passageways create enhanced extraction efficiencies and allow for a more thorough distribution of <i>in situ</i> remediation technologies.</p> |                                |
| 8. Long-Term Effectiveness/Permanence?                                                                                                                                                                                                        | Yes                            |
| 9. Time To Complete Cleanup                                                                                                                                                                                                                   | Rating: Better                 |
| 10. System Reliability/Maintainability                                                                                                                                                                                                        | Rating: Better                 |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**12. Awareness of Remediation Consulting Community****Rating: Worse**

The technology has been used in three EPA SITE Program demonstrations.

**12. Regulatory/Permitting Acceptability****Rating: Better****13. Community Acceptability****Rating: Average**

## **AIR SPARGING:**

Air is injected into a saturated matrices creating an underground stripper that removes contaminants through volatilization. The technology is designed to operate at high air flow rates in order to effect volatilization (as opposed to the lower air flow rates used to increase groundwater oxygen concentrations to stimulate biodegradation). Air sparging must operate in tandem with SVE systems that capture volatile contaminants stripped from the saturated zone. **Air sparging is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- Depth of contaminants and specific site geology must be considered.
- Pressure levels must be designed for site-specific conditions.
- Channeling of the air flow can occur.
- Using air sparging without SVE could create a net positive subsurface pressure that could induce contaminant migration beyond the contaminated zone.

The target contaminant groups for air sparging are halogenated and non-halogenated volatile organic compounds and fuels (1, 3, and 5). Only limited information is available on the process.

<b>1. Overall Cost</b>	<b>Rating: Better</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>Neither</b>
<b>3. Commercial Availability</b>	<b>Rating: Better</b>
<b>4. Typically Part of a Treatment Train?</b>	<b>Yes</b>
Air sparging must operate in tandem with SVE systems that capture volatile contaminants stripped from the saturated zone.	
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Vapor</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Average</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Volume</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Better</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Better</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Average</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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**12. Regulatory/Permitting Acceptability**

**Rating: Better**

**13. Community Acceptability**

**Rating: Better**

## **DIRECTIONAL WELLS (enhancement):**

Drilling techniques are used to position wells horizontally, or at an angle, to reach contaminants not accessible via direct vertical drilling. Directional well technology is at full-scale development.

The following factors may limit the applicability and effectiveness of this technology:

- Well failures are possible during system installation.
- Potential exists for the wells to collapse.

Directional well technology is applicable to the complete range of contaminant groups (1-7) with no particular target group.

<b>1. Overall Cost</b>	<b>Rating: Inadequate Information</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>Neither</b>
<b>3. Commercial Availability</b>	<b>Rating: Worse</b>
<b>4. Typically Part of a Treatment Train?</b>	<b>Yes</b>
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Solid, Liquid</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Not Applicable</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Rating: Not Applicable</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Better</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Average</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Average</b>
<b>12. Regulatory/Permitting Acceptability</b>	<b>Rating: Better</b>
<b>13. Community Acceptability</b>	<b>Rating: Better</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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## **DUAL PHASE EXTRACTION:**

A high vacuum system is applied to simultaneously remove liquid and gas from low permeability or heterogeneous formations. The vacuum extraction well includes a screened section in the zone of contaminated soils and groundwater. As the vacuum is applied to the well, soil vapor is extracted, and groundwater is entrained by the extracted vapors. Once above grade, the extracted vapors and groundwater are separated and treated. **Dual phase extraction is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- Depending upon the specific site geology, the technology may have limited effectiveness.
- Dual phase extraction is not applicable to *in situ* recovery of metals.
- Unless it is combined with other technologies, such as bioremediation, air sparging, or bioventing, the technology is not applicable to certain long-chained hydrocarbons.
- Combination with complementary technologies (*e.g.* pump-and-treat) may be required to recover groundwater from high yielding aquifers.

The target contaminant groups for dual phase extraction are halogenated and non-halogenated volatile organic compounds and fuel hydrocarbons (1, 3, and 5).

<b>1. Overall Cost</b>	<b>Rating: Average</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>O&amp;M</b>
<b>3. Commercial Availability</b>	<b>Rating: Better</b>
<b>4. Typically Part of a Treatment Train?</b>	<b>Yes</b>
Dual phase extraction is generally combined with bioremediation, air sparging, or bioventing when the target contaminants include long-chained hydrocarbons. It also can be used with pump-and-treat technologies to recover groundwater from high yielding aquifers.	
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Liquid, Vapor</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Average</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Volume</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Average</b>

Use of dual phase extraction with bioremediation, air sparging, or bioventing can shorten the cleanup time at a site.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**10. System Reliability/Maintainability**

**Rating: Average**

**11. Awareness of Remediation Consulting Community**

**Rating: Better**

**12. Regulatory/Permitting Acceptability**

**Rating: Average**

**13. Community Acceptability**

**Rating: Better**

## **VACUUM VAPOR EXTRACTION:**

Air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, some of the volatile organic compounds in the contaminated groundwater are transferred from the water to air bubbles which rise and are collected at the top of the well by vapor extraction. The partially treated groundwater is never brought to the surface; it is forced into the unsaturated zone, and the process is repeated. As groundwater circulates through the treatment system *in situ*, contaminant concentrations are gradually reduced. Vacuum vapor extraction is a pilot-scale technology.

A variation of this process, called UVB, has been used at numerous sites in Germany and has been introduced recently into the United States.

Stanford University has developed another variation of this process, an in-well sparging system, which is currently being evaluated as part of the U.S. Department of Energy's Integrated Technology Demonstration Program. The Stanford system combines air-lift pumping with a vapor stripping technique.

The following factors may limit the applicability and effectiveness of the process:

- Shallow aquifers may limit process effectiveness.
- Depth of the saturated and unsaturated zones and soil permeability must be considered.

The target contaminant groups for vacuum vapor extraction are halogenated volatile and semivolatile organic compounds, and fuels (1, 2, and 5). Variations of the technology may allow for its effectiveness against some non-halogenated volatile and semivolatile organic compounds, pesticides, and inorganics (3, 4, 6, and 7).

<b>1. Overall Cost</b>	<b>Rating: Average</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>Capital</b>
<b>3. Commercial Availability</b>	<b>Rating: Worse</b>
This process has been used extensively in Germany, but technologies based on the process have only recently been introduced in the United States.	
<b>4. Typically Part of a Treatment Train?</b>	<b>No</b>
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Liquid, Vapor</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Better</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Volume</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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**9. Time To Complete Cleanup** **Rating: Average**

**10. System Reliability/Maintainability** **Rating: Better**

**11. Awareness of Remediation Consulting Community** **Rating: Worse**

Awareness of this process is limited in the United States but can be expected to increase as development and demonstration of technologies based on the process continue.

**12. Regulatory/Permitting Acceptability** **Rating: Average**

**13. Community Acceptability** **Rating: Better**

## **FREE PRODUCT RECOVERY:**

Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (e.g., pumping) or a passive collection system. This process is used primarily in cases where a fuel hydrocarbon lens is floating on the water table. The free product is generally drawn up to the surface via a pumping system. Following recovery, it can be disposed, re-used directly in an operation not requiring high-purity materials, or purified prior to re-use. **Free product recovery is a full-scale technology.**

The following factor may limit the applicability and effectiveness of the process:

- Depending upon the specific site geology, the technology may have limited effectiveness.

The target contaminant groups for free product recovery are non-halogenated semivolatiles and fuel hydrocarbons (4 and 5).

<b>1. Overall Cost</b>	<b>Rating: Better</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>Neither</b>
<b>3. Commercial Availability</b>	<b>Rating: Better</b>
<b>4. Typically Part of a Treatment Train?</b>	<b>No</b>
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Liquid</b>
Free product recovered in this process can be disposed, re-used directly in an operation not requiring high-purity materials, or purified prior to re-use.	
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Not Applicable</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Volume</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Better</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Average</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Better</b>
<b>12. Regulatory/Permitting Acceptability</b>	<b>Rating: Better</b>
<b>13. Community Acceptability</b>	<b>Rating: Better</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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## **BIOREACTORS:**

Contaminants in extracted groundwater are put into contact with microorganisms through attached or suspended biological systems. In suspended growth systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces new cells. The new cells form a sludge, which is settled out in a clarifier, and the sludge biomass is recycled to the aeration basin. In attached growth systems, such as rotating biological contactors and trickling filters, microorganisms are established on an inert support matrix to aerobically degrade groundwater contaminants. The microbial population may either be derived from the contaminant source or from an inoculum of organisms specific to a contaminant. Attached and suspended systems often are used together. **Bioreactors are full-scale technologies.**

The following factors may limit the applicability and effectiveness of the process:

- Solid residuals from sludge processes may require treatment or disposal.
- Skilled, competent microbiologists are required to start and maintain the biological systems.
- Metals may need to be removed prior to treatment in the bioreactors.
- The precipitation of iron may clog treatment systems.
- Treatability studies should be conducted to determine if contaminants are biodegradable and to estimate the rate of biodegradation.
- Air pollution controls may need to be applied if there is volatilization from activated sludge processes.
- Low temperatures significantly decrease biodegradation rates, resulting in longer cleanup times or increased costs for heating.

Bioreactors are used primarily to treat non-halogenated volatile and semivolatile organics and fuel hydrocarbons (3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be treated, but the process may be less effective and may be applicable only to some compounds within these groups. Successful pilot-scale field studies have been conducted on some halogenated compounds, such as chlorobenzene and dichlorobenzene isomers.

### **1. Overall Cost Rating: Better**

Costs are highly dependent on the contaminants and their concentrations in the influent stream. Biological treatment has often been found to be more economical than carbon adsorption.

### **2. Capital (Cap) or O&M Intensive? Capital**

### **3. Commercial Availability Rating: Better**

This is a well developed technology that has been used for many years in the treatment of municipal wastewater. Equipment and materials are readily available.

### **4. Typically Part of a Treatment Train? No**

### **5. Residuals Produced (Solid, Liquid, Vapor) Solids**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**6. Minimum Contaminant Concentration Achievable****Rating: Average**

As with other biological treatments, this is highly dependent upon the biodegradability of the contaminants.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?****Toxicity****8. Long-Term Effectiveness/Permanence?****Yes**

Biological reactors can permanently destroy selected contaminants.

**10. Time To Complete Cleanup****Rating: Not Applicable**

As with other pump-and-treat technologies, time to clean up is dependent upon subsurface conditions and the rate of desorption of contaminants from subsurface materials. A bioreactor system can be established to treat extracted groundwater at virtually any rate.

**10. System Reliability/Maintainability****Rating: Average**

Suspended systems are more difficult to maintain than attached systems because bacteria must be kept in a form that settles easily. Start-up time can be slow if organisms need to be acclimated to the wastes, however, the existence of cultures that have been previously adapted to specific hazardous wastes can decrease start-up and detention time.

**11. Awareness of Remediation Consulting Community****Rating: Average**

Bioreactors have been used for the treatment of municipal wastewaters for many years, but their application to Superfund wastes is relatively new.

**12. Regulatory/Permitting Acceptability****Rating: Better****13. Community Acceptability****Rating: Average**



## **AIR STRIPPING:**

Volatile organics are partitioned from groundwater by greatly increasing the surface area of the contaminated water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration. Air stripping is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- Potential exists for inorganic or biological fouling of the equipment.
- Consideration should be given to the Henry's Law constant of the VOCs in the water stream, and the type and amount of packing used in the tower.
- Compounds with low volatiles at ambient temperature may require pre-heating of the groundwater.
- Clogging of the stripping column packing material due to inorganics in the groundwater (especially dissolved ferrous iron, which precipitates out as insoluble ferrous hydroxide species upon aeration) and biofouling are common problems. Air strippers must be taken out of service and packing materials acid-washed.

The target contaminant groups for air stripping systems are halogenated and non-halogenated volatile organic compounds (1 and 3). The technology can be used but may be less effective against halogenated and non-halogenated semivolatile organic compounds and fuels (2, 4, and 5).

<b>1. Overall Cost</b>	<b>Rating: Better</b>
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>O&amp;M</b>
<b>3. Commercial Availability</b>	<b>Rating: Better</b>
More than 1,000 air stripping units are in operation in the United States.	
<b>4. Typically Part of a Treatment Train?</b>	<b>No</b>
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>Liquid, Vapor</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Better</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Volume</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Not Applicable</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Average</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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**11. Awareness of Remediation Consulting Community****Rating: Better**

The approach to packed tower design has become standardized. Numerous published and unpublished articles and technical papers are available on the design of air strippers.

**12. Regulatory/Permitting Acceptability****Rating: Worse****13. Community Acceptability****Rating: Average**

## CARBON ADSORPTION (LIQUID PHASE):

Groundwater is pumped through a series of canisters containing activated carbon to which dissolved organic contaminants adsorb. The technology requires periodic replacement or regeneration of saturated carbon. Carbon adsorption (liquid phase) is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The solubility and concentration of the contaminants can impact process performance.
- Metals can foul the system.
- Costs are high if used as the primary treatment on waste streams with high contaminant concentration levels.
- Type and pore size of the carbon, as well as the operating temperature, will impact process performance.

The target contaminant groups for carbon adsorption (liquid phase) are halogenated and non-halogenated semivolatile organic compounds (2 and 4). The technology can be used, but may be less effective in treating halogenated volatile organic compounds, fuel hydrocarbons, pesticides, and inorganics (1, 5, 6, and 7).

- |                                                                                                                                                                                                    |                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| 1. Overall Cost                                                                                                                                                                                    | Rating: Worse          |
| 2. Capital (Cap) or O&M Intensive?                                                                                                                                                                 | O&M                    |
| 3. Commercial Availability                                                                                                                                                                         | Rating: Better         |
| Adsorption by activated carbon has a long history of use in treating municipal, industrial, and hazardous wastes.                                                                                  |                        |
| 4. Typically Part of a Treatment Train?                                                                                                                                                            | No                     |
| 5. Residuals Produced (Solid, Liquid, Vapor)                                                                                                                                                       | Solid                  |
| When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be regenerated in place, removed and regenerated at an off-site facility, or disposed. |                        |
| 6. Minimum Contaminant Concentration Achievable                                                                                                                                                    | Rating: Better         |
| 7. Addresses Toxicity (T), Mobility (M), or Volume (V)?                                                                                                                                            | Volume                 |
| 8. Long-Term Effectiveness/Permanence?                                                                                                                                                             | Yes                    |
| 9. Time To Complete Cleanup                                                                                                                                                                        | Rating: Not Applicable |
| 10. System Reliability/Maintainability                                                                                                                                                             | Rating: Better         |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**11. Awareness of Remediation Consulting Community**

**Rating: Better**

**12. Regulatory/Permitting Acceptability**

**Rating: Better**

Regulatory agencies actively support this technology, which has been used at many Superfund sites.

**13. Community Acceptability**

**Rating: Better**

## **UV OXIDATION:**

Ultraviolet (UV) radiation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows into a treatment tank. An ozone destruction unit is used to treat off-gas from the treatment tank. UV oxidation is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The technology cannot be applied on all contaminants.
- The presence of inorganics and naturally occurring soil organics (*e.g.*, humic substances) can adversely affect system performance.

The target contaminant groups for UV oxidation are halogenated volatile and semivolatile organic compounds and pesticides (1, 2, and 6). The technology also can be used, but may be less effective, in treating non-halogenated volatile organics and fuels (3 and 5). The potential for exposure is minimal as the system does not produce air emissions.

<b>1. Overall Cost</b>	<b>Rating: Average</b>
The cost of this process is highly dependent upon the amount of influent pre-treatment required and the type of processing units needed.	
<b>2. Capital (Cap) or O&amp;M Intensive?</b>	<b>Capital</b>
<b>3. Commercial Availability</b>	<b>Rating: Better</b>
The technology is readily available.	
<b>4. Typically Part of a Treatment Train?</b>	<b>No</b>
<b>5. Residuals Produced (Solid, Liquid, Vapor)</b>	<b>None</b>
<b>6. Minimum Contaminant Concentration Achievable</b>	<b>Rating: Better</b>
<b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>	<b>Toxicity</b>
<b>8. Long-Term Effectiveness/Permanence?</b>	<b>Yes</b>
<b>9. Time To Complete Cleanup</b>	<b>Rating: Not Applicable</b>
<b>10. System Reliability/Maintainability</b>	<b>Rating: Worse</b>
<b>11. Awareness of Remediation Consulting Community</b>	<b>Rating: Average</b>

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**Reference Guide: Remediation Technologies Screening Matrix**

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**12. Regulatory/Permitting Acceptability****Rating: Average**

Units have been permitted without unusual difficulty.

**13. Community Acceptability****Rating: Average**

## NATURAL ATTENUATION:

Natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels.

Natural attenuation is not a “technology” per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option requires modeling and evaluation of contaminant degradation rates to determine feasibility, and special approvals may be needed. In addition, sampling and sample analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives. It has been included in the *Matrix* and this *Guide* for completeness only.

Natural attenuation is not the same as “no action,” although it often is perceived as such. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requires evaluation of a “no action” alternative, but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving. It has been selected at Superfund sites where, for example, PCBs are strongly sorbed to deep subsurface soils and are not migrating; where removal of dense non-aqueous phase liquids (DNAPLs) has been determined to be technically impracticable (Superfund is developing technical impracticability (TI) guidance); and where it has been determined that active remedial measures would be unable to significantly speed remediation time frames. Where contaminants are expected to remain in place over long periods of time, as in the first two examples, TI waivers must be obtained. In all cases, extensive site characterization is required.

The attitude toward natural attenuation varies among agencies. The Air Force carefully evaluates the potential for use of natural attenuation at its sites. However, EPA accepts its use only in certain special cases.

No handling of contaminated materials is required. Therefore, site workers require no protective equipment. There are potential risks to the community from migration of contaminants to areas where groundwater is being used.

The following factors may limit the applicability and effectiveness of the process:

- Data must be collected to determine model input parameters.
- Although commercial services for evaluating natural attenuation are widely available, the quality of these services varies widely among the many potential suppliers. Highly skilled modelers are required.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation should be used only in low-risk situations.
- Contaminants may migrate before they are degraded.
- The site may have to be fenced and may not be available for reuse until contaminant levels are reduced.
- If free product exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.

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**Reference Guide: Remediation Technologies Screening Matrix**

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Target contaminants for natural attenuation are non-halogenated volatile and semivolatile organics and fuel hydrocarbons (groups 3, 4, and 5). Halogenated volatiles and semivolatiles and pesticides (1, 2, and 6) also can be allowed to naturally attenuate, but the process may be less effective and may only be applicable to some compounds within these contaminant groups.

**1. Overall Cost** **Rating: Better**

**2. Capital (Cap) or O&M Intensive?** **Neither**

There are no capital or O&M costs associated with natural attenuation. However, there are costs for modeling contamination degradation rates to determine whether natural attenuation is a feasible remedial alternative, and there are costs for subsurface sampling and sample analysis (potentially extensive) to determine the extent of contamination and confirm contaminant degradation rates and cleanup status. Skilled labor hours are required to conduct the modeling, sampling, and analysis.

**3. Commercial Availability:** **Rating: Better**

Many potential suppliers can perform the modeling, sampling, and sample analysis required for justifying and monitoring natural attenuation. However, the quality of services provided varies widely.

**4. Typically Part of a Treatment Train?** **No**

**5. Residuals Produced (Solid, Liquid, Vapor)?** **None**

**6. Minimum Contaminant Concentration Achievable:** **Rating: Inadequate Information**

The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen, nitrate).

**7. Addresses Toxicity, Mobility, or Volume?** **Toxicity**

**8. Long-Term Effectiveness/Permanence?** **Yes**

**9. Time To Complete Cleanup:** **Rating: Worse**

Natural attenuation does not involve active remedial measures. Subsurface environments are often oxygen limited in regards to the needs of microorganisms that can degrade organic contaminants. Without active measures to increase the oxygen supply (or supply of other electron acceptors), biodegradation can be slow.

**10. System Reliability/Maintainability:** **Rating: Better**

Natural attenuation requires no equipment to maintain.



**11. Awareness of the Remediation Consulting Community:**

**Rating: Average**

A large amount of information is available on subsurface processes that affect contaminant transport and transformation. In addition, subsurface transport and fate models are available to estimate times required for natural attenuation to attain cleanup goals. EPA's Robert S. Kerr Environmental Research Laboratory sponsored the development of Bioplume II, which models the natural attenuation of BTEX in groundwater, and is working with the Air Force Center for Environmental Excellence to improve it. However, natural attenuation is considered a viable alternative only for a limited number of contaminated sites.

**12. Regulatory/Permitting Acceptability:**

**Rating: Worse**

Because it involves no active remedial measures, natural attenuation is not well accepted by the regulatory community. However, regulatory/permitting acceptance may be possible where alternative remedial options are technically or economically infeasible and where a very strong scientific case can be made predicting its success and protectiveness.

**13. Community Acceptability:**

**Rating: Worse**

The public generally prefers active remedial alternatives.

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## Reference Guide: Remediation Technologies Screening Matrix

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## Air Emissions/Off-Gases

### **CARBON ADSORPTION (VAPOR PHASE):**

Carbon, processed into hard granules or pellets, is used to capture molecules of gas-phase pollutants. Typically, the granulated activated carbon (GAC) is contained in a packed bed through which contaminated emissions/off-gases flow. When the carbon has been saturated with contaminants, it is regenerated in place, removed and regenerated at an off-site facility, or disposed. Carbon adsorption (vapor phase) is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- High contaminant concentration levels limit effectiveness.
- Temperature and moisture/humidity must be controlled.

The target contaminant groups for carbon adsorption (vapor phase) are volatile and semivolatile organic compounds, fuel hydrocarbons, and pesticides (1-6). Carbon adsorption (vapor phase) systems are most effective for contaminants with molecular weights between 50 and 200 and boiling points between 75° and 300°F (24° and 149°C).

**1. Overall Cost** **Rating: Better**

**2. Capital (Cap) or O&M Intensive?** **Neither**

**3. Commercial Availability** **Rating: Better**

Carbon adsorption (vapor phase) has a long history of use and is readily available. Activated carbon producers are able to manufacture carbon adsorption (vapor phase) systems to meet specific applications.

**4. Typically Part of a Treatment Train?** **Not Applicable**

The definition of this factor is not applicable to this technology. The technology, by design, is the finishing step in treatment processes.

**5. Residuals Produced (Solid, Liquid, Vapor)** **Solid**

When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be regenerated in place, removed and regenerated at an off-site facility, or disposed.

**6. Minimum Contaminant Concentration Achievable** **Rating: Better**

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Volume**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**8. Long-Term Effectiveness/Permanence?****Yes**

The target contaminants are permanently separated from the vapor stream.

**9. Time To Complete Cleanup****Rating: Not Applicable**

Since carbon adsorption (vapor phase) is a support technology used to treat off-gases produced by another remediation technology, the site cleanup time is wholly dependent upon the cleanup time associated with the primary technology.

**10. System Reliability/Maintainability****Rating: Better**

Regular maintenance checks are required during operation. Carbon adsorption (vapor phase) is a well developed technology with high reliability.

**11. Awareness of Remediation Consulting Community****Rating: Better**

The concepts, theory, and engineering aspects of the technology are well developed and disseminated throughout the remediation consulting community.

**12. Regulatory/Permitting Acceptability****Rating: Average**

Carbon adsorption (vapor phase) is a mature technology and has been used without unusual regulatory or permitting difficulty.

**13. Community Acceptability****Rating: Better**

## **CATALYTIC OXIDATION (NON-HALOGENATED):**

Trace organics in contaminated air streams are destroyed at lower temperatures, 842°F (450°C), than conventional combustion by passing the air/VOC mixture through a catalyst designed for non-halogenated compounds. Catalytic oxidation (non-halogenated) is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- If sulfur or halogenated compounds are in the emissions stream, the catalyst can be poisoned/deactivated and require replacement.
- The technology requires operation in the optimum containment range.

The target contaminant groups for catalytic oxidation (non-halogenated) are non-halogenated volatile and semivolatile organic compounds and fuel hydrocarbons (3, 4 and 5). Because the maximum permissible total hydrocarbon concentration is usually limited to control the temperature in the oxidizer and reduce the risk of an explosion, contaminant concentrations over certain levels, typically 3,000 ppm volatile organic compounds, are usually diluted with ambient air. Catalytic oxidation has long been used for emissions control of air/VOC mixtures. An advantage of catalytic oxidation is that it occurs at lower temperatures than thermal oxidation.

- |                                                                                                                                               |                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| <b>1. Overall Cost</b>                                                                                                                        | <b>Rating: Better</b> |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                                 | <b>Neither</b>        |
| <b>3. Commercial Availability</b>                                                                                                             | <b>Rating: Better</b> |
| Commercial equipment is in operation, and there are at least five vendors promoting the technology. Some processes are proprietary in nature. |                       |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                                | <b>Not Applicable</b> |
| The definition of this factor is not applicable to this technology. The technology, by design, is the finishing step in treatment processes.  |                       |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                           | <b>None</b>           |
| <b>6. Minimum Contaminant Concentration Achievable</b>                                                                                        | <b>Rating: Better</b> |
| The process normally begins with very low concentration levels and the technology cleans the emissions to regulatory standards.               |                       |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>                                                                                | <b>Toxicity</b>       |
| <b>8. Long-Term Effectiveness/Permanence?</b>                                                                                                 | <b>Yes</b>            |

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**Reference Guide: Remediation Technologies Screening Matrix**

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**9. Time To Complete Cleanup****Rating: Not Applicable**

Since catalytic oxidation (non-halogenated) is a support technology used to treat off-gases produced by another remediation technology, the site cleanup time is wholly dependent upon the cleanup time associated with the primary technology.

**10. System Reliability/Maintainability****Rating: Better**

Although there appears to be a low probability of failure, careful monitoring to prevent overheating of the catalyst and daily maintenance are required.

**11. Awareness of Remediation Consulting Community****Rating: Better****12. Regulatory/Permitting Acceptability****Rating: Better**

There are no federal regulations on catalytic oxidation. However California, New Jersey, and Texas regulate this technology, and its use is increasing nationwide. With the trend in regulations to limit emissions from vacuum extraction and air strippers, catalytic oxidation is likely to receive more attention.

**13. Community Acceptability****Rating: Better**

## CATALYTIC OXIDATION (HALOGENATED):

Trace organics in contaminated air streams are destroyed at lower temperatures, 842°F (450°C), than conventional combustion by passing the air/VOC mixture through a catalyst designed for halogenated compounds. Catalytic oxidation (halogenated) is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The catalyst can be poisoned/deactivated and require replacement.
- The technology requires operation in the optimum containment range.

The target contaminant group for catalytic oxidation (halogenated) is halogenated volatile and semivolatile organic compounds (1 and 2), but the technology has been evaluated below based only on its use in cleaning media contaminated with TCE and, in some instances, PCE. An advantage of catalytic oxidation is that it occurs at lower temperatures than thermal oxidation.

- |                                                                                                                                                     |                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>1. Overall Cost</b>                                                                                                                              | <b>Rating: Better</b>         |
| <b>2. Capital (Cap) or O&amp;M Intensive?</b>                                                                                                       | <b>Neither</b>                |
| <b>3. Commercial Availability</b>                                                                                                                   | <b>Rating: Average</b>        |
| <b>4. Typically Part of a Treatment Train?</b>                                                                                                      | <b>Not Applicable</b>         |
| <p>The definition of this factor is not applicable to this technology. The technology, by design, is the finishing step in treatment processes.</p> |                               |
| <b>5. Residuals Produced (Solid, Liquid, Vapor)</b>                                                                                                 | <b>None</b>                   |
| <b>6. Minimum Contaminant Concentration Achievable</b>                                                                                              | <b>Rating: Better</b>         |
| <p>The process normally begins with very low concentrations and the technology cleans the emissions to regulatory standards.</p>                    |                               |
| <b>7. Addresses Toxicity (T), Mobility (M), or Volume (V)?</b>                                                                                      | <b>Toxicity</b>               |
| <b>8. Long-Term Effectiveness/Permanence?</b>                                                                                                       | <b>Yes</b>                    |
| <b>9. Time To Complete Cleanup</b>                                                                                                                  | <b>Rating: Not Applicable</b> |

Since catalytic oxidation (halogenated) is a support technology used to treat off-gases produced by another remediation technology, the site cleanup time is wholly dependent upon the cleanup time associated with the primary technology.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**10. System Reliability/Maintainability****Rating: Average**

When PCE is present, catalyst deactivation can occur.

**11. Awareness of Remediation Consulting Community****Rating: Worse**

The development of a catalytic oxidizer specifically designed to treat halogenated compounds is relatively new and not well known.

**12. Regulatory/Permitting Acceptability****Rating: Average**

There are no federal regulations on catalytic oxidation. However, California, New Jersey, and Texas regulate this technology. With the trend in regulations to limit emissions from vacuum extraction and air strippers, catalytic oxidation is likely to receive more attention.

**13. Community Acceptability****Rating: Average**



## BIOFILTRATION:

Vapor-phase organic contaminants are pumped through a soil bed and sorb to the soil surface where they are degraded by microorganisms in the soil. Specific strains of bacteria may be introduced into the filter and optimal conditions provided to preferentially degrade specific compounds. Biofiltration is a full-scale technology.

The following factors may limit the applicability and effectiveness of the process:

- The size of the biofilter is constrained by the rate of influent air flow.
- Fugitive fungi may be a problem.

Biofiltration is used primarily to treat non-halogenated volatile organics and fuel hydrocarbons (3 and 5). Halogenated volatiles (1) also can be treated, but the process may be less effective.

1. Overall Cost Rating: Better

2. Capital (Cap) or O&M Intensive? Neither

3. Commercial Availability Rating: Average

Non-proprietary filters that require low air loading rates for organics ( $\geq 100$  ppm) have been used successfully for more than 20 years. Proprietary designs that support higher air loadings also are available. Biofilters have been used extensively in Europe and Japan, but only recently have they received attention in the United States.

4. Typically Part of a Treatment Train? Not Applicable

The definition of this factor is not applicable to this technology. The technology, by design, is the final step in treatment processes.

5. Residuals Produced (Solid, Liquid, Vapor) None

6. Minimum Contaminant Concentration Achievable Rating: Better

As with other biological treatment processes, this is highly dependent upon the biodegradability of the contaminants. Under proper conditions, biofilters can remove virtually all selected contaminants.

7. Addresses Toxicity (T), Mobility (M), or Volume (V)? Toxicity

8. Long-Term Effectiveness/Permanence? Yes

Under proper conditions, biofilters can completely degrade selected contaminants to harmless products.

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**Reference Guide: Remediation Technologies Screening Matrix**

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**9. Time To Complete Cleanup****Rating: Not Applicable****10. System Reliability/Maintainability****Rating: Average**

The primary maintenance concern is moisture control in the filter bed. Moisture levels, pH, and other filter conditions may have to be monitored to maintain high removal efficiencies. Filter flooding and plugging due to excessive biomass accumulation may require periodic mechanical cleaning of the filter.

**11. Awareness of Remediation Consulting Community****Rating: Worse**

Little use has been made of this technology in the United States. However, the technology has been used for about 20 years, mainly to remove odors from sewage, and more than 500 biofilters are being used in Europe and Japan.

**12. Regulatory/Permitting Acceptability****Rating: Inadequate Information****13. Community Acceptability****Rating: Inadequate Information**

## **THERMAL OXIDATION:**

Organic contaminants are destroyed in a high temperature 1,832°F (1,000°C) combustor. **Thermal oxidation is a full-scale technology.**

The following factors may limit the applicability and effectiveness of the process:

- Potential problems exist when using the technology on waste streams containing chlorinated materials.

The target contaminant groups for thermal oxidation are non-halogenated volatile and semivolatile organic compounds and fuel hydrocarbons (3, 4, and 5). Only non-halogenated hydrocarbon systems were evaluated. If halogens are present, the system is then RCRA regulated as a hazardous waste incinerator.

**1. Overall Cost** **Rating: Better**

**2. Capital (Cap) or O&M Intensive?** **Neither**

**3. Commercial Availability** **Rating: Better**

Commercial equipment is in operation, and there are at least five vendors promoting the technology.

**4. Typically Part of a Treatment Train?** **Not Applicable**

The definition of this factor is not applicable to this technology. The technology, by design, is the final step in treatment processes.

**5. Residuals Produced (Solid, Liquid, Vapor)** **None**

**6. Minimum Contaminant Concentration Achievable** **Rating: Better**

The process normally begins with very low concentrations and the technology cleans the emissions to regulatory standards.

**7. Addresses Toxicity (T), Mobility (M), or Volume (V)?** **Toxicity**

**8. Long-Term Effectiveness/Permanence?** **Yes**

**9. Time To Complete Cleanup** **Rating: Not Applicable**

Since thermal oxidation is a support technology used to treat off-gases produced by another remediation technology, the site cleanup time is wholly dependent upon the cleanup time associated with the primary technology.

**10. System Reliability/Maintainability** **Rating: Better**

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**Reference Guide: Remediation Technologies Screening Matrix**

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**11. Awareness of Remediation Consulting Community****Rating: Better****12. Regulatory/Permitting Acceptability****Rating: Better****13. Community Acceptability****Rating: Average**

There is occasional resistance if the community focuses on the thermal oxidizer as an incinerator.

## APPENDIX A: INFORMATION RESOURCES

### General:

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## Reference Guide: Remediation Technologies Screening Matrix

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## APPENDIX B: CONTAMINANT GROUPS

Major contaminant groups used in the *Matrix* are:

- (1) Halogenated volatiles
- (2) Halogenated semivolatiles
- (3) Non-halogenated volatiles
- (4) Non-halogenated semivolatiles
- (5) Fuel Hydrocarbons
- (6) Pesticides
- (7) Inorganics

These major groups include the contaminants listed below. These are not comprehensive lists, but they contain examples of contaminants encountered at many sites.

## (1) Halogenated Volatiles

Bromodichloromethane  
 Bromoform  
 Bromomethane  
 Carbon tetrachloride  
 Chlorodibromomethane  
 Chloroethane  
 Chloroform  
 Chloromethane  
 Chloropropane  
 Cis-1,2-dichloroethylene  
 Cis-1,3-dichloropropene  
 Dibromomethane  
 1,1-Dichloroethane  
 1,2-Dichloroethane  
 1,2-Dichloroethene  
 1,1-Dichloroethylene  
 Dichloromethane  
 1,2-Dichloropropene  
 Ethylene dibromide  
 Fluorotrichloromethane (Freon 11)  
 Hexachloroethane  
 Monochlorobenzene  
 1,1,2,2-Tetrachloroethane  
 Tetrachloroethylene (Perchloroethylene)  
 1,2-Trans-dichloroethylene  
 Trans-1,3-dichloropropene  
 1,1,1-Trichloroethane

1,1,2-Trichloroethane  
 Trichloroethylene  
 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)  
 Vinyl chloride

## (2) Halogenated Semivolatiles

Bis(2-chloroethoxy)ether  
 1,2-Bis(2-chloroethoxy)ethane  
 Bis(2-chloroethoxy)methane  
 Bis(2-chloroethoxy)phthalate  
 Bis(2-chloroethyl)ether  
 Bis(2-chloroisopropyl)ether  
 4-Bromophenyl phenyl ether  
 4-Chloroaniline  
 p-Chloro-m-cresol  
 2-Chloronaphthalene  
 2-Chlorophenol  
 4-Chlorophenyl phenylether  
 1,2-Dichlorobenzene  
 1,3-Dichlorobenzene  
 1,4-Dichlorobenzene  
 3,3-Dichlorobenzidine

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## Reference Guide: Remediation Technologies Screening Matrix

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### Halogenated Semivolatiles (Con'd.)

2,4-Dichlorophenol  
 Hexachlorobenzene  
 Hexachlorobutadiene  
 Hexachlorocyclopentadiene  
 Pentachlorophenol  
 Polychlorinated biphenyls (PCBs)  
 Tetrachlorophenol  
 1,2,4-Trichlorobenzene  
 2,4,5-Trichlorophenol  
 2,4,6-Trichlorophenol

### (3) Non-Halogenated Volatiles

Acetone  
 Acrolein  
 Acrylonitrile  
 n-Butyl alcohol  
 Carbon disulfide  
 Cyclohexanone  
 Ethyl acetate  
 Ethyl ether  
 2-Hexanone  
 Isobutanol  
 Methanol  
 Methyl ethyl ketone  
 Methyl isobutyl ketone  
 4-Methyl-2-pentanone  
 Styrene  
 Tetrahydrofuran  
 Vinyl acetate

### (4) Non-Halogenated Semivolatiles

Benzidine  
 Benzoic acid  
 Benzyl alcohol  
 Bis(2-ethylhexyl)phthalate  
 Bis phthalate  
 Butyl benzyl phthalate  
 Dibenzofuran  
 Di-n-butyl phthalate  
 Diethyl phthalate

Dimethyl phthalate  
 4,6-Dinitro-2-methylphenol  
 2,4-Dinitrophenol  
 2,4-Dinitrotoluene  
 2,6-Dinitrotoluene  
 Di-n-octyl phthalate  
 1,2-Diphenylhydrazine  
 Isophorone  
 2-Nitroaniline  
 3-Nitroaniline  
 4-Nitroaniline  
 2-Nitrophenol  
 4-Nitrophenol  
 n-Nitrosodimethylamine  
 n-Nitrosodiphenylamine  
 n-Nitrosodi-n-propylamine  
 Phenyl naphthalene

### (5) Fuel Hydrocarbons

Acenaphthene  
 Anthracene  
 Benz(a)anthracene  
 Benzene  
 Benzo(b)fluoranthene  
 Benzo(k)fluoranthene  
 Benzo(ghi)perylene  
 Benzo(a)pyrene  
 Chrysene  
 Cis-2-butene  
 Cresols  
 Cyclohexane  
 Cyclopentane  
 Dibenzo(a,h)anthracene  
 2,3-Dimethylbutane  
 3,3-Dimethyl-1-butene  
 Dimethylethylbenzene  
 2,2-Dimethylheptane  
 2,2-Dimethylhexane  
 2,2-Dimethylpentane  
 2,3-Dimethylpentane  
 2,4-Dimethylphenol  
 Ethylbenzene  
 3-Ethylpentane  
 Fluoranthene  
 Fluorene



Indeno(1,2,3-c,d)pyrene  
 Isobutane  
 Isopentane  
 2-Methyl-1,3-butadiene  
 3-Methyl-1,2-butadiene  
 2-Methyl-butene  
 2-Methyl-2-butene  
 3-Methyl-1-butene  
 Methylcyclohexane  
 Methylcyclopentane  
 2-Methylheptane  
 3-Methylheptane  
 3-Methylhexane  
 Methylnapthalene  
 2-Methylnapthalene  
 2-Methylpentane  
 3-Methylpentane  
 3-Methyl-1-pentene  
 2-Methylphenol  
 4-Methylphenol  
 Methylpropylbenzene  
 M-Xylene  
 Napthalene  
 N-Butane  
 N-Decane  
 N-Dodecane  
 N-Heptane  
 N-Hexane  
 N-Hexylbenzene  
 Nitrobenzene  
 N-Nonane  
 N-Octane  
 N-Pentane  
 N-Propylbenzene  
 N-Undecane  
 O-Xylene  
 1-Pentene  
 Phenanthrene  
 Phenol  
 Propane  
 P-Xylene  
 Pyrene  
 Pyridine  
 1,2,3,4-Tetramethylbenzene  
 1,2,4,5-Tetramethylbenzene  
 Toluene  
 1,2,4-Trimethylbenzene

1,3,5-Trimethylbenzene  
 1,2,4-Trimethyl-5-ethylbenzene  
 2,2,4-Trimethylheptane  
 2,3,4-Trimethylheptane  
 3,3,5-Trimethylheptane  
 2,4,4-Trimethylhexane  
 3,3,4-Trimethylhexane  
 2,2,4-Trimethylpentane  
 2,3,4-Trimethylpentane  
 Trans-2-butene  
 Trans-2-pentene

#### (6) Pesticides

Aldrin  
 Bhc-alpha  
 Bhc-beta  
 Bhc-delta  
 Bhc-gamma  
 Chlordane  
 4,4'-DDD  
 4,4'-DDE  
 4,4'-DDT  
 Dieldrin  
 Endosulfan I  
 Endosulfan II  
 Endosulfan sulfate  
 Endrin  
 Endrin aldehyde  
 Ethion  
 Ethyl parathion  
 Heptachlor  
 Heptachlor epoxide  
 Malathion  
 Methylparathion  
 Parathion  
 Toxaphene

#### (7) Inorganics

Aluminum  
 Antimony  
 Arsenic  
 Asbestos  
 Barium  
 Beryllium

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**Reference Guide: Remediation Technologies Screening Matrix**

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Bismuth  
Cadmium  
Calcium  
Chromium  
Cobalt  
Copper  
Cyanide  
Fluorine  
Iron  
Lead  
Magnesium  
Manganese  
Mercury  
Metallic cyanides  
Nickel  
Potassium  
Selenium  
Sodium  
Tin  
Vanadium  
Zinc

**Rating Codes**

■	Better
○	Average
△	Worse
I	Inadequate information
NA	Not applicable