

AR0222

REMEDIAL INVESTIGATION /
FEASIBILITY STUDY
REPORT

(First Operable Unit - Source Control)

BROWN & BRYANT SUPERFUND SITE
Arvin, California

Prepared by
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Region IX

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ORGANIZATION OF REPORT

This document is the combined Remedial Investigation (RI) report and the Feasibility Study (FS) report for the first operable unit at the Brown & Bryant site in Arvin, California. The RI/FS reports address the surface soils, the vadose zone soils to the first groundwater and the first groundwater. The reports were written to be stand alone, therefore neither the table of contents nor the executive summary for either report has been combined. The order of this document is the RI table of contents, the RI executive summary, the RI report, the FS table of contents, the FS executive summary, the FS, a combined reference section and finally, the FS appendix. The RI appendices are in a separate document.

BROWN & BRYANT
REMEDIAL INVESTIGATION REPORT
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EXECUTIVE SUMMARY

This report presents the findings of a Remedial Investigation (RI) conducted for the Brown & Bryant (B&B) Superfund Site in Arvin, California. The investigation focused on the surface soil, subsurface soil to the first water bearing unit (the A-zone soils), and the first water bearing unit located approximately 65 to 70 feet below ground surface (A-zone groundwater). The soil below the A-zone groundwater (the B-zone soils) and the second water bearing unit (B-zone groundwater) were also investigated to a limited extent during this RI; however, these areas will be fully addressed as part of a second operable unit RI.

B&B was a pesticide reformulator and custom applicator facility from 1960 to 1989. The facility is approximately 5 acres located at 600 South Derby Road in Arvin, California. Arvin is an agriculture community with a population of approximately 9,300 people. The site is located in a light industrial and commercial area, with a residential area located across the street.

Contamination of soil and groundwater resulted primarily from poor housekeeping, spills, and leaks from a surface pond and sumps. In 1981, the facility was licensed under RCRA as a hazardous waste transporter.

Investigations at the site began in 1983 when the State required B&B to conduct site investigations and dispose of contaminated soil. In 1989, the site was listed on the National Priorities List of Superfund sites. In 1990, EPA conducted an emergency response site assessment and began the RI.

The field investigations for the RI consisted of the following main activities: surface and subsurface soil sampling events; the installation of seventeen monitoring wells, thirteen of these were installed by the Potentially Responsible Parties as part of an Unilateral Administrative Order; and five rounds of groundwater sampling. A total of twenty A-zone groundwater wells, seven B-zone groundwater wells and two City wells were sampled during the RI. Fifty-seven soil borings were drilled by EPA and thirty-nine surface soil samples were collected. Soil and groundwater samples were analyzed for a wide array of pesticides and herbicides, volatile and semivolatile organic chemicals, and metals. Tests were also performed to characterize the physical properties of the soil and to characterize general groundwater quality.

The geology at the site is an alluvial deposit of alternating layers and mixtures of unconsolidated sands, silts and clay. The stratigraphy is very heterogeneous and layers tend to be discontinuous. The site geology has been divided into two

zones. The A-zone includes unsaturated soil to 65 to 75 feet below ground surface (bgs) and includes the first water bearing unit, the A-zone groundwater. The base of the A-zone is a thin sandy clay layer from 75 to 85 feet bgs. The clay layer and the A-zone groundwater occur under the entire site but disappear within 900 feet south of the site. The B-zone includes unsaturated soil below the A-zone and the second water bearing unit or the B-zone groundwater at 150 to 155 feet bgs. The B-zone extends to at least 250 feet bgs and ends at a clay layer known as the Corcoran Clay which confines the drinking water aquifer below it. The thickness of this clay layer at the site is unknown.

Groundwater in the A-zone flows in a generally southern direction, with some mounding of the water table observed from the southwest corner of the site extending south. Water levels measured during the RI have shown a steady decline in the water table, probably as a result of the long drought in California. The saturated thickness of the A-zone groundwater is from 0 to 10 feet. The hydraulic conductivity in this zone was measured at low levels of 10^{-4} to 10^{-6} cm/s, and from a slug test the groundwater velocity was estimated at 53 feet/year. Extraction of contaminated A-zone groundwater for site remediation is expected to be difficult due to its low permeability and thinness. Slug test results suggest that a yield of less than 100 gallons per day can be expected for wells in this groundwater.

The B-zone groundwater is actually composed of a series of water bearing units. All of the new wells in the B-zone were installed in the B-2 water bearing unit, located at approximately 170 feet bgs. The direction of flow in this unit is to the south, and the gradient is very flat (0.0004). Permeabilities are much higher than for the A-zone groundwater. The pump test indicated that wells could be pumped at 7 gpm for an extended period.

Sampling results for surface soils and the construction zone (to 7 feet bgs) identified dinoseb as the only contaminant of concern. Dinoseb was detected at over 7,000,000 ug/kg. The principal hot spot of dinoseb contamination occurs in the location of a former spill, along the east fence-line. High concentrations of dinoseb in surface soils were also found scattered in three other locations on-site and low concentrations were found over much of the site. Within the construction zone for the site, the spill area was the only location where high concentrations of dinoseb were found.

Soil contamination down to the A-zone groundwater was found over much of the site, but was primarily concentrated in three areas: the sump and wash pad area, the dinoseb spill area, and the pond and area between the pond and the large storage tank in

the southwest corner of the site. Within these three areas and over the entire site, six chemicals were identified as occurring at highest concentrations and to the greatest extent within the A-zone soils. These chemicals are 1,2-dichloropropane, 1,3-dichloropropane, dibromochloropropane, 1,2,3-trichloropropane, ethylene dibromide, and dinoseb. All of these chemicals except for dinoseb are volatile organic chemicals.

Dinoseb was found concentrated in the top 30 feet of the spill area and then declined significantly in concentration down to the A-zone groundwater. In the pond and sump areas, the concentrations were significantly less than in the spill area.

Volatile organic contaminants were found in highest concentrations in the sump and wash pad area. One boring in particular, boring I (located in the center of the sump), stands out for its exceptionally high concentrations. These contaminants were also found at significant levels in the area of the pond, and then were found in only relatively small concentrations elsewhere at the site. In the sump and wash pad area, concentrations were highest from 20 and 30 ft bgs, but were also found at concentrations greater than 1,000 ug/kg over most of the A-zone within this area. 1,2-DCP was the volatile contaminant found at highest concentrations, followed by DBCP, TCP, EDB, and 1,3-DCP. In the area of the pond, concentrations were highest from 30 to 40 ft bgs, but in general were found fairly evenly distributed over the A-zone. From highest to lowest, the contaminants in the pond area were the same as in the sump and wash pad area.

Within the A-zone groundwater the same six chemicals plus chloroform were found in highest concentrations and were most widely distributed. The reservoir of contamination in the A-zone groundwater appears to be significantly larger than any other contaminated media at the site. Concentrations for each of the seven contaminants, except for 1,3-DCP, were found at levels as high as 1,000 to 100,000 ug/l. The highest concentrations were consistently observed in well AMW-2P, located near the sump, and at well WA-6, which is directly west of the sump, and at wells AMW-1P, EPAS-2 and EPAS-3, which are all located near the pond. The distribution of contaminants was consistent with the locations of the major sources areas and follow a pattern consistent with the groundwater flow in the A-zone. In general, contamination was observed at slightly higher levels at wells near the pond when compared with the wells near the sump; 1,2-DCP was a notable exception.

1,2-DCP was found to be the most wide ranging contaminant in the A-zone groundwater and was at higher concentrations than any other contaminant. It was found over an area of approximately 5 $\frac{1}{2}$ acres at concentrations greater than or equal to 50 ug/l, or ten times the MCL, and was detected at concentrations as high as

100,000 ug/l in well WA-6. The other six contaminants were also found over large portions of the A-zone groundwater unit, though to lesser extent than 1,2-DCP.

In the B-zone, 1,2-DCP was also observed at levels significantly higher than any other contaminant and was observed at least once in every well. The highest observed concentration of 1,2-DCP in the B-zone was 1,700 ug/l in well WB2-1, which is directly south of the site (the MCL for 1,2-DCP is 5 ug/l). Except for chloroform, the other principal contaminants from the A-zone groundwater were also observed in the B-zone, though all at concentrations below 100 ug/l.

The fate and transport of contaminants at the site are controlled by chemical specific properties and environmental characteristics and the interaction of these factors. Except for dinoseb which is non-volatile, the key site contaminants are all volatile organic chemicals. All of the contaminants are relatively mobile in the environment. The volatile contaminants are transported in the environment as gases or in solution, whereas dinoseb is transported primarily in solution in the subsurface and in either solution or adsorbed to soil at the surface. All of the chemicals are weakly absorbed in soil, although the adsorption of dinoseb is pH dependent.

Vadose zone modeling was conducted to characterize the transport of key site chemicals in subsurface soil under site conditions. The modeling results predict that 1,2-DCP is the most mobile of the key site contaminants. This appears to be related to its greater mobility as a gas when compared with the other site contaminants. The mobility of dinoseb on the other hand is highly dependent on the amount of water infiltration. In the absence of any water infiltrating into the subsurface, as would occur with a cap, dinoseb migration would be significantly retarded. The solubility of dinoseb is also highly pH dependent. Under neutral or basic pH conditions, as generally occur at the site, dinoseb is highly soluble.

Also crucial to the fate of site contaminants are their degradation rates. The modeling looked at a range of possible degradation rates based on literature values for key site volatile contaminants. The results of this modeling showed that the degradation rate was generally the most significant variable affecting the long term impact from site contamination.

Probably the most important environmental factors influencing the fate and transport of contaminants at the site are the geology and the amount of water infiltrating into the A-zone. As discussed above, the site geology is a heterogeneous mixture of different soil types characteristic of an alluvial geology typical of that region. This type of geology results in a high degree of variability both vertically and laterally in the

permeability of the soil material, which in turn results in spacial variability in the rate of contaminant transport at the site. Where possible regional features have been identified and some generalizations have been made with regard to the site geology. Within the A-zone it was generally observed that finer grained sediments are more common below 30 feet until the A-zone water bearing unit is encountered. The base of the A-zone is a thin, mostly sandy clay unit that retards downward water movement.

Groundwater flow within the A-zone water bearing unit is very slow as a result of a low hydraulic conductivity. However, local variations in flow are expected due to difference in the lithology of this water bearing unit over the site; high hydraulic conductivities are expected at the south-east side of the site where more sand was observed within this unit. Patterns of contaminant distribution in the A-zone groundwater are generally consistent with the direction of groundwater flow. The exact nature of water movement between the A-and B-zone is not known. The A-zone is expected to be leaky and it may be that there are preferential downward flow paths where the clay layer at the base of the A-zone thins out. At a soil boring located 900 feet south of the site this clay layer and the A-zone groundwater were not observed.

The infiltration of water into the A-zone is important because of its impact on contaminant movement in the vadose zone and as a source for the groundwater in the A-zone. The transport of dinoseb in particular is directly related to the amount of water infiltration because of its high solubility and low volatility.

Site risks were formally characterized in the RI for the surface soil and the construction zone. A screening risk assessment was conducted for these areas to analyze only the dominant pathways and contaminants that may significantly contribute to site risk. Risks from ingestion of contaminated surface soil were characterized for a child and young adult, and risk from ingestion of contaminated soil in the construction zone was characterized for an adult worker. Each of these exposure scenarios exceeded the threshold for deleterious effects to human health for the maximum detected concentration and only the child exposure scenario exceeded the threshold for the average detected concentration.

The other dominant pathway of concern at B&B is exposure from ingestion of contaminated groundwater either as a result of contamination reaching the City Well or from future use of the B-zone groundwater; there is no current exposure to contaminated groundwater. The screening risk assessment did not characterize this risk. Instead, concentrations in groundwater and predicted impacts from the modeling results were compared to drinking water

Maximum Contaminant Levels or other published health-based levels were MCLs are not available. Contaminant levels in the B-zone groundwater exceeded MCL in two wells for both 1,2-DCP and DBCP. Concentrations in the A-zone groundwater exceeded MCLs by orders of magnitude; however, because this groundwater is not a potential drinking water source, the concentrations are more important for characterizing the A-zone groundwater as a contaminant source that threatens the B-zone groundwater. A groundwater risk assessment may be a component of the second operable unit RI.

Based on data from the City well closest to the site and from the B-zone well nearest to the City well, B-zone contamination is not currently impacting drinking water at levels that can be detected, and it is not expected that this will change at all in the near future.

SECTION 1: INTRODUCTION

1.1 Purpose and Scope of the Report

The purpose of the Remedial Investigation (RI) at Superfund sites is "to collect data necessary to adequately characterize the site for the purpose of developing remedial alternatives" (NCP, 40 CFR Part 300). The remedial alternatives are then presented and evaluated in the Feasibility Study (FS). The RI also includes a risk assessment to characterize the risks to public health and the environment posed by the site. The risk assessment provides the basis for identifying the media and chemicals of concern at the site that will require remediation and the rationale for conducting remediation activities at the site. This report presents the findings of an RI conducted by the U.S. Environmental Protection Agency (EPA) at the Brown and Bryant (B&B or site) Superfund Site located in Arvin, California.

The media and areas of concern at B&B include surface soils, subsurface soils, and three groundwater units (Figure 1.1). The surface soils include soil directly at the surface and soil within the construction zone, which extends to a depth of 7 feet below ground surface (bgs), the maximum depth for any utility lines that may be installed at the site. The subsurface soils can be divided into two zones: the A-zone which extends from the surface to 85 feet bgs, and the B-zone which extends below the A-zone to approximately 300 feet bgs. Within each of these zones are both saturated and unsaturated zones. The main unsaturated portion of the A-zone extends from the surface to between 65 and 72 feet bgs. The main unsaturated portion of the B-zone extends from approximately 85 feet to 150 feet bgs. The A-zone water bearing unit (or A-zone groundwater) is located from approximately 65 to 85 feet bgs, and the B-zone water bearing unit (or B-zone groundwater) is located from approximately 150 feet to 300 feet bgs (this zone is actually composed of a number of distinct water bearing units--see section 3). The A-zone groundwater is not considered to be a potential drinking water source due to the extremely low production capacity of this water bearing unit. The B-zone groundwater, however, is considered a potential drinking water source for the purpose of setting clean up standards, though it is not currently used for drinking water. The aquifer currently used for drinking water is located approximately 350 feet bgs.

In previous reports the A-zone water bearing unit has been referred to as the "perched aquifer" or "perched zone," and the B-zone water bearing unit has been referred to as the "regional unconfined aquifer." Because these designations do not always accurately describe the hydrogeology of these water bearing units, the "A" and "B" designations were adopted.

This RI report addresses contamination in the surface soils,

the A-zone soils, and the A-zone groundwater. The B-zone soils and groundwater are addressed in only a limited manner in this report, and will be more thoroughly investigated as a separate operable unit, to be reported on at a later date. Data from sampling two City of Arvin drinking water supply wells will also be presented in this report. However, since no contamination from B&B has been detected in the drinking water, a comprehensive investigation of this aquifer is not intended in this report nor is it planned for in future investigations. EPA intends to continue to monitor the closest drinking water well on a regular basis and periodic monitoring by the City will also occur under requirements of the Safe Drinking Water Act.

1.1.1 Site Conceptual Model

The following discussion provides an initial site conceptual model for the RI. This model was refined and expanded based on the data from the RI. Following a review of site data and chemical fate and transport factors contained in this report, an expanded site conceptual model is presented in section 5.

Two principal risks from contamination at B&B have been identified: 1) the current and future risk from exposure to contaminated surface soil, and 2) the potential future risk if site contamination were to reach current drinking water sources or from the future use of potential drinking water sources that are currently or may in the future be contaminated from the site. The ultimate intent of the RI/FS is to determine the nature and extent of site contamination so that these risks can be properly characterized and appropriate remediation measures for the site can be selected.

Contamination of surface soils at B&B has resulted largely from spills and improper housekeeping. During the RI, source areas for this contamination were characterized. In addition, characterization was conducted for other portions of the site where contamination may have migrated. At B&B, on-site ponding, water erosion and possibly wind erosion may have played a role in distributing surface soil contamination over portions of the site. During the RI, surface soil samples were collected to determine if an unacceptable risk is associated with surface soil contamination and to determine the locations of areas where contamination exceeds health-based levels.

The risks to current and potential drinking water sources involve complicated pathways of contaminant migration. Initially, contamination resulted from spills and improper disposal practices. During the RI the principal source areas were characterized to determine which locations on-site were and are currently significant sources of subsurface contamination. Contamination from these source areas migrated through the vadose zone as a result of both liquid and gas phase transport

mechanisms; this vadose zone contamination was also part of the RI investigation. Eventually contamination moved through the vadose zone to the first water bearing unit, the A-zone groundwater, where its vertical migration was somewhat retarded and contamination spread laterally as a result of the flow characteristics of the A-zone groundwater. The nature and extent of contamination in the A-zone groundwater is presented in this report.

The A-zone groundwater is not a potential drinking water source. Instead, due to its effect of retarding the vertical migration of contamination, it has become a significant source for contamination that threatens existing and potential drinking water sources. Some if not most of the water in the A-zone eventually leaks through the A-zone into the B-zone. Directly below the A-zone groundwater is an approximately 65 foot thick vadose zone. Contamination slowly leaks through the A-zone and down through the unsaturated portion of the B-zone.

At approximately 150 feet a second water bearing unit is encountered, the B-zone groundwater. This groundwater is a potential drinking water source but is not currently used for drinking water. Because it is a potential drinking water source, site contamination between the surface and this zone is largely a concern because of the possibility for the contamination to reach the B-zone groundwater. Site contamination has already entered the B-zone groundwater. During this RI, only a preliminary investigation of the B-zone was conducted in order to gather enough information to evaluate the threat that contamination in the A-zone soil and groundwater poses to the B-zone. An investigation of contamination currently in the B-zone will be completed as part of a second operable unit RI/FS.

Finally, there is the current drinking water source located at greater than 300 feet bgs. This aquifer is believed to be protected from contamination in the B-zone as a result of a large regional clay layer known as the Corcoran Clay that separates the B-zone from this drinking water zone. However, another route for contamination to reach the drinking water also exists. City Well 1, located downgradient from the site is gravel packed to near the ground surface. As a result of this well design, contaminated water in the B-zone could enter the well if the contamination migrates in the B-zone to the City Well and then contaminated B-zone groundwater cascades into the well to mix with the deeper drinking water aquifer. Contamination from the B-zone, however, would be diluted considerably by the larger volume of water being extracted from the drinking water aquifer. During the RI, B-zone wells were located between the site and the city well in order to monitor the progress of contamination towards this well.

1.2 Site Background

1.2.1 Site Description

Brown & Bryant, Inc. (B&B) was a pesticide reformulation and custom applicator facility located in Arvin, California, southeast of Bakersfield (Figure 1.2). B&B also owned and operated a similar facility in Shafter, northeast of Bakersfield, which was not part of this investigation. The Arvin facility is on an approximately 5-acre parcel of land at 600 South Derby Road in Arvin (Figure 1.3). The adjacent land is agricultural, light industrial and residential. Arvin is an agricultural community of approximately 9,300 people. The site is also located within one-half mile of Sierra Vista School, Haven Drive School and Di Giorgio County Park.

1.2.2 Site Operation History

The site history summarized below can be found in greater detail in the Closure Plan for the Site prepared by Canonie Environmental (the report does not have a date).

From 1960 to 1989, the B&B Arvin facility formulated agricultural chemicals, including pesticides, herbicides, fumigants and fertilizers, for sale to the local farming community. Prior to this time the site was used as farmland.

From 1960 to 1975, the western boundary of the facility was the edge of the warehouse, and a railroad spur ran along the outside of this boundary. These tracks were used for shipping bulk products to the site. After 1975, this spur was decommissioned and the facility boundary was expanded west to its current boundary.

During B&B's operation, a number of tanks and sumps and a waste pond were used in different portions of the facility's operations. Discussed below is a history of some of the most important on-site features that have or may have had an influence on contamination at the site (see Figure 1.3 for the location of these features).

The waste pond located in the southeast portion of the site was originally excavated as an unlined earthen pond in 1960. The pond was used to collect run-off water from the yard and from two sumps (since excavated). The pond was also used to collect rinse water from rinsing tanks used for fumigants. Pond water was periodically pumped into a storm water storage tank through an above-ground rubber hose, and the contents of this tank were periodically drained into mobile tanks for off-site disposal.

During the early 1970's the pond overflowed and breached the east fence line berm. Excess pond water collected in a low area

on-site to the east and south of the pond. In addition, ponded water from precipitation and irrigation from the east has occasionally breached the berm in the southeast corner of the pond and drained into the pond. The pond was double lined with a synthetic liner in November 1979. The liner and additional soil was excavated in August 1987. Approximately 640 cubic yards of soil that showed visible signs of contamination were removed from the pond at that time. The depths of this excavation ranged from approximately one and one-half feet on the sides to five feet on the bottom. The pond was singled-lined after this excavation and currently collects only precipitation.

Two primary "tank areas" were located at the site, one to the north where there were several above ground storage tanks, and one large tank to the south (tank UN-32). In the north tank area, the largest tank had a maximum capacity of 130,000 gallons and had been used most recently for storage of rain water collected on-site. This tank had been referred to as the pond water tank, and was also used to store various liquid fertilizers. Also within the northern tank area were four 20,000 gallon storage tanks located south of the storm water tank. In 1983, the northeastern tank of the group of four tanks was replaced because it had a leaky valve. At that time the tank was filled with BB Weedkiller D. The Closure Plan reports that several gallons of weedkiller leaked onto the ground, and approximately 10 cubic yards of contaminated soil was excavated as a result of the leak. Post excavation sampling does not appear to have been conducted. In 1980, a 20,000 gallon storage tank with a concrete containment was installed just south of the four other storage tanks; three tanks occupying that site were also removed. In 1987, this tank was found to be leaking the fumigant telone (a dichloropropane based fumigant). The tank and gravel in the containment area were removed and the concrete pad was cleaned. The tanks in the center of the site have been recently removed by EPA.

Tank UN-32 is the largest tank on-site. The Closure Plan is unclear as to the use of this tank. The tank appears to be in good condition.

A third, smaller tank storage and drum storage area was also located along the eastern fence line, just north of the pond. Based on historical areal photographs it appears that this area was used for storage from beginning in the mid 1970's. In 1983, a significant spill of dinoseb occurred in this area. As a result, concentrations of dinoseb in soil are highest in this portion of the site.

In 1960, an unlined earthen sump was constructed in the center of the site (Figure 1.3). This sump was used to collect wash water from two wash pads used for washing equipment and tanks used for liquid fertilizers and fumigants; the wash pads

were located directly to the north and west of the sump area. Water from the sump was drained to the pond through an underground pipeline.

In 1980, the unlined sump was replaced with two double lined sumps (sumps 1 and 2), and two double lined sand traps were installed west of the pond. The sumps and sand traps were each constructed as 6 ft. wide by 12 ft. long by 12 ft. deep concrete "tanks" set on gravel underlain by a PVC liner. A leak detection system with 4 inch PVC access pipes was installed at the sumps and the sand traps. No information exists as to maintenance and monitoring of the leak detection system.

Rinsate from the wash pads drained into both sumps 1 and 2 and then into a sand trap via an underground PVC pipe. The rinsate drained from the sand trap to another sand trap to the east and then into the pond. The sand trap to the west was constructed at an elevation that allowed ponded water from the area west of the traps to drain into the traps. Ponding of surface run-off has historically occurred in this area (between tank UN-32 and the pond).

Sumps 1 and 2 were later both excavated to a depth of thirteen feet and backfilled with clean fill material. A synthetic liner was then placed over the excavation area to prevent surface water infiltration. The sand traps have to date not been removed.

An underground, 1,000 gallon storage tank for gasoline was installed at the site on the east side of the warehouse in 1966. The tank was used until 1983, and no leaks were ever detected during its use. Available evidence from seismic reflection measurements at the site and the Closure Plan suggest that the tank was removed sometime after 1987. However, no documentation from the removal is available.

1.2.3 Site Regulatory History

In compliance with RCRA regulations, B&B notified EPA in July 1980 that it generated, transported, treated, stored and disposed of hazardous waste at the Arvin facility. In April 1981, B&B notified EPA that the Arvin facility was limited to the transport of hazardous waste and that only the Shafter facility was a treatment, storage and disposal facility (TSDF) for hazardous wastes. As a result, the Arvin facility was not permitted as a TSDF, but was given a transporter license.

In May 1983, the California Department of Health Services (DHS) inspected the Arvin site to determine compliance with hazardous waste laws. At the time of the inspection, several violations involving storage, disposal and transportation of hazardous waste were noted. Following the inspection, the DHS

directed B&B to correct the violations and to conduct a site assessment. Between 1983 and 1988, B&B conducted site investigations under the supervision of DHS.

The B&B site was listed by EPA on the National Priorities List (NPL) of Superfund sites on October 4, 1989 and in that same year all operations at the site ceased. The principal threats that formed the basis for EPA listing of the site were the presence of groundwater contamination which could potentially migrate to Arvin drinking water wells, and the potential for exposure to highly contaminated soils on-site. In March 1990, EPA's Emergency Response Section conducted a site assessment and subsequently performed various tasks to treat the most contaminated on-site soils and to remove a number of on-site structures. In December 1990, EPA began a Remedial Investigation and Feasibility Study for the site.

1.2.4 Previous Site Investigations

From 1983 through 1988, B&B conducted several soil and groundwater investigations and remediations under DHS supervision. The most significant work included the installation of ten monitoring wells and the removal of some heavily contaminated soil beneath the two sumps and the waste pond.

B&B hired two engineering firms to conduct the site investigations. Canonie Environmental investigated the soil contamination problem at the site and removed contaminated soil beneath the waste disposal pond and the two sumps. Hargis and Associates investigated both soil and groundwater contamination.

On-site soils were collected and analyzed for organics and trace metals by Canonie (July 1988) and Hargis (1987). The results of the analyses indicated soil contamination from pesticides generally within the first few feet of the ground surface and to greater depths in portions of the site with especially higher concentrations. The areas of higher concentration appeared to correlate to past chemical handling practices. These areas include the former sump location, the former waste pond, and the location of the dinoseb spill.

The data collected by these investigations were used during the RI to identify areas of concern for additional sampling. None of the analytical data collected by Canonie or Hargis is presented in this report because it is of unknown or questionable quality.

1.3 Report Organization

This report is divided into seven sections, including this introductory section. Section 2 provides a summary of the field activities and data that were collected during the RI. Section 3

summarizes the results of data collection and literature research to characterize the physical properties of the site, and Section 4 summarizes the results of data collected to characterize the nature and extent of chemical contamination at the site. Section 5 draws on the findings from sections 3 and 4 and from literature research on the contaminants found at the site to estimate the fate and transport of contamination at the site; the results of vadose zone modeling of site contaminant movement is also presented. Section 6 draws on the previous sections to characterize the risks associated with contamination at the site. Section 7 summarizes the findings of the investigation and any significant limitations in the data and/or data gaps. Figures and Tables are presented at the end of each section and the Appendices are presented in a separate volume.

1.3.1 Sample Identification Numbering System

In order to compile and track data collected during the RI/FS a computer data base was established. Within the data base, each sample collected has been assigned a unique sample identification number. These ID numbers appear throughout this report in various tables and appendices. This section outlines the codes used in the data base so that the reader can interpret these codes when they appear in this report.

The sample ID number is an alphanumeric code that defines the matrix, location, depth, sampling event and type of sample collected (an example code would be SB01D020E05A).

The first two letter code indicates the matrix: SS=surface soil, SB=soil boring, MW= monitoring well, DW=drinking water well.

The second two letter or two number code refers to the location. All the wells have two digit codes; these are listed in table 1.1. For soil borings and surface soil samples the location code was derived from the codes used during the sampling. There were two sampling events for subsurface soils (see section 2); the locations for the first event correspond to the two letter location codes in Figure 2.1 (the codes in parentheses were used), and the locations for the second event correspond to the last two digits of the numerical location numbers in Figure 2.2; none of the soil boring performed by the potentially responsible parties were entered into this data base. The location codes for the surface soil samples correspond to the last two digits of the numerical codes in Figure 2.5. In some cases the same location code was used for samples collected in different events; in these cases, the event code can be used to distinguish the samples.

The third portion of the ID number, which begins with a "D," is the depth. For soil samples this code equals the depth in

feet below ground surface. For groundwater samples, "D001" refers to the A-zone, "D002" refers to the B-zone, "D003" refers to the drinking water aquifer; "D000" was assigned to all water blanks.

The fourth portion of the ID number, which begins with an "E," is the sampling event. Each event code includes a two digit number or a letter and a single number. Table 1.1 lists all the sampling events for the RI/FS and their corresponding event code.

The final portion of the ID number is a single letter code that distinguishes the type of sample for quality assurance purposes. There are seven different types of samples, each is listed in Table 1.1. All of the sample results, except for the results for samples designated "T" (for Technical Assistance Team) and "F" (for field laboratory analyses), went through the same quality assurance and data validation procedures. The "F" and "T" designations were used to distinguish those samples where the quality assurance and quality control methods were different from the other samples collected (see section 2.7).

1.4 Tables and Figures

Table 1.1: Sample Identification Numbering System

Figure 1.1: Media of Concern at Brown & Bryant

Figure 1.2: Location Map

Figure 1.3: Brown & Bryant Site Map

**Table 1.1: Sample Identification
Numbering System**

Matrix Codes	Matrix
MW	Groundwater (monitoring well)
DW	Drinking Water
SS	Surface Soil
SB	Subsurface Soil
Well Location Codes	Well Location
MW01	AMW-1P
MW02	AMW-2P
MW11	AP-1
MW12	AP-2
MW13	AP-3
MW14	AP-4
MW15	AP-5
MW21	EPAS-1
MW22	EPAS-2
MW23	EPAS-3
MW24	EPAS-4
MW41	WA-1
MW42	WA-2
MW43	WA-3
MW44	WA-4
MW45	WA-5
MW46	WA-6
MW47	WA-7
MW48	WA-8
MW49	WA-9
MW31	AR-1
MW33	AMW-3R
MW34	AMW-4R

Table 1.1: Sample Identification Numbering System (cont'd)	
Well Location Codes	Well Location
MW51	WB2-1
MW52	WB2-2
MW53	WB2-3
MW54	WB2-4
DW01	City Well 1
DW05	City Well 5
Event Code	Date--Work
ES1	1990--Emerg. Resp.
E01	1/91--Grndwtr & Surface Soil
E02	4/91--Grndwtr
E03	8/91--Grndwtr
E04	9/91--Soil
E05	12/91--Grndwtr & Surface Soil
E06	12/91--Treatability Study
E07	4/92--Grndwtr
E08	7/92--Grndwtr
Sample Type Code	Sample Type
A	Routine Sample
E	Equipment Blank
F (Water Samples)	Field Blank
F (Soil Samples)	Field Lab Analysis ¹
L	Lab QC Sample
R	Field Replicate
T	TAT Lab Analysis

¹Field Laboratory Analyses were only for soils.

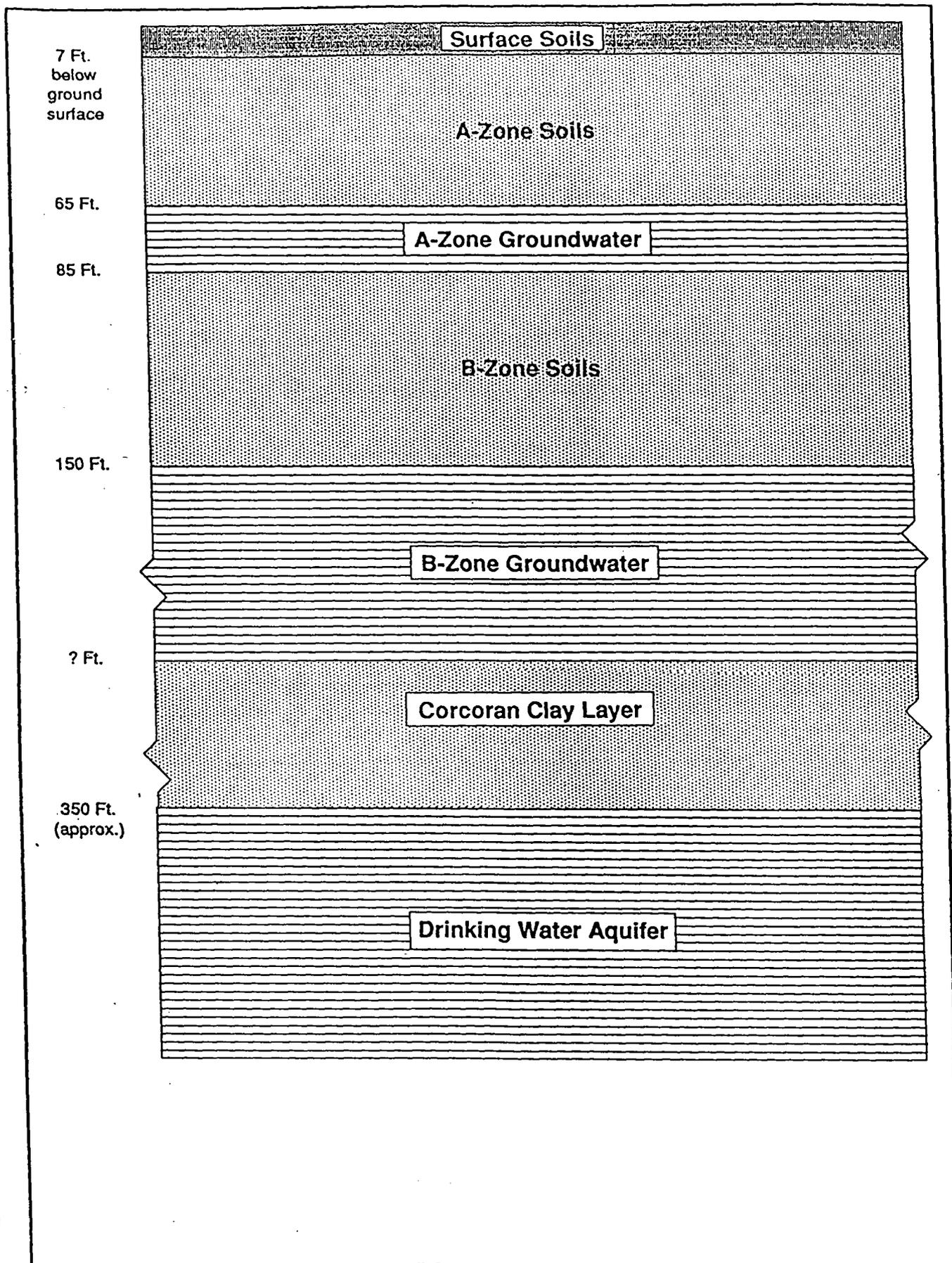
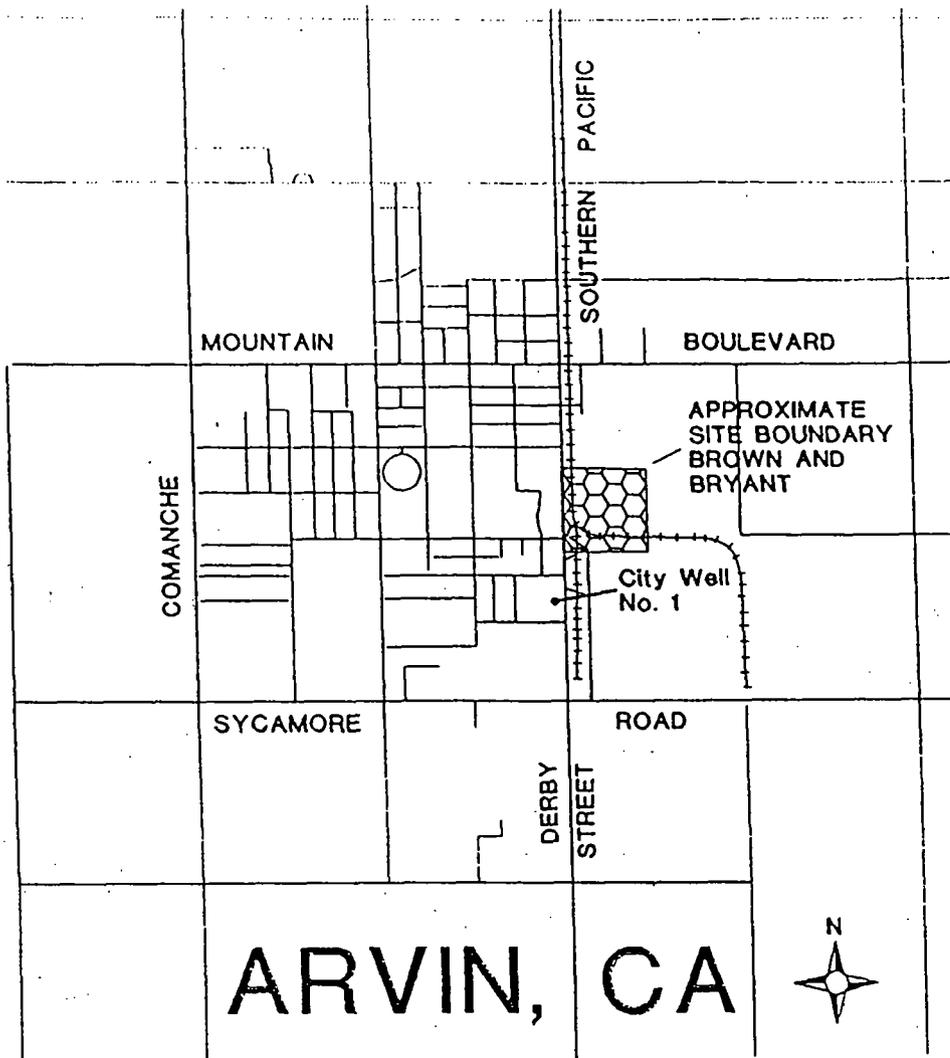


Figure 1.1: Brown & Bryant Media of Concern



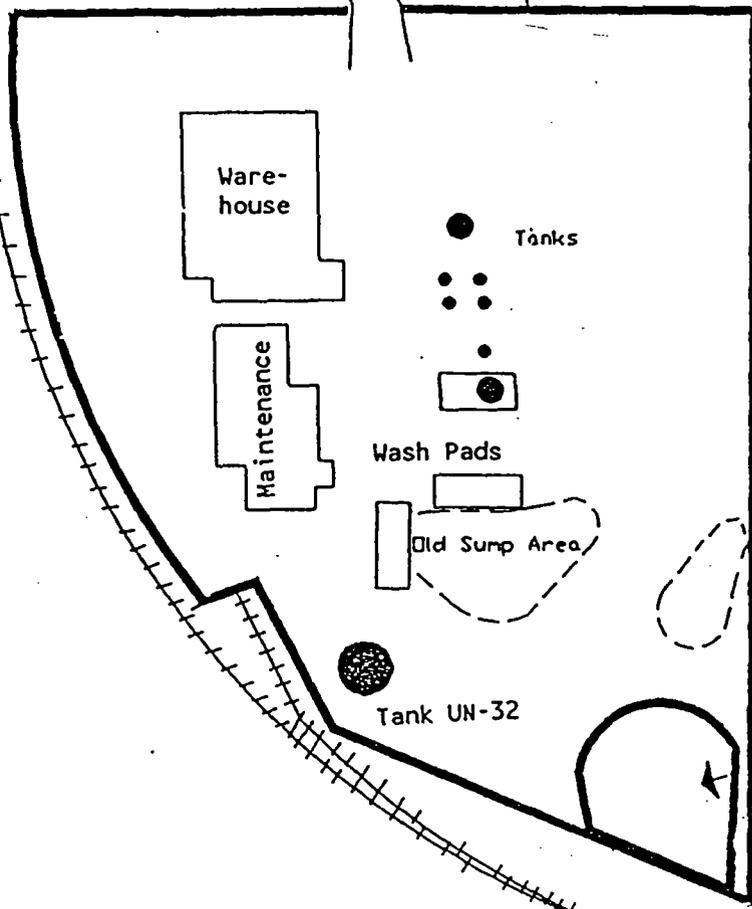
Brown & Bryant, Arvin Calif.

Figure 1.2

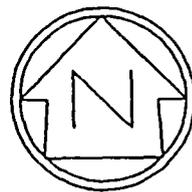
LOCATION MAP

Brown and Bryant

Derby Street



0 100
Scale in Feet



Brown & Bryant, Arvin Calif.

Figure 1.3

SITE MAP

SECTION 2: REMEDIAL INVESTIGATION FIELD ACTIVITIES

This section is a summary of the different field activities conducted to collect data for the RI. Summarized below for each field activity are the objectives of the field activities and the types of data collected. Table 2.1 also lists each of the RI field activities and summarizes the sampling objectives. The results of the field activities are not summarized in this section; they have been combined and are summarized in the remainder of the RI report to form the basis for the site characterization presented in the report. The last subsection below summarizes the data quality for each field activity and any limitations to the use of the data.

Included with each summary of field activities is a list of all relevant planning documents and data reports specific to that activity. The following two general planning documents have been used throughout most of the RI:

Brown & Bryant Superfund Site, Remedial Investigation and Feasibility Study Workplan, EPA Region 9, December 1990.

Quality Assurance Project Plan for the Brown & Bryant Site Remedial Investigation and Feasibility Study, EPA Region 9, March 1991.

2.1 Emergency Response Site Assessment (2/90 - 5/90)

In 1990, EPA identified the B&B site as posing a potential imminent and substantial threat to human health. As a result, a Site Assessment was conducted by the EPA Region 9, Emergency Response Section, with support from EPA's Technical Assistance Team Contractor, Ecology and Environment (E&E-TAT). The most significant threats identified were the presence of elevated levels of contamination in surface soils, and the potential for contaminants to migrate into and through the A- and B-zone groundwater to municipal supply wells and irrigation wells which are gravel packed to near the surface, thus allowing contamination of the drinking water aquifer. Arvin City Well #1, located 1,700 feet south, southwest of the site was the closest supply well downgradient from the site. As a result of these concerns, an extensive soils investigation was conducted, along with a limited groundwater investigation and some geophysical testing, to determine if such a threat exists and to characterize the nature of the threat.

From February 1990 through May 1990, 37 soil borings were drilled and four A-zone wells were installed as part of this investigation. The locations of the soil borings can be found in Figure 2.1, and a list of the borings, location coordinates, and total depth drilled can be found in Appendix A. A total of 1,285

analyses were performed on soil samples collected during this investigation; Table 2.2 includes a summary of the soil sample analyses performed. The four A-zone groundwater wells installed were wells EPAS-1, EPAS-2, EPAS-3, and EPAS-4 (Figure 2.6). One sampling round of all site wells was also conducted by E&E-TAT; the samples were analyzed for volatile organic compounds and dinoseb. The geophysical investigations are discussed in the following subsection.

The objectives, rationales, procedures, and results for the work conducted during this investigation can be found in the following document:

Brown & Bryant Site Assessment, Arvin, CA, Prepared for EPA Region 9 by Ecology and Environment, November 16, 1990.

2.2 EMSL Geophysical Investigations (1989-1991)

The EPA Environmental Monitoring and Systems Laboratory (EMSL) in Las Vegas provided technical support to the RI by assisting the characterization of the site geology. During three separate field events (8/89, 2/90 & 2/91), EMSL conducted electric resistivity, seismic refraction and down hole seismic measurements. The purpose of this work was to locate and determine the extent and continuity of the subsurface clay layer that is associated with the A-zone groundwater.

In October 1989, seismic and resistivity measurements were made along two transects at the site, and down hole seismic measurements were made at A-zone well AP-1. In the second field event, conducted in February 1990, seismic reflection measurements were made along three transects at the site to further define the subsurface clay layer. The results of the February 1990 measurements indicated a possible fault or discontinuity in the clay layer near the west side of the warehouse. As a result, further testing was conducted in February 1991 to try to better determine if a discontinuity exists. This testing involved seismic reflection measurements along two previous transects and four new transects. The results of these investigations are discussed in section 3.

The objectives, rationales, procedures, and results for the work conducted during the first two investigations can be found in Appendix D of the Emergency Response Site Assessment document, and for the third field event these items can be found in the following document:

Results of Seismic Reflection Measurements, Brown & Bryant Facility, Kern County, CA, Prepared for EMSL by Lockheed Engineering and Sciences Co., March 19, 1991.

2.3 EPA Region 9 Groundwater Investigations (1/91 - 7/92)

The EPA Region 9, Environmental Services Branch, was responsible for collecting groundwater samples from on- and off-site wells located in both the A- and B-zone groundwater. A quarterly sampling program was begun in January 1991, and has continued through July 1992. Samples were collected in January, April, July and December of 1991, and in April and July of 1992. The December sampling round was a combination of the 4th and 5th quarterly sampling events. This alteration in the quarterly sampling program was justifiable, based on the results of prior sampling, and was necessary due to budget and logistical constraints. Additional groundwater monitoring on a semiannual basis began in November 1992. Results from these sampling rounds will be presented, as needed, at a later date.

The objectives of these sampling investigations were to determine and monitor levels of contamination and water quality at the site in the A- and B-zone, and in the drinking water aquifer; to determine seasonal changes in groundwater contamination and long term trends in contaminant levels and contaminant migration in the A- and B-zone groundwater; to determine seasonal and long term fluctuations in hydraulic gradients and the direction of flow in the A- and B-zone; to detect contaminant movement towards the City drinking water well; and to estimate the extent of contamination in the A- and B-zones. The results for the B-zone are largely inconclusive because of an insufficient number of wells and because the older on-site wells were screened over more than one water-bearing unit in the B-zone; this zone will be investigated further in a second operable unit RI/FS.

During the first four sampling events the existing on-site wells installed by Hargis and the new wells installed by E&E-TAT were sampled along with two Arvin drinking water wells; the on-site wells sampled included nine A-zone wells and three B-zone wells. A-zone wells AP-5 and EPAS-1 have always been dry. Beginning with the April 1992 sampling event, nine additional A-zone wells and four additional B-zone wells (see section 2.6) were added to the sampling program (Figure 2.6). Table 2.7 summarizes the well specification for the wells sampled during the RI.

Table 2.3 provides a summary of the chemical data that were collected during these sampling events. As indicated by this table, not all chemical analyses were performed on each sample or for each sampling event; in some cases only the highest contaminated wells were targeted to screen for the presence of certain contaminants in the A-zone. The specific rationale for the analyses performed and the wells sampled can be found in the Field Sampling Plan or in amendments or revisions to the plan. In addition to the chemical data collected, water level

measurements were made at all wells during each sampling event in order to determine groundwater gradients and the direction of flow.

The following documents address the objectives, rationales, and procedures for the work conducted during these investigations. Appendix B summarizes the work performed and any discrepancies from the original sampling plan.

Field Sampling Plan, Quarterly Groundwater Monitoring and Surface Soil Sampling, Brown & Bryant Site, Arvin CA, EPA Region 9, January 1991, Revised March 1992.

"Amendment to Field Sampling Plan for Quarterly Monitoring and Surface Soil Sampling, Brown and Bryant Site,"
Memorandum from Tom Huetteman to Cynthia Wetmore, 4/2/91.

"July Groundwater Sampling at the Brown and Bryant Site,"
Memorandum from Robbie Hedeem to Cynthia Wetmore, 7/25/91.

"Amendment to Field Sampling Plan for Quarterly Monitoring and Surface Soil Sampling, Brown and Bryant Site,"
Memorandum from Robbie Hedeem to Cynthia Wetmore, 11/30/91.

"Revised Amendment to the FSP for Quarterly Groundwater Monitoring, Brown & Bryant Site, Arvin, CA, March, 1992 Revision," Memorandum from Tina Diebold to Cynthia Wetmore, 7/13/92.

2.4 EPA Region 9 Surface Soils Investigations (1/91 & 12/92)

Two sampling events were conducted by the EPA Region 9, Environmental Services Branch to collect samples of surface soils within the property boundary. This data was collected from locations of known or suspected hot-spots of contamination for use in a risk assessment. The risk assessment, discussed in section 6, estimates the potential risk from current or potential exposure pathways. The primary contaminant of concern in surface soils is dinoseb.

In January 1991, seven surface soil samples and seven samples from one foot below the surface were collected from two hot-spots, one in the northeast corner of the site and one along the eastern fence line (Figure 2.5). These samples were analyzed for herbicides and semivolatile organic compounds. The Field Sampling Plan (FSP) had also called for collecting samples in the area between the pond and the large on-site holding tank; however, these samples could not be collected due to rain water ponding in the area.

In December 1991, additional surface soil samples were collected from portions of the site not previously characterized

by other investigations, including the area between the pond and the holding tank. A total of 19 samples were collected (Figure 2.5). These samples were analyzed for volatile and semivolatile organic compounds, herbicides, chlorinated pesticides and PCBs, organophosphorus pesticides, carbamate and urea pesticides, and metals. Due to laboratory problems, no data were obtained for carbamate and urea pesticides; these pesticides, however, were not expected to be detected, and have so far only been detected in small concentrations in the A-zone groundwater.

Additional surface soil samples were also collected during the October 1991 soil sampling (discussed below) for use in the risk assessment. Table 2.4 summarizes the analyses performed on all the surface samples collected during the RI.

The following documents address the objectives, rationales and procedures for the work conducted during these investigations. Appendix B includes summaries of the work performed and any discrepancies from the original plans.

Field Sampling Plan, Quarterly Groundwater Monitoring and Surface Soil Sampling, Brown & Bryant Site, Arvin CA, EPA Region 9, January 1991.

Field Sampling Plan for Soil Sampling, Brown & Bryant, Arvin, CA, EPA Region 9, September 23, 1991.

2.5 EPA Region 9/Ecology and Environment (E&E-ARCS) Soils Investigation and Slug Tests (10/91 & 4/92)

In October 1991, a single soil sampling event was conducted for EPA by the ARCS Contractor, Ecology and Environment (E&E-ARCS) according to a sampling plan developed by EPA Region 9. This sampling event included the collection of both surface and subsurface soil samples. The objectives of this sampling event were to supplement past soil sampling efforts to further define the vertical and lateral extent of contamination, to better define the chemicals of concern in soil, to better characterize background concentrations, to characterize physical properties over the soil profile for use in fate and transport modeling and in treatability studies, and to collect data for use in the FS. The data collected from surface soil samples were also used in the risk assessment.

Seventeen surface soil samples were collected and twenty soil borings were drilled. The locations of the surface soil samples and soil borings can be found in Figure 2.2 (surface soil and soil boring locations are the same except that no surface soil was collected at location 404, 421 and 422), and a list of the borings, location coordinates, and total depth drilled can be found in Appendix A. A total of 143 subsurface samples were collected for a variety of chemical and physical property

analyses. The analyses performed on these samples are summarized in Table 2.5. Some of the chemical analyses were rejected during the data validation due to laboratory problems and some sample results were not received, also due to laboratory problems. The effect of these problems is discussed in section 2.7.

On March 31, 1992 and April 1, 1992, E&E-ARCS conducted nine slug tests (eight rising head and one falling head test) on four A-zone wells at the site (wells EPAS-2, EPAS-3, AMW-2P, and AP-2). The tests were part of an EPA Region 9 plan to determine the hydraulic conductivity of the A-zone groundwater. The results are discussed in section 3.

The following documents address the objectives, rationales, procedures, and part of the results for the work conducted during these investigations. The Final Report summarizes the results of the field work for the soils investigation, but does not include the results of the laboratory analyses. Those results are discussed in section 4.

Field Sampling Plan for Soil Sampling, Brown & Bryant, Arvin, CA, EPA Region 9, September 23, 1991.

Final Report, Task 6 -- Soil Sampling, Brown & Bryant, Arvin, CA, Prepared for EPA by Ecology and Environment, April 22, 1992.

"Technical Definition Memorandum #9 for Contractor Assistance" (includes SOW for Slug Tests), Prepared by Cynthia Wetmore, EPA, December 6, 1991.

Final Report, Task 9 -- Slug Testing, Brown & Bryant, Arvin, CA, Prepared for EPA by Ecology and Environment, July 17, 1992.

2.6 PRP Groundwater and Soils Investigations (6/91-4/92)

In January 1991, Southern Pacific Transportation Company and the Atchison, Topeka & Santa Fe Railway were issued a Unilateral Administrative Order by EPA to conduct work at B&B. Specifically, these potentially responsible parties (PRPs) were ordered to install additional monitoring wells in the A and B-zone groundwaters. The objectives of this work were to provide additional monitoring wells to determine if groundwater contamination in the B-zone is reaching the vicinity of the municipal supply well (City Well #1), and to determine how the contaminated A-zone groundwater is impacting deeper groundwater. The PRPs were originally ordered to install sixteen wells, ten in the A-zone and six in the B-zone. However, as a result of additional field data collected by the PRPs, only nine A-zone wells and four B-zone wells were ultimately installed, all either off-site or on the PRPs' property (Figure 2.6). The final

locations of some wells were adjusted slightly due to access restraints.

The original Order to the PRPs only instructed them to install monitoring wells. At the PRPs' choice, however, additional soil and groundwater sampling was conducted. The PRPs' consultant, Kennedy/Jenks (K/J), prepared a Sampling and Analysis Plan for this work, but the document was only approved by EPA to the extent that it addressed the scope of the EPA Order. It is not EPA's intention here to call into question the PRPs' data. However, due to resource limitations and because the data K/J collected was not within the scope of EPA's RI/FS, EPA has only integrated the geology data collected by the PRPs into the RI/FS. The remaining sampling data, however, has been reviewed by EPA and the results were found to be consistent with EPA's assessment of the site as presented in EPA's RI/FS Report.

The additional work performed by the PRPs included drilling 42 soil borings and conducting 914 analyses of soil samples and 89 analyses of groundwater grab samples from these borings. The locations of the soil borings can be found in Figure 2.3, and Appendix A includes a list of the borings, location coordinates, and total depth drilled. Samples collected from the soil borings were analyzed at both an on-site and off-site laboratory. Table 2.6 summarizes the analyses performed. Each borehole was also logged during drilling by a geologist, and a suite of electric and geophysical logging was run on the six deep borings. This logging included electric logs, caliper/sonic logs, gamma-ray/guard logs and temperature logs.

The objectives, rationales, procedures, and results for the work conducted during this investigation can be found in the following documents:

Brown & Bryant - Arvin Facility, Work Plan Part I, Prepared for Southern Pacific Transportation Co. and The Atchison, Topeka & Santa Fe Railway Co. by Kennedy/Jenks Consultants, March 27, 1991.

Brown & Bryant - Arvin Facility, Work Plan Part II, Prepared for Southern Pacific Transportation Co. and The Atchison, Topeka & Santa Fe Railway Co. by Kennedy/Jenks Consultants, April 10, 1991.

Quality Assurance Project Plan, Brown & Bryant Superfund Site, Prepared for Southern Pacific Transportation Co. and The Atchison, Topeka & Santa Fe Railway Co. by Kennedy/Jenks Consultants, April 10, 1991.

Activity Summary and Data Report, Prepared for Southern Pacific Transportation Co. and The Atchison, Topeka & Santa Fe Railway Co. by Kennedy/Jenks Consultants, August 1992.

2.7 Overview of Data Quality for the Remedial Investigation Field Activities

A variety of quality assurance measures were taken during the RI/FS so that the quality of the analytical data could be evaluated. These procedures are generally documented in the Quality Assurance Project Plan (QAPP). The routine quality assurance measures included the collection of field blank, duplicate and split samples and the validation of laboratory data. Quality assurance procedures varied depending on whether the samples were analyzed in the field or at an off-site laboratory.

The sampling conducted by EPA's Emergency Response included the analysis of soil samples for seven volatile organic chemicals (see Table 2.2) using a field laboratory, confirmation analyses for a percentage of the field analyses using a laboratory from EPA's Contract Laboratory Program (CLP), dinoseb analyses using both a CLP and TAT contract laboratory, and a CLP laboratory for the other chemical analyses listed in Table 2.2. All CLP analyses were formally validated using standard EPA protocols for data validation. For the field analyses the formal data validation protocol was not used; instead the data were evaluated using a combination of blank, duplicate, matrix spike and confirmation samples. An evaluation of the field data can be found in appendix E of the TAT site assessment report (E&E, 1990). Data from TAT's contract laboratories were evaluated by TAT chemists and all CLP data went through a formal data validation. The sample identification numbers used in the RI/FS data base include codes that distinguish the different types of analyses (see section 1.3.1).

All other analyses performed as part of this RI/FS were conducted using CLP procedures and were validated using standard EPA protocols.

Appendix C includes a list of all the analytes and associated quantitation limits for each of the analyses performed during the RI/FS. Appendix D includes a list of all the data validation reports for the RI/FS. Table 2.8 provides a list of all the data qualifiers used in data validation. These qualifiers tell the reader whether or not the laboratory result met all the quality control parameters; if a quality control parameter is not met the data is either flagged as estimated and valid for limited purposes (usually a "J" flag), or it is flagged as rejected (an "R" flag). Results that are flagged with a "U" are non-detect at the detection limit listed before the "U." These qualifier are included with the results presented in the RI/FS reports.

Sample results collected during the RI/FS were compromised significantly as a result of laboratory problems only during the

October 1991 soil boring sampling event. Nearly all of the soil samples analyzed for organophosphorus pesticides and carbamate and urea pesticides were rejected due to gross laboratory errors. As a result of these errors, the soil has not been adequately characterized for these chemicals. The overall impact of these deficiencies is not considered significant because these chemicals were generally not found or found infrequently and at low levels in the A-zone groundwater, which suggests that they are unlikely to be present in soil at significant levels. In addition, historical information about the facility suggests that these chemicals were not a major part of the business at the facility. If necessary, additional sampling can be included during site remedial design.

2.8 Tables and Figures

- Table 2.1: Summary of Objectives for RI Sampling Events
Table 2.2: Summary of Soil Analyses from E&E-TAT Sampling
Table 2.3: Summary of Groundwater Analyses from EPA Sampling
Table 2.4: Summary of Surface Soil Analyses
Table 2.5: Summary of Subsurface Soil Analyses from E&E-ARCS Sampling
Table 2.6: Summary of Sample Analyses from Kennedy/Jenks Sampling
Table 2.7: Summary of Groundwater Monitoring Well Specifications
Table 2.8: Data Validation Qualifiers
- Figure 2.1: Soil Borings Conducted by E&E-TAT
Figure 2.2: Soil Borings Conducted by E&E-ARCS
Figure 2.3: Soil Borings Conducted by Kennedy/Jenks
Figure 2.4: Soil Borings Conducted during the RI
Figure 2.5: Surface Soil Sample Locations
Figure 2.6: Groundwater Monitoring Wells

Table 2.1
Summary of Objectives for RI Sampling Events

Sampling Event	Media Investigated	Sampling Objectives
Emergency Response Site Assessment	Soil Groundwater	To determine nature and extent of soil contamination and A-zone groundwater contamination
EMSL Geophysical Investigation	Soil	To determine nature and extent of the clay aquitard in the A-zone water bearing unit
EPA Groundwater Investigation (including PRP installation of wells)	Groundwater	To determine the nature and extent of groundwater contamination; to characterize temporal trends in groundwater contamination; to characterize hydraulic gradients.
EPA Surface Soil Investigation	Surface Soil	To characterize surface soil contamination for conducting a risk assessment.
EPA/E&E Soil Investigation and Slug Tests	Soil Groundwater	To fill in data gaps from characterizations of surface and subsurface soil; to determine hydraulic conductivity of the A-zone water bearing unit.

**Table 2.2: Summary of Soil Analyses
from E&E-TAT Sampling**

Analyses Performed	Number of Analyses
VOCs (field lab) ¹	438
VOCs (confirmation by CLP) ²	63
VOCs (CLP) ³	180
Dinoseb (TAT lab) ⁴	127
Dinoseb (CLP)	209
Semivolatiles	169
Metals	43
Moisture Content	19
Dry Density	19
Specific Gravity	9
Effective Porosity	5
Permeability	23
Grain Size Distribution	24
TOTAL	1328

¹Field laboratory analyses were performed for the following 6 volatile organic compounds: 1,2-dichloropropane, 1,3-dichloropropane, ethylene dibromide, dibromochloropropane, 1,2,3-trichloropropane, chloroform.

²Confirmation of field laboratory analyses for the 6 target VOCs by CLP analysis was performed on selected samples.

³CLP analysis for a full scan of VOCs.

⁴Dinoseb analyses were performed by a TAT contract laboratory or a CLP laboratory (listed in next column).

Table 2.3: Summary of Groundwater Analyses from EPA Sampling

Analyses Performed	Numbers of Samples Analyzed						
	1991				1992		Total
	JAN	APR	JULY	DEC	APR	JULY	
VOCs ¹ (low CRQLs ²)	8	8	8	8	15	14	61
VOCs (routine CRQLs)	11	11	11	11	19	12	75
EDB & DBCP ³	19	19	19	19	34	26	136
Herbicides	19	19	19	19	NA ⁴	NA	76
Dinoseb Only	--	--	--	--	34	27	61
Pesticides/PCBs	19	NA	NA	NA	NA	NA	19
Organophosphorus Pest.	19	NA	NA	NA	NA	NA	19
Carbamate & Urea Pest.	19	NA	19	19	8	NA	68
Semivolatile Organics	19	19	19	19	NA	NA	76
Metals	19	19	19	19	34	24	134
Anions & TDS	19	19	19	19	34	24	134
Number of Wells Sampled							
A-Zone Wells	9	9	9	9	16	11	63
B-Zone Wells	3	3	3	3	7	7	26
City Wells	2	2	2	2	1	1	10
Total Wells Sampled	14	14	14	14	24	19	99

¹Volatile Organic Compounds.

²Low Contract Required Quantitation Limits are 5 times below the routine CRQLs; only B-Zone and City Well samples were analyzed for low CRQLs.

³Ethylene dibromide and dibromochloropropane.

⁴Not Analyzed.

Table 2.4: Summary of Surface Soil Analyses

Analyses Performed	Numbers of Samples Analyzed			
	JAN	OCT	DEC	Total
VOCs ¹	NA	5	19	24
Herbicides	NA	NA ²	19	19
Dinoseb Only	13 ³	19	-	31
Chlorinated Pest./PCBs	NA	NA	19	19
Organophosphorus Pest.	NA	NA	19	19
Carbamate & Urea Pest.	NA	NA	19	19
Semivolatiles Organics	13	NA	19	32
Metals	NA	NA	19	19
pH	NA	3	NA	3
Nitrate/Nitrite	NA	3	NA	3
Oil & Grease	NA	3	NA	3
Total Organic Carbon	NA	3	NA	3
Sulfates	NA	3	NA	3
TOTAL	26	39	126	191

¹Volatile Organic Compounds

²Not Analyzed

³6 out of the 13 samples were from a one foot depth. These were not included in the risk assessment calculations in section 6.

**Table 2.5: Summary of Soil Analyses
from E&E-ARCS/EPA Sampling**

Analyses Performed	Number of Analyses
VOCs ¹	119
Herbicides	117
Carbamate & Urea Pesticides	108
Organophosphorus Pesticides	96
Organochlorine Pesticides/PCBs	108
Semivolatile Organics	88
Metals	83
Moisture Content	10
Porosity	10
Specific Gravity	10
Permeability	10
pH	4
Nitrate/Nitrite	4
Oil & Grease	4
Total Organic Carbon	4
Sulfates	4
TOTAL	779

¹Volatile Organic Compounds

**Table 2.6: Quantities of Samples Analyzed
by Kennedy/Jenks Consultants for the PRPs**

Type of Samples	Samples Performed by Field Laboratory	Samples Performed by Off-Site Lab
Soil Samples	641	273
Split Soils Samples from Field Analyses	NA	193
Groundwater Recon Samples	47	42
Split Groundwater Samples from Field Analyses	NA	29
Monitoring Well Groundwater Samples	0	25

Table 2.7: Groundwater Monitoring and City Well Specifications

Well I.D. Number	Surveyed Elevation (ft) ¹	Total Well Depth (ft BGS)	Screened Interval (ft BGS)
AP-1	433.86	69.5	NA
AP-2	431.98	70.3	NA
AP-3	431.16	71.0	NA
AP-4	431.32	73.5	NA
AP-5	433.75	71.0	NA
AMW-1P	432.32	70.7	60.75-70.75
AMW-2P	433.24	73.6	63.6-73.6
EPAS-1	432.74	89	77-87
EPAS-2	433.11	86	64-84
EPAS-3	431.62	86	64-86
EPAS-4	435.55	84	62-82
WA-1	429.35	78	63-78
WA-2	430.95	73	63-73
WA-3	436.36	78	68-78
WA-4	437.30	76	66-76
WA-5	435.64	77	67-77
WA-6	434.73	74	64-74
WA-7	435.13	76	66-76
WA-8	433.79	71	61-71
WA-9	429.10	78	68-78
AR-1	434.46	182.0	NA
AMW-3R	433.03	201.5	121.5-201.5
AMW-4R	432.57	203.0	139-198
WB2-1	432.29	211	169.5-179.5
WB2-2	434.84	204	168-178
WB2-3	430.71	190	172-182
WB2-4	425.19	210	168-178
City Well 1	NA	730	350-700
City Well 5	NA	702	402-702

¹Surveyed elevations are to the top of the well casing.

TABLE 2.8
DATA VALIDATION QUALIFIERS

FOR ORGANIC DATA

The definition of the following qualifiers are prepared according to the EPA draft document, "National Functional Guidelines for Organic Data Review," December, 1990 (6/91 Revision).

NO QUALIFIERS indicates that the data are acceptable both qualitatively and quantitatively.

- U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

- L Indicates results which fall below the Contract Required Quantitation Limit. Results are estimated and are considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.

- J The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

- N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."

- NJ The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.

- UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

- R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

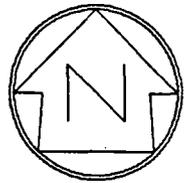
TABLE 2.8 (cont'd)

FOR INORGANIC DATA

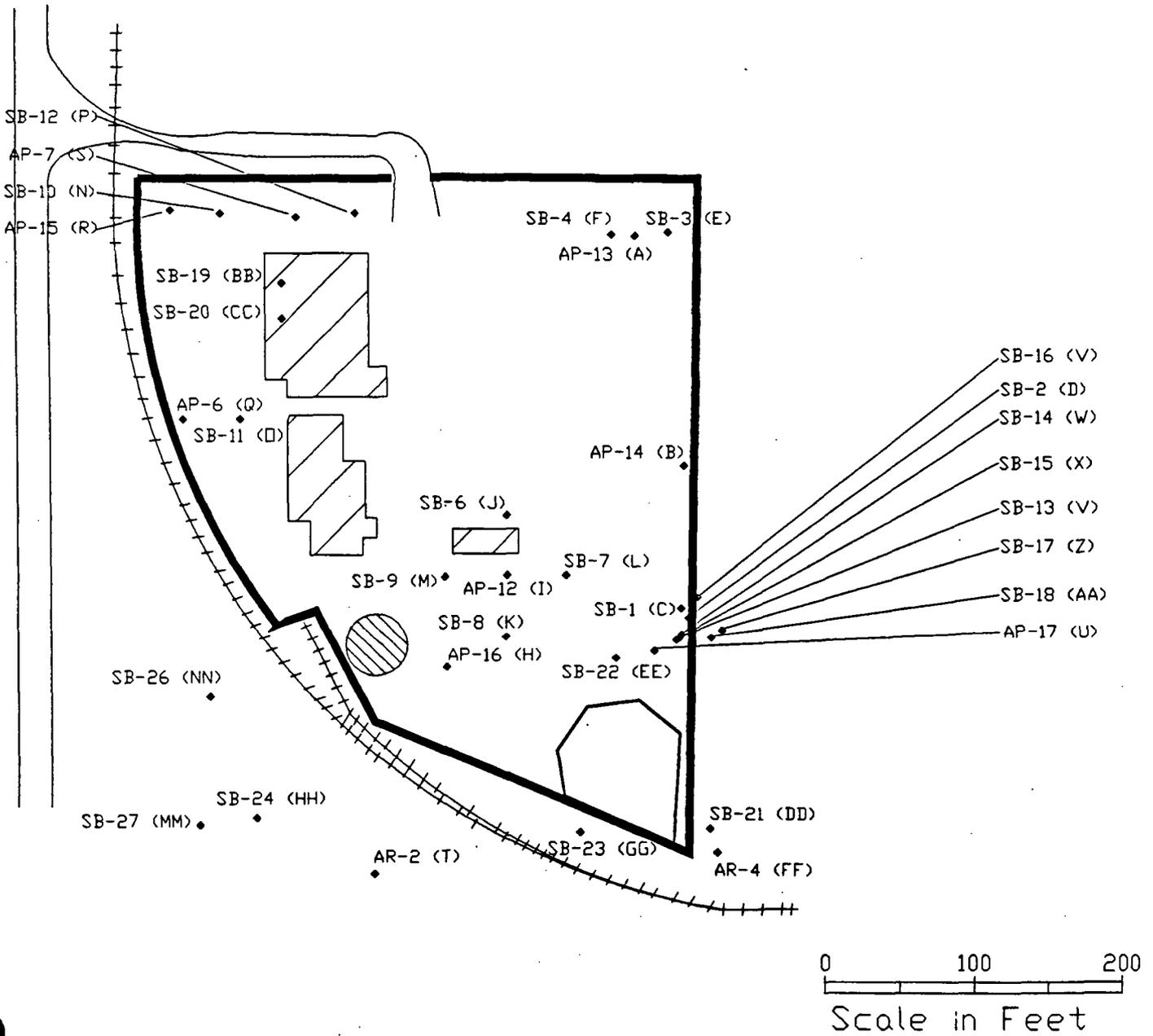
The definition of the following qualifiers are prepared in accordance with the EPA draft document, "Laboratory Data Validation Functional Guidelines For Evaluating Inorganic Analyses," October, 1989.

NO QUALIFIER indicates that the data are acceptable both qualitatively and quantitatively.

- U The analyte was analyzed for but was not detected above the level of the reported value. The reported value is the Instrument Detection Limit (IDL) for waters and the Method Detection Limit (MDL) for soils for all the analytes except Cyanide (CN) and Mercury (Hg). For CN and Hg, the reported value is the Contract Required Detection Limit (CRDL).
- L The analyte was analyzed for but results fell between the IDL for waters or the MDL for soils and the CRDL. Results are estimated and are considered qualitatively acceptable but quantitatively unreliable due to uncertainties in the analytical precision near the limit of detection.
- J The analyte was analyzed for and was positively identified, but the reported numerical value may not be consistent with the amount actually present in the environmental sample.
- R The analyte was analyzed for, but the presence or absence of the analyte has not been verified. Resampling and reanalysis are necessary to confirm or deny the presence of the analyte.
- UJ A combination of the "U" and the "J" qualifier. The analyte was analyzed for but was not detected above the reported value. The reported value may not accurately or precisely represent the sample IDL or MDL.



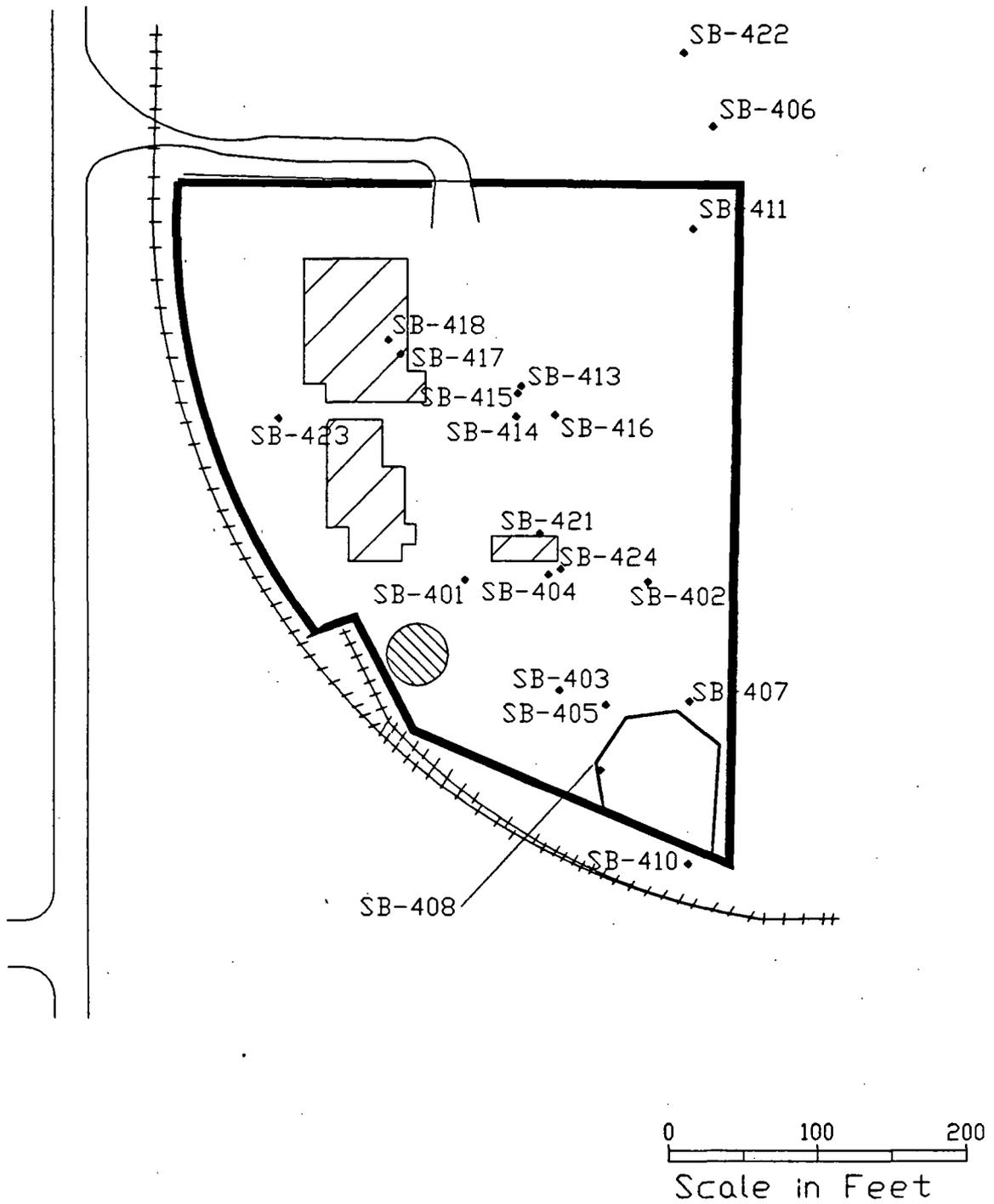
SB-29 (DD)
SB-5 (G)



Brown and Bryant Arvin, California

Figure 2.1

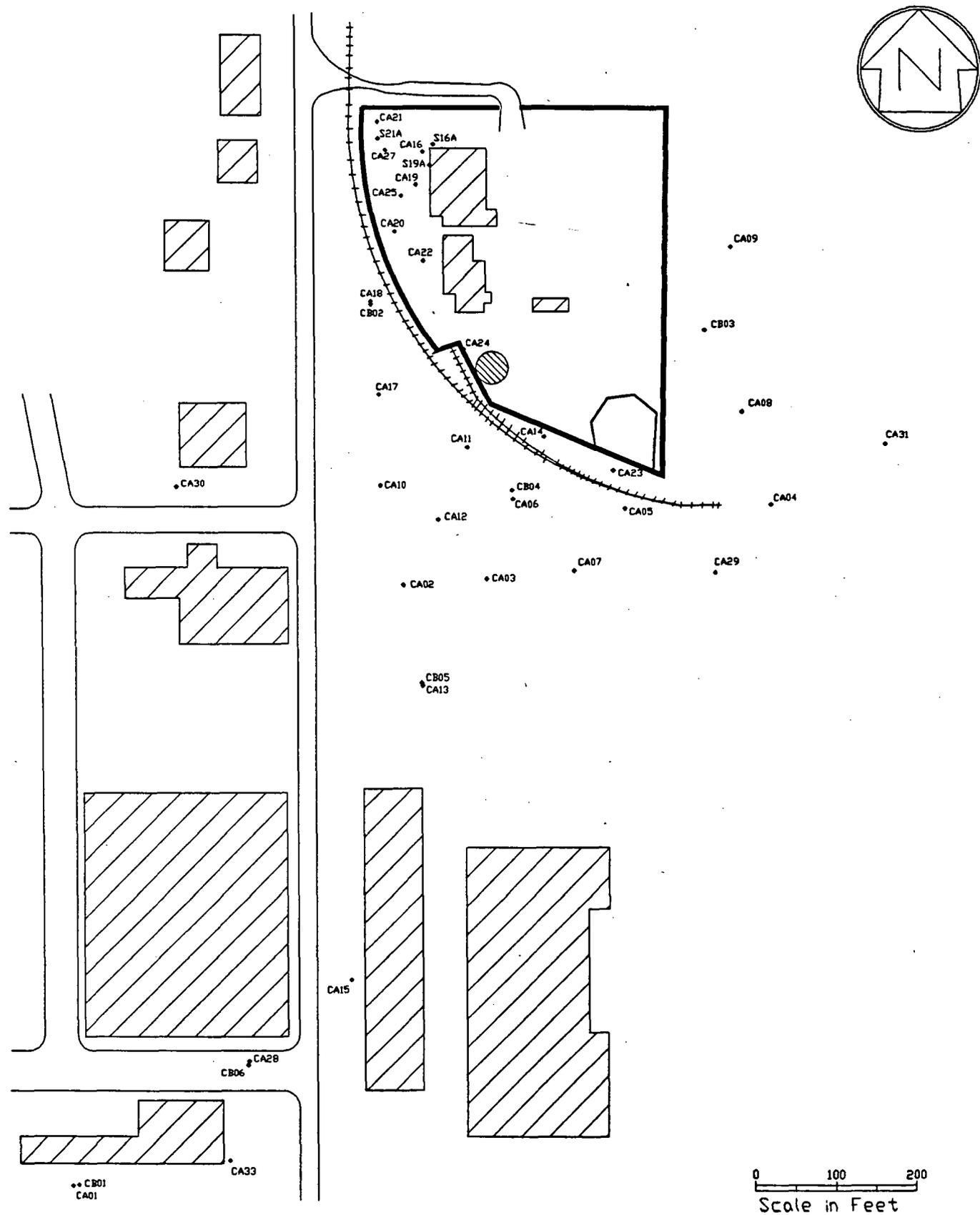
Emergency Response Soil Boring Location Map



Brown and Bryant Arvin, California

Figure 2.2

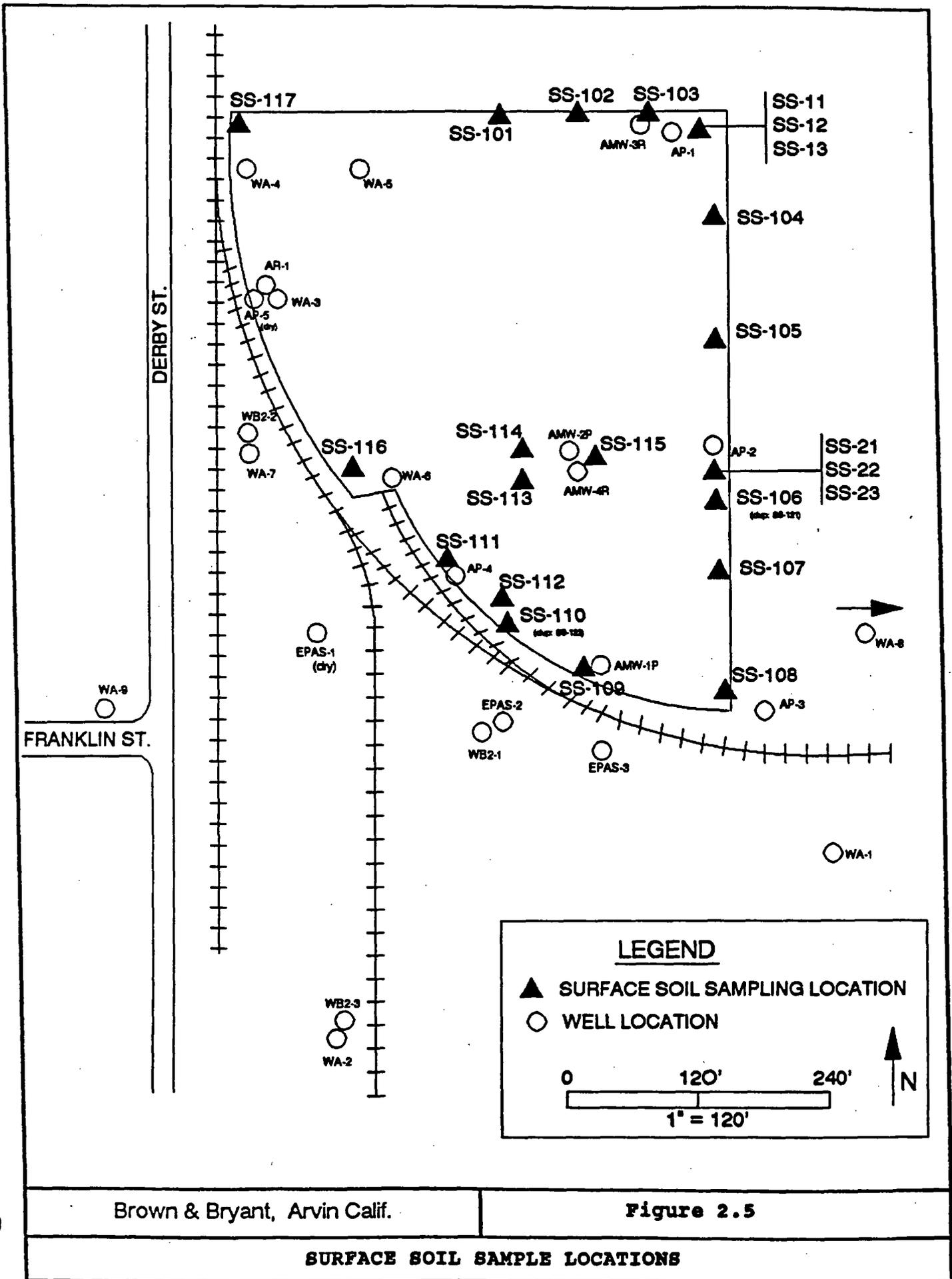
Ecology and Environment Soil Boring Location Map



Brown and Bryant Arvin, California

Figure 2.3

Kennedy Jenks Soil Boring Location Map



LEGEND

▲ SURFACE SOIL SAMPLING LOCATION

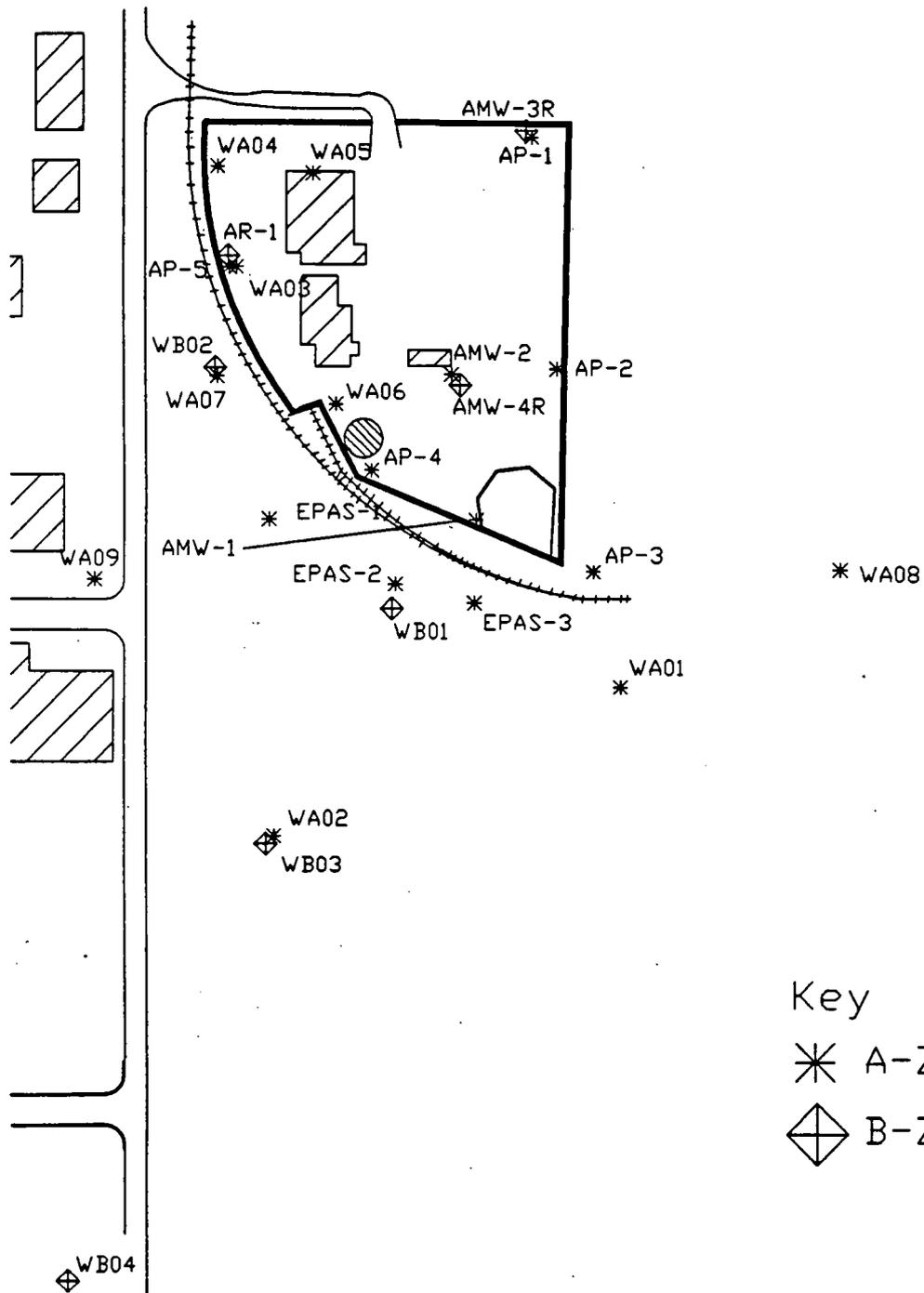
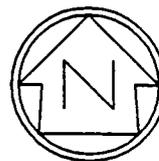
○ WELL LOCATION

0 120' 240'

1" = 120'

↑ N

* EPAS-4



Key
* A-Zone Wells
◇ B-Zone Wells

0 100 200
Scale in Feet

SECTION 3: PHYSICAL CHARACTERISTICS OF THE SITE AND THE SITE VICINITY

3.1 Environmental Setting and Surface Features

Arvin is situated on the southeastern edge of California's Central Valley which is over four hundred miles long and ranges in width from about twenty to seventy miles. The Central Valley is surrounded by mountains and is filled with alluvium and other sediments. Topographically, the Valley is relatively flat and has an elevation of 440 feet above sea level at Arvin. The Valley can be subdivided into four major river systems: the Sacramento, the Delta, the San Joaquin and the Tulare basin. Arvin is located in the Tulare basin.

The B&B site is topographically flat, with only a slight downward slope to the south. On-site are two moderate sized warehouse structures, a large storage tank in the southwest portion of the site, and a moderate sized empty pond in the southeast corner of the site (Figure 1.3). One to two sumps were located on-site during part of the site operation history, but were removed in the early to mid 1980s. Various small tanks and pumps were also located in the center of the site; these structures were removed by EPA during the RI. Much of the site has been paved with a thin layer of low-grade asphalt and in many places the asphalt has been covered by up to six inches of soil, probably resulting from both wind deposits and water run-on. The site is bordered by a chain-link fence around the entire site perimeter, and railway tracks border the site to the west and south.

The drainage of rain water from the site is generally poor due to inadequate surface grading. In the winter months, rain water frequently ponds in the southern portion of the site, between the tank and pond, and also to the west of the warehouses. This ponding is now periodically controlled by pumping the ponded water into the large on-site tank. In addition, EPA ordered the PRPs to install a berm around the site to prevent rain water draining onto or off of the site. Site historical documents suggest that on-site ponding of rain water has occurred during some or all of the operational history of the site. This condition may have accelerated contaminant migration in the vadose zone (see sections 4 & 5).

3.2 Demography and Land Use

The population of Arvin is 9,286 (1990 Census). The population is 75% hispanic, 22% caucasian, and 3% other ethnic minorities; approximately 50% of the population is under 25 years old. Within a one half mile radius of the site approximately 4,225 people live.

Arvin is surrounded by agriculture crop land. Farming and related enterprises provide the primary source of employment for the community; no other major industries are located in the Arvin area. B&B is bordered to the east by irrigated agriculture fields; its neighbors to the north and south are food packing and shipping facilities, and to the west is the residential area of Arvin.

Arvin is located in the Arvin-Edison Water district and derives its water supply from a regional confined aquifer. This aquifer is used for both drinking water and irrigation in the Arvin area and elsewhere. Within one-half mile of B&B are located two of the six supply wells operated by the city of Arvin as well as a number of irrigation wells (Figure 3.1). Arvin City Well #1, the closest drinking water well to the site, is located 1,700 feet south, southwest of B&B.

3.3 Meteorology

The climate in Arvin as well as in the entire Central Valley is Mediterranean type (dry summers). Average climatic data for Bakersfield, which is located 10 mile northwest of Arvin, was obtained from National Weather Service and is consistent with data obtained from weather stations near Arvin. The National Weather Service data is summarized below and in Table 3.1.

Rainfall occurs primarily from November through April, with average annual precipitation ranging from five to ten inches. The mean annual rainfall over the last 30 years was 5.87 inches. Temperatures range over the year from averages in the winter months in the 40s and 50s F° to averages in the summer months in the low 80s F°. Average minimum temperatures for the winter months are in the high 30s F°, and average maximum temperatures in the summer months are in the high 90s F°. The prevailing wind direction for most of the year is to the northwest; however, in February, November and December the prevailing wind is to the east, northeast. Prevailing wind speeds average 5 to 8 miles per hour (mph). Sustained winds reach maximum speeds of between 30 and 50 mph, while peak gusts reach maximum speeds of between 40 and 60 mph.

3.4 Site Ecology

A detailed discussion of the site ecology and an assessment of ecological risks can be found in Appendix E. Summarized below is a brief description of the site ecology taken from this appendix.

The area surrounding the site is arid/semiarid with no surface water bodies. There are no wetlands or streams within one-half mile of the site. Little or no native vegetation is found on the site. Currently, the primary vegetation on-site is

tumbleweed; however, coverage is insignificant. Little wildlife has been seen on-site. This may be due to a lack of food and appropriate habitat and suggests that the use of the site by wildlife is insignificant. No significant ecological risks are associated with the site.

3.5 Geologic and Hydrologic Setting

The geology in the Arvin area is comprised of alternating layers and mixtures of gravel, sand, silt, and clay. This is typical for sediment deposited within basins bounded by mountain ranges where alluvial fan and braided stream environments produce alternate layering that is heterogeneous and laterally discontinuous. The presence of these alternating and discontinuous layers of varying permeability produce both confined and unconfined water bearing units.

The Tulare basin, which is part of the San Joaquin Valley located in the Great Valley geomorphological province, is bounded to the east by the Tehachapi Mountains. B&B is within two miles of these mountains, on the distal end of an alluvial fan. The eastern edge of the basin is fault controlled, bounded by the White Wolf Fault to the southeast and the Edison Fault to the northeast. These faults probably control the slope of geologic units towards the east (Kern County Water Agency, 1988).

The unconsolidated deposits in the Arvin area are mostly part of the younger alluvium map unit. This unit is characterized as moderately permeable and consists of unconsolidated sand, gravel, silt and clay which make up the alluvium and stream-wash deposits (Wood & Dale, 1964). The major groundwater features within the Arvin area consist of a deep confined aquifer, which is located below the Corcoran Clay, and a shallower confined aquifer (the B-zone), located above the Corcoran Clay. In some previous reports the B-zone has been referred to as the regional unconfined aquifer. The Corcoran Clay has been described as a thick, impermeable layer of clay which lies under much of the San Joaquin Valley (Kern County Water Agency, 1991). The Arvin drinking and irrigation water is drawn from the deep confined aquifer.

The RI focused on the surface soils, the vadose zone, and the water bearing unit which make up the A-zone. Preliminary data was also collected on the soil and groundwater in the B-zone (see Section 1.1 and Figure 1.1). Discussed below are the findings from the RI for data collected on the hydrology and geology for the A- and B-zones under B&B.

3.5.1 Geology of A-Zone Soils

Soils located at the surface to a depth of approximately 85 feet below ground surface (bgs) at the B & B site are called the

A-zone. Based on cross-sections (Figures 3.2 through 3.4) made using the soil borings and the seismic reflection study, individual beds are relatively flat lying across the site, although cross-section A-A' shows that the A-zone water bearing unit thins to the southwest of the site (Figure 3.3). Some beds are continuous while others are more lenticular in nature. The shallow soils may be divided into four general layers, which will be discussed separately. However, these four layers are not well defined in all areas.

LAYER 1

The shallowest layer occurs from the surface to a depth of about 25 to 35 feet. This layer, which consists predominantly of silty sands, is thinner in the middle of the site and thickens toward the mid southern site boundary. The sands range from fine to coarse grained with occasional gravel up to 1/3-inch. The sands are composed of dark mafic minerals, lithic fragments, quartz, and mica, thus having a "salt and pepper" appearance. Two soil samples were collected from this layer for geotechnical analysis. These samples have a laboratory permeability averaging 1.1×10^{-3} cm/sec (which is typical for a fine sand), a porosity of 46%, moisture content of 5.1%, and a total organic carbon (TOC) content of 16,500 mg/kg.

LAYER 2

The second layer extends from a depth of about 30 to 55 feet bgs. This layer consists predominantly of silts and clays with occasional thin sands. Small rootlet holes are common in this zone, suggesting vegetation growth soon after deposition. Ten soil samples were collected from this layer for geotechnical analysis. The average soil porosity was 41% (three samples and one duplicate); the average moisture content was 14.5% (nine samples); permeability ranged from 10^{-4} to 10^{-6} cm/sec (three samples and one duplicate); and the averaged TOC content was 3,950 mg/kg. Hard, grayish-white calcareous nodules occur between approximately 40 to 55 feet bgs. These nodules were possibly caused by the evaporation of shallow groundwater or ponds shortly after the time of deposition.

LAYER 3

The third layer is sandier than the second layer and extends from approximately 55 to 75 feet bgs. This layer contains thin bedded clays, silts, and sands and includes the water bearing zone at about 65 to 75 feet. The sands are typically dirty, consisting of quartz, rock fragments, mica, and some silt and clay. Grain size varies from clay to fine (1/4-inch) gravel.

The map in Figure 3-5 shows the predominate lithology in the A-zone saturated horizon. This figure show that the southeast

area of the site is the sandiest, and thus has the highest permeability, while the area west of the site is the least permeable, consisting of silt and clay. The boundaries of the third layer can not always be distinguished from adjacent layers.

Fourteen soil samples for various geotechnical analyses were obtained from this layer during three phases of drilling. The average values are 40% for porosity (three samples); moisture content of 24% (three samples); TOC content of 55 mg/kg (two samples); and 3×10^{-5} cm/sec permeability (five samples). Results from slug tests performed in four wells screened in this zone show an average hydraulic conductivity of 4×10^{-4} cm/sec. Since the lab measures the vertical permeability (k) of a soil sample, while the slug test measures the horizontal k, it is not surprising that the slug k is higher than the lab k. In sedimentary deposits the horizontal k is typically much higher than the vertical k.

LAYER 4

The base of the A-zone, that extends from approximately 75 to 85 feet bgs, is mostly sandy clay. Of the 10 soil samples obtained from depths of 82 to 85 feet bgs, eight were predominantly clays and silts (based on grain size analysis). The remaining two samples were clayey to silty sand. Permeability ranged from 1.0×10^{-8} to 8.2×10^{-6} cm/sec, with 10^{-8} being the most common. Moisture content averaged 16.4% (seven samples) and measured effective porosity was 34%. This clay layer grades to sand in the southwest and was completely missing approximately 900 feet south of the B&B property at boreholes CA-01 and CA-28 (see Figures 3.2 and 3.3).

3.5.2 Hydrology of A-Zone Water Bearing Unit

Groundwater is first encountered at depths of about 65 to 72 feet bgs. In previous reports this water bearing layer has been referred to as the perched zone. Water table elevations for July 1992 show a maximum variation of 3.1 feet between on-site wells AP-01 and WA-04. Maps of the water table consistently suggest that water moves west and south off the site (Figures 3.6 and 3.7). A possible limb or mound in the water table extends from the southwest site corner, southward approximately parallel and next to the railroad tracks. This groundwater limb has a similar shape to the groundwater contaminate plume which is discussed in Section 4.

With only minor anomalies, the water levels in all wells have steadily fallen over the last 18 months (Figures 3.8 and Table 3.2). The drop in the water levels range from a maximum of 7.19 feet in the upgradient well EPAS-4 to a minimum of 2.54 feet in the downgradient well EPAS-2. The average drop in water levels was 3.86 feet over this 18 month period in the nine A-zone

wells. With the completion of nine additional wells, more information is now available. Over the last quarter an average drop of 0.36 feet has taken place. Over both three month and 18 month periods the water table drop has been greatest in the northeast and least in the southwest. This has caused a flattening of the water table with a corresponding decrease in groundwater velocity. It also suggests a decrease in upgradient recharge to this layer.

The drop in the water table is probably a reflection of the continuing drought in California, and possibly the cessation of irrigation on the field located immediately to the east of the site. A noticeable exception to the gradual decrease in the water table is found in well AMW-1P. The one time high in the water table in well AMW-1 in December 1991 was confirmed by water levels in nearby borings (see Figure 3.8). This well is located near a low spot on the site where rain water ponds and could reflect recharge from such an event.

Two shallow wells are dry, namely EPAS-1 and AP-5. Well EPAS-1 is screened from 77 to 87 feet bgs and appears too deep to tap the water bearing zone. The tops of the screens in the five closest surrounding wells range from 64 to 68 feet and the depth to water in each well is 68 to 70 feet. Conversely, well AP-5 stopped approximately one foot short of the water table. AP-5 is 71 feet deep and depth to water in the new adjacent well (WA-03) is 72 feet bgs.

Identification of the actual water bearing horizon is difficult. When the water levels are plotted against lithology from individual wells, it appears that the water table may be in sands, silts, or clays (see Figures 3.3 and 3.4). Likewise, the sealing clay at the base of the A-zone is not always well defined.

Based on a review of many boring and well logs, it appears that the saturated thickness of this water bearing zone ranges from 0 to 10 feet. The thickest portion occurs on an NW-SE line running through the middle of the site (from well WA-5 to borehole CA-29). The average saturated thickness is estimated at 4.5 feet based on July 1992 water levels. The basal clay (layer 4) turns to sand south of well WB-4, and no shallow water was found south of this point. Where this clay pinches out may provide an avenue for the shallow groundwater to infiltrate downward to deeper zones. The fact that some vertical leakage takes place on site, or just to the south of the site, is seen in the chemicals that are found in the deeper (B-zone) groundwater wells.

As mentioned previously, the typical permeability, or hydraulic conductivity of the water bearing zone is 10^{-4} to 10^{-5} cm/s. The slug test report (E&E 1992) indicated an estimated

groundwater velocity of 53 feet/year near the wells tested based on permeability, gradient, and assumed porosity. This velocity compares favorably with a groundwater contaminant plume that extends ± 500 feet south of the site (see Figures 4.7 through 4-10).

The thinness of this zone and its low permeability will make it difficult to extract groundwater effectively for site remediation. The slug test results suggests that the yield of the tested wells would be less than 100 gallons per day per well. Based on Figure 3-5, wells placed in the sandier area of the A-zone, located near the south-east corner, may yield more water. Flushing could increase, with time, the available drawdown, gradient (and thus velocity), yield, and radius of influence of extraction wells.

3.5.3 Overview of B-Zone Geology and Hydrology

The B-zone starts below the basal A-zone clay at a depth of about 85 feet bgs and extends to the regional Corcoran Clay at depths of greater than 200 feet. Seismic reflection suggests a basal reflection at approximately 300 feet which may be the Corcoran clay. The B-zone makes up a second operable unit and additional data will be required to better understand it.

Geology

The B-zone contains sand layers 5 to 15 feet thick that consists predominantly of silty sands to gravelly sands to a depth of approximately 180 feet. The sand layers are thicker and more continuous in the B-zone than in the A-zone (see the cross-sections, Figures 3.3 and 3.4). The thicker sand layers indicate that there were larger more continuous streams at the time of deposition of the B-zone, than during A-zone deposition, or under current conditions. More clay beds occur below a depth of 180 feet.

Unsaturated but fairly clean sands are typically found at a depth of about 95 to 135 feet bgs. Water bearing sands are labeled B-1, B-2, B-3, and B-3 ranging from the shallowest to the deepest (see the log for boring CB-02 on Figure 3.4). The first wet sand (called B-1) appears at a depth of approximately 150 feet bgs. Of the six deep boreholes that were geophysically logged (CB-01, CB-02, CB-03, CB-04, CB-05, CB-06), the B-1 sand is thickest and best defined at CB-02 and CB-05. This sand appears to be fully saturated only at borehole CB-05. Of the six boreholes, sands B-1 through B-4 are structurally lowest at CB-05. The top of the B-2 zone is 10 feet deeper at boreholes CB-05 than at CB-02 and CB-06, five feet deeper than at boreholes CB-03 and CB-04, and 16 feet deeper than at CB-01.

The B-2 sand is located at a depth of approximately 170

feet, the B-3 sand at 185, and the B-4 sand at 200 feet bgs. Each of these sands is saturated and under some confining pressure. The B-2 and B-4 are the most continuous sands, while the B-3 sand is thickest at boring CB-02.

Hydrogeology of the B-zone

A map of the piezometric surface (Figure 3.9) shows that water in the B-2 zone flows southerly beneath the site. For wells WB-1, -2, and -3, the B-1 zone has a 15- to 20-foot pressure head. The groundwater gradient is very flat near these wells (0.0004 ft/ft). This flat gradient may reflect a high permeability for this zone. The water level in well WB-4 is much deeper (approximately 19 feet) than expected from the trend of the other wells (See Figure 3-3). The reason that the water level in WB-4 is so much lower is not yet known.

The water levels in the older wells (AR-1, AMW-3, and AMW-4) have shown a very consistent drop of from 0.86 to 0.94-feet over the 18 months from January 1991 to July 1992 (see Figure 3.10). For the three month period April to July 1992, the water level in the seven B-zone wells dropped an average of 0.35 feet. Similar to the A-zone water levels, the drop has been greatest in the northeast.

Analysis of a 6-hour pump test on well WB-1, which screens the B-2 sand layer, gives a transmissivity of the sand as $2.7 \text{ cm}^2/\text{sec}$, and a hydraulic conductivity (k) of $8.7 \times 10^{-3} \text{ cm}/\text{sec}$ (E&E 1993). This pump test analysis also indicates that well WB-2 could be pumped continuously at 7 gpm for several months.

Each new B-zone well (WB-1 through WB-4) is screened across the B-2 zone from about 170 to 180 feet bgs. The screened interval for some of the wells is indicated on the cross-sections (Figures 3-3 and 3-4). The screened interval of the older well AR-1 is not known; however, this well is 182 feet deep. Wells AMW-3R and AMW-4R are screened from approximately 130 to 200 feet. Therefore, these last two wells screen B-1, B-2, B-3, and B-4 sands. As a result, the water level in the old cross-screened wells cannot be directly correlated with the water level in the new wells. The water levels are 0.6 feet deeper in the old wells than in the new wells.

3.6 Figures and Tables

Table 3.1: Climate Data Summary, 1951-1980

Table 3.2: Water Level Measurements

Figure 3.1: Water supply/irrigation well location map

Figure 3.2: Cross-section location map

Figure 3.3: Cross-section A-A'

Figure 3.4: Cross-section B-B'

- Figure 3.5: Lithology map of the A-zone water bearing layer.
Figure 3.6: Water Contours--A-zone, April 1992
Figure 3.7: Water Levels--A-zone, July 1992
Figure 3.8: Graphs of water table trends, A-zone.
Figure 3.9: Water Level Contours--B-zone, map.
Figure 3.10: Graphs of Water Level trends--B-zone.

TABLE 3.1
Climate Data Summary, 1951 to 1980

NORMALS, MEANS, AND EXTREMES

BAKERSFIELD, CALIFORNIA

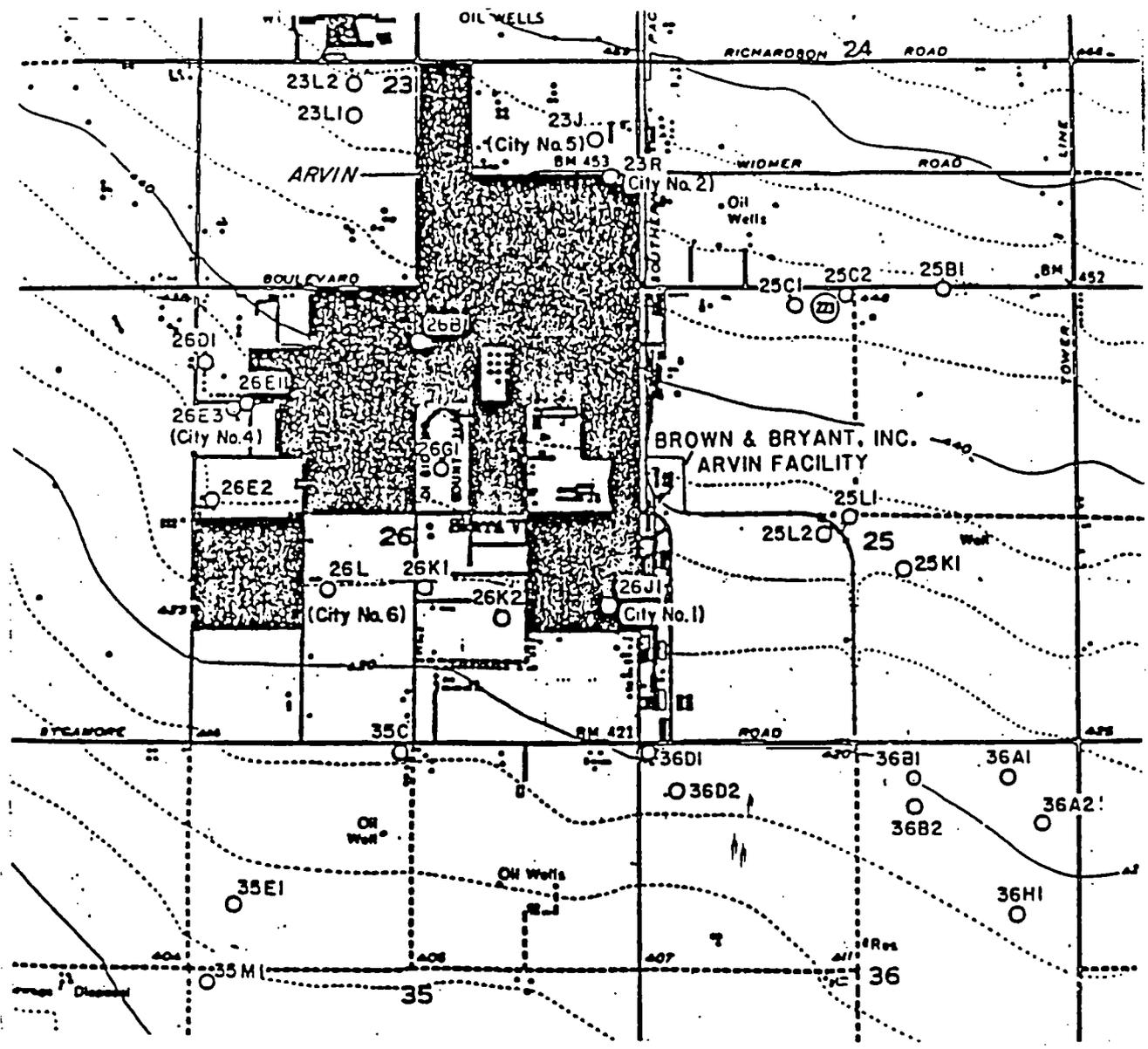
LATITUDE: 35°25'N		LONGITUDE: 119°03'W		ELEVATION: FT. GRND 496 BARO 499		TIME ZONE: PACIFIC		WBAN: 23155						
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR	
TEMPERATURE OF:														
Normals														
-Daily Maximum	57.4	63.7	68.6	75.1	83.9	92.2	98.8	96.4	90.8	81.0	67.4	57.6	77.7	
-Daily Minimum	38.9	42.6	45.5	50.1	57.2	64.3	70.1	68.5	63.8	54.9	44.9	38.7	53.3	
-Monthly	48.2	53.2	57.1	62.7	70.6	78.3	84.5	82.4	77.3	68.0	56.2	48.2	65.6	
Extremes														
-Record Highest	54	82	87	92	101	107	114	115	112	112	103	91	83	115
-Year		1984	1989	1969	1981	1982	1976	1950	1981	1955	1990	1949	1979	JUL 1950
-Record Lowest	54	20	25	31	34	37	45	52	52	45	29	28	19	19
-Year		1963	1990	1955	1984	1988	1988	1987	1942	1948	1971	1941	1990	DEC 1990
NORMAL DEGREE DAYS:														
Heating (base 65°F)														
		521	335	255	137	35	6	0	0	0	50	268	521	2128
Cooling (base 65°F)														
		0	0	10	68	208	405	605	539	365	143	0	0	2347
% OF POSSIBLE SUNSHINE														
MEAN SKY COVER (tenths)														
Sunrise - Sunset														
	46	6.6	6.0	5.5	4.5	3.2	1.7	1.3	1.4	1.8	3.0	4.9	6.5	3.9
MEAN NUMBER OF DAYS:														
Sunrise to Sunset														
-Clear	51	7.0	7.7	10.0	12.6	17.9	23.3	26.5	25.9	23.8	19.6	12.0	7.3	193.7
-Partly Cloudy	51	7.9	8.3	9.4	9.1	8.7	4.7	3.1	3.7	4.3	6.4	8.1	7.5	81.1
-Cloudy	51	16.2	12.3	11.6	8.3	4.4	2.0	1.3	1.4	1.9	5.0	9.9	16.2	90.5
Precipitation														
.01 inches or more	54	5.9	6.1	6.6	4.1	1.6	0.5	0.1	0.4	1.0	1.7	3.6	5.2	36.6
Snow, ice pellets, hail	54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
1.0 inches or more	54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*
Thunderstorms														
Heavy Fog Visibility	53	0.1	0.2	0.5	0.5	0.3	0.3	0.2	0.2	0.6	0.3	0.1	0.1	3.3
1/4 mile or less	53	8.3	2.7	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.1	2.7	8.0	22.5
Temperature of														
-Maximum	28	0.0	0.0	0.1	2.4	10.0	19.6	28.5	26.0	17.3	5.9	0.0	0.0	109.9
90° and above	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32° and below	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-Minimum	28	4.7	1.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	5.0	11.6
32° and below	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0° and below	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AVG. STATION PRESS. (mb)														
	10	1002.0	1001.7	999.0	998.6	995.4	994.8	994.7	994.7	995.0	998.4	1001.4	1003.2	998.2
RELATIVE HUMIDITY (%)														
Hour 04														
	19	83	78	72	65	55	50	48	53	57	63	75	83	65
Hour 10														
	28	77	66	57	46	38	34	33	37	41	46	63	75	51
Hour 16 (Local Time)														
	28	62	50	43	33	25	23	21	24	28	33	49	61	38
Hour 22														
	19	78	71	63	53	40	34	33	38	44	52	69	79	55
PRECIPITATION (inches):														
Water Equivalent														
-Normal														
	54	0.98	1.07	0.87	0.70	0.24	0.07	0.01	0.05	0.13	0.30	0.65	0.65	5.72
-Maximum Monthly														
	54	2.87	4.68	4.61	2.65	2.39	1.11	0.30	1.18	1.06	1.82	3.04	1.80	4.68
-Year		1943	1978	1938	1967	1971	1972	1965	1983	1976	1974	1960	1977	FEB 1978
-Minimum Monthly														
	54	T	0.03	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Year		1972	1967	1972	1966	1982	1983	1981	1981	1978	1959	1989	1989	DEC 1989
-Maximum in 24 hrs														
	54	1.09	3.02	1.68	1.00	1.40	1.10	0.30	1.08	0.63	1.51	1.54	1.15	3.02
-Year		1954	1978	1938	1943	1971	1972	1965	1983	1978	1940	1960	1974	FEB 1978
Snow, ice pellets, hail														
-Maximum Monthly														
	54	T	T	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	1.5
-Year		1987	1990	1974									1990	MAR 1974
-Maximum in 24 hrs														
	54	T	T	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T	1.5
-Year		1987	1990	1974									1990	MAR 1974
WIND:														
Mean Speed (mph)														
	43	5.2	5.8	6.5	7.1	7.9	7.9	7.2	6.8	6.2	5.5	5.1	5.0	6.4
Prevailing Direction through 1963														
		NW	ENE	NW	NW	NW	NW	NW	NW	WNW	NW	ENE	ENE	NW
Fastest Obs. 1 Min.														
-Direction (!!!)	43	02	29	36	29	32	15	29	31	14	08	30	13	13
-Speed (MPH)	43	35	44	38	40	40	41	25	30	35	38	35	46	46
-Year		1960	1960	1973	1958	1990	1972	1950	1987	1976	1986	1985	1977	DEC 1977
Peak Gust														
-Direction (!!!)	8	SE	SE	SE	NW	NW	NW	SE	S	N	E	NW	SE	SE
-Speed (mph)	8	48	58	49	43	45	35	33	49	39	48	49	56	58
-Date		1986	1986	1987	1984	1990	1990	1986	1987	1989	1986	1985	1987	FEB 1986

Source: National Weather Service

**TABLE 3.2
GROUNDWATER LEVEL MEASUREMENTS**

WELL I.D.	SURVEY ELEV (FT)	1/28/91		4/8/91		7/30/91		12/9/91		04/21/92		07/27/92	
		DEPTH TO WATER (FT)	WATER ELEV (FT)	DEPTH TO WATER (FT)	WATER ELEV (FT)	DEPTH TO WATER (FT)	WATER ELEV (FT)	DEPTH TO WATER (FT)	WATER ELEV (FT)	DEPTH TO WATER (FT)	WATER ELEV (FT)	DEPTH TO WATER (FT)	WATER ELEV (FT)
A-ZONE													
AMW-1P	432.32	66.09	366.23	66.42	365.90	66.43	365.89	65.65	366.67	67.95	364.37	68.88	363.44
AMW-2P	433.24	66.79	366.45	67.14	366.10	67.73	365.51	68.76	364.48	69.71	363.53	70.14	363.10
AP-1	433.86	65.14	368.72	65.40	368.46	66.44	367.42	67.81	366.05	68.96	364.90	69.43	364.43
AP-2	431.98	64.88	367.10	65.26	366.72	65.96	366.02	67.09	364.89	68.33	363.65	68.84	363.14
AP-3	431.16	65.03	366.13	66.50	364.66	66.25	364.91	67.23	363.93	68.45	362.71	69.01	362.15
AP-4	431.32	65.91	365.41	66.30	365.02	66.75	364.57	67.56	363.76	68.60	362.72	69.01	362.31
AP-5	433.75	dry*	dry*										
EPAS-1	432.74	dry*	dry*										
EPAS-2	433.11	69.17	363.94	69.56	363.55	69.92	363.19	70.55	362.56	71.60	361.51	71.71	361.40
EPAS-3	431.62	68.23	363.39	68.72	362.90	69.23	362.39	70.16	361.46	71.54	360.08	71.77	359.85
EPAS-4	435.55	64.45	371.10	64.64	370.91	66.65	368.90	69.33	366.22	71.07	364.48	71.64	363.91
WA-1	429.35	NA	NA	NA	NA	NA	NA	NA	NA	67.04	362.31	66.55	362.80
WA-2	430.95	NA	NA	NA	NA	NA	NA	NA	NA	68.91	362.04	69.52	361.43
WA-3	435.85	NA	NA	NA	NA	NA	NA	NA	NA	73.82	362.03	74.22	361.63
WA-4	436.72	NA	NA	NA	NA	NA	NA	NA	NA	75.01	361.71	75.39	361.33
WA-5	435.64	NA	NA	NA	NA	NA	NA	NA	NA	72.19	363.45	72.60	363.04
WA-6	434.73	NA	NA	NA	NA	NA	NA	NA	NA	71.84	362.89	72.32	362.41
WA-7	434.59	NA	NA	NA	NA	NA	NA	NA	NA	73.12	361.47	73.46	361.13
WA-8	433.08	NA	NA	NA	NA	NA	NA	NA	NA	70.46	362.62	70.88	362.20
WA-9	429.10	NA	NA	NA	NA	NA	NA	NA	NA	69.80	359.30	69.55	359.55
B-ZONE													
AR-1	434.46	156.16	278.30	156.34	278.12	156.35	278.11	156.71	277.75	156.88	277.78	157.08	277.40
AMW-3R	433.03	154.56	278.47	154.76	278.27	154.75	278.28	155.15	277.88	155.06	277.97	155.50	277.53
AMW-4R	432.57	154.52	278.05	154.74	277.83	154.66	277.91	155.03	277.54	155.02	277.55	155.38	277.19
WB2-1	432.29	NA	NA	NA	NA	NA	NA	NA	NA	154.25	278.04	154.52	277.77
WB2-2	434.84	NA	NA	NA	NA	NA	NA	NA	NA	156.59	278.25	156.91	277.93
WB2-3	430.71	NA	NA	NA	NA	NA	NA	NA	NA	152.72	277.99	153.02	277.69
WB2-4	425.19	NA	NA	NA	NA	NA	NA	NA	NA	166.75	258.44	167.15	258.04

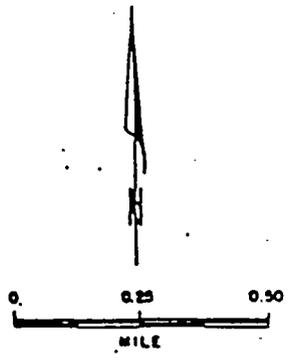
* - These wells do record water; however, the depth to water measured was equal to the total well depth.



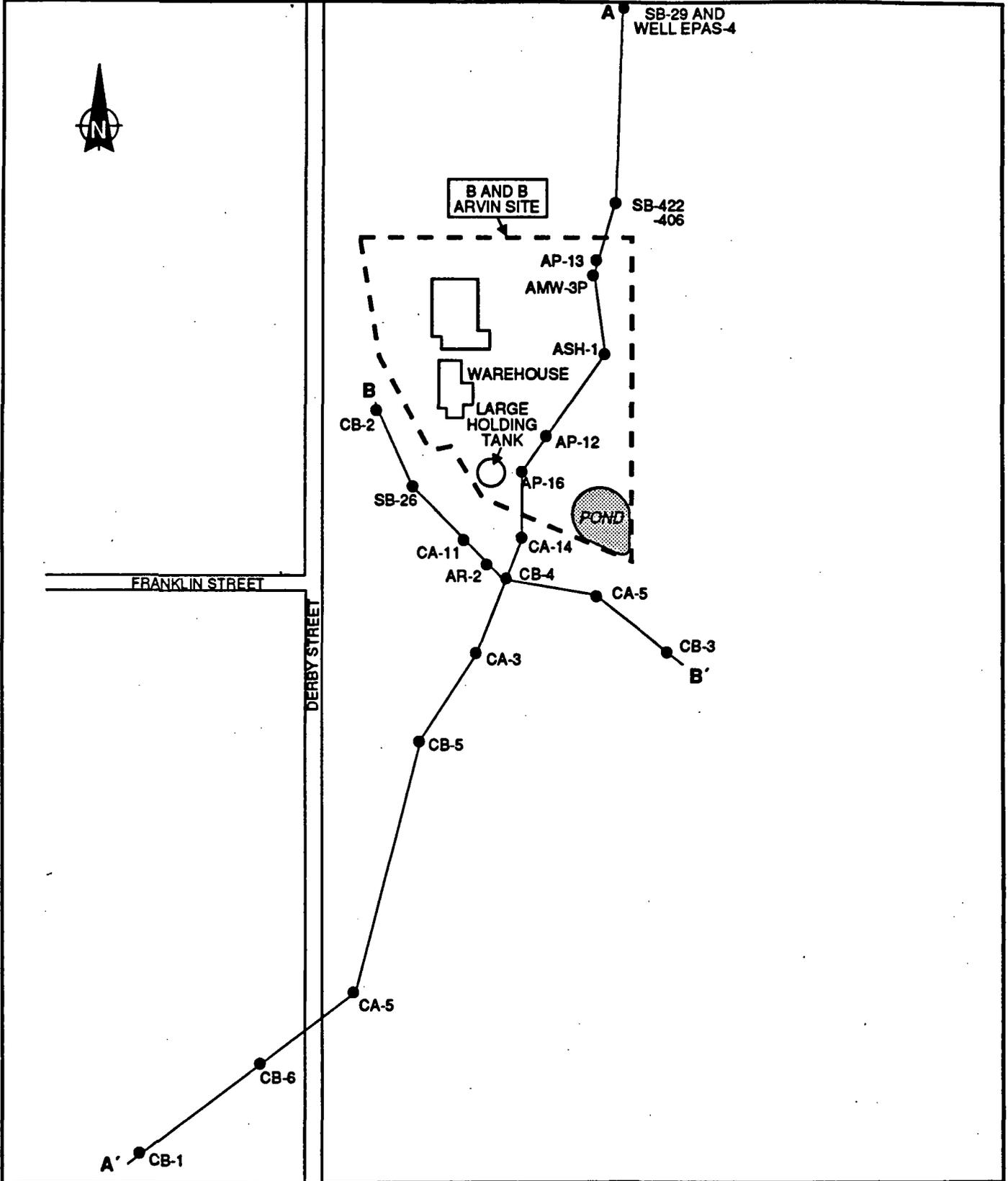
EXPLANATION

- 25C1 WELL IDENTIFIER
- WELL LOCATION

NOTE: IDENTIFIERS FOR INVENTORIED WELLS REFER TO THE STANDARD WELL NUMBERING SYSTEM EMPLOYED BY THE STATE OF CALIFORNIA.



Brown & Bryant, Arvin Calif.



SOURCE: Ecology and Environment, Inc. 1993.

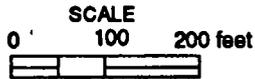
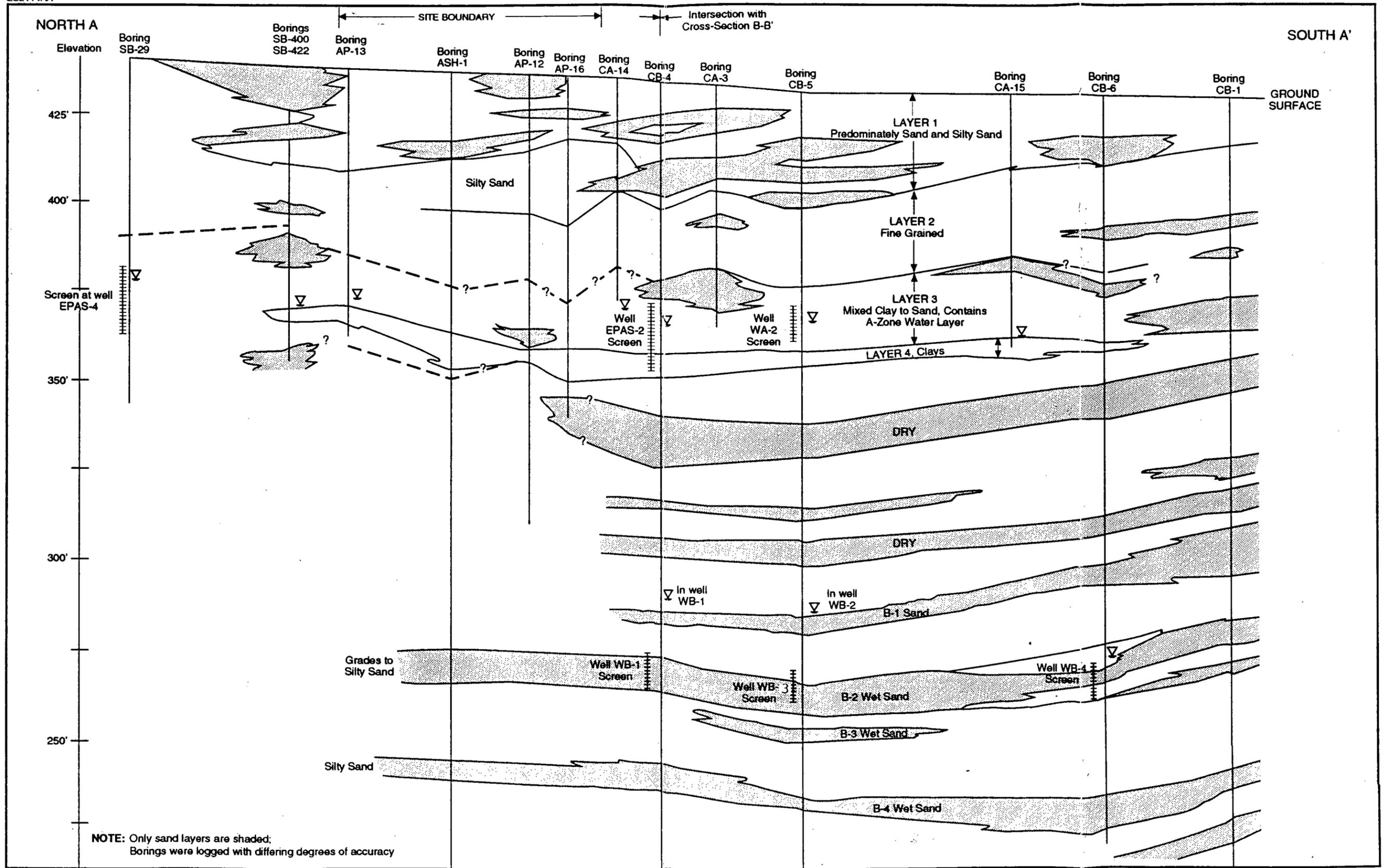


Figure 3-2
CROSS-SECTION LOCATION MAP
BROWN AND BRYANT, ARVIN

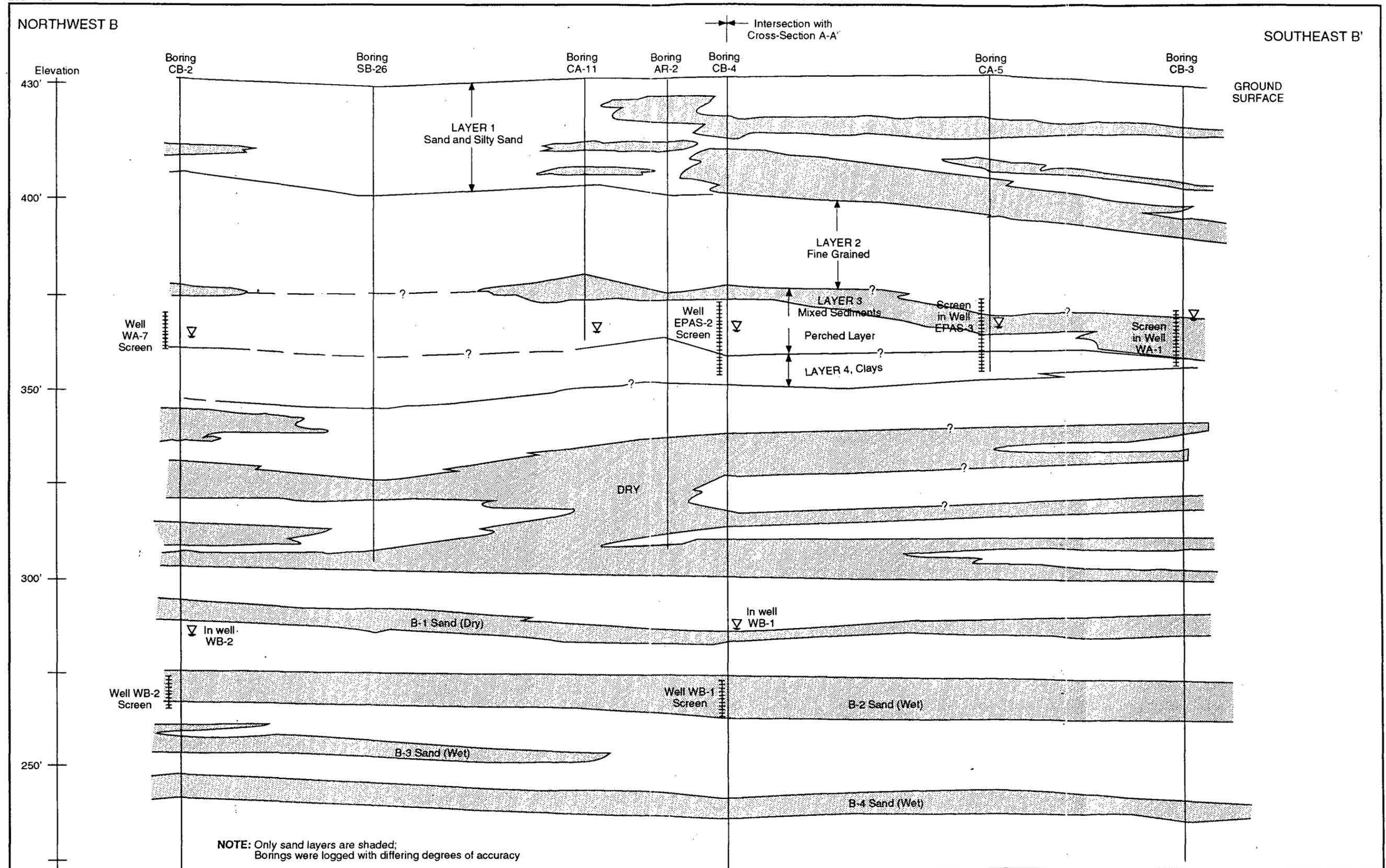


SOURCE: Ecology and Environment, Inc. 1993

Vertical Scale
 0 10 20 Feet
 (8 x Vertical Exaggeration)

Horizontal Scale
 0 80 160 Feet

Figure 3-3
 SIMPLIFIED CROSS-SECTION A-A'
 BROWN AND BRYANT, ARVIN

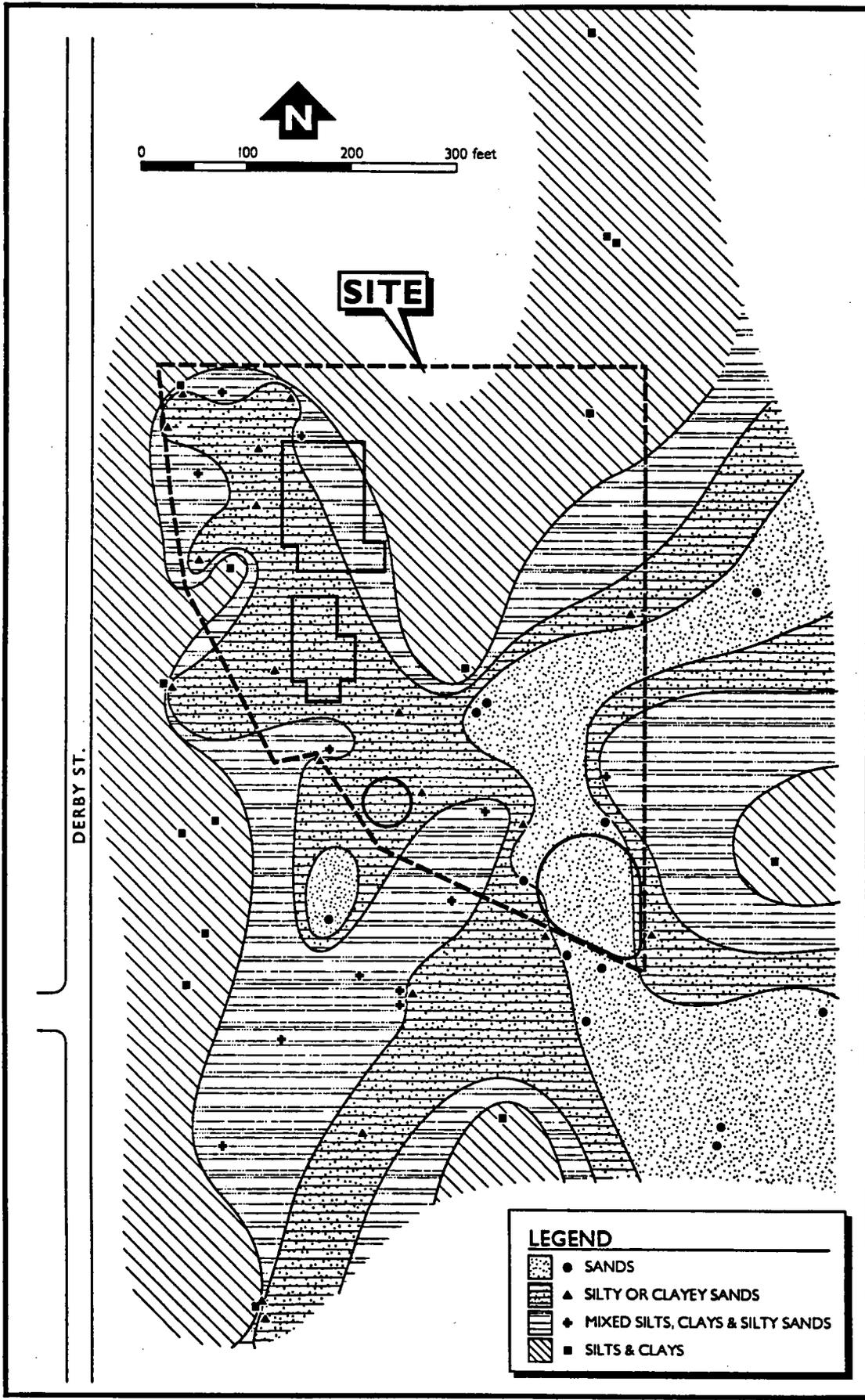


SOURCE: Ecology and Environment, Inc. 1993

Vertical Scale
 0 10 20 Feet
 (2.5 x vertical exaggeration)

Horizontal Scale
 0 25 50 Feet

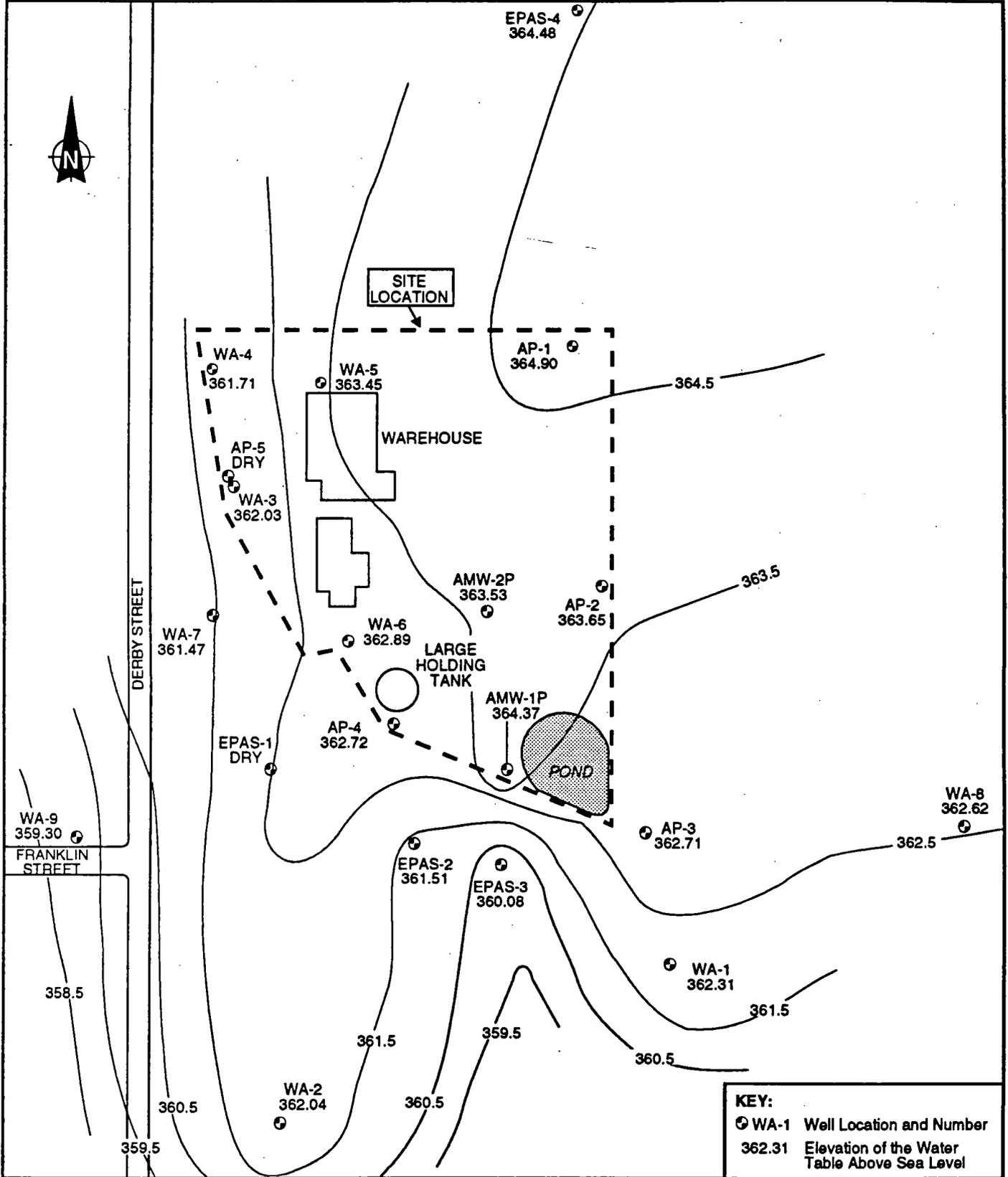
Figure 3-4
SIMPLIFIED CROSS-SECTION B-B'
BROWN AND BRYANT, ARVIN



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Z52114a.ai 03/23/93

Figure 3-5
**PREDOMINANT LITHOLOGY OF
 THE A-ZONE WATER-BEARING LAYER**
 Brown & Bryant - Arvin



SOURCE: Ecology and Environment, Inc. 1993.

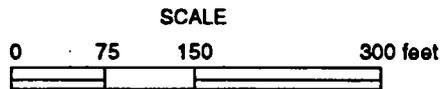
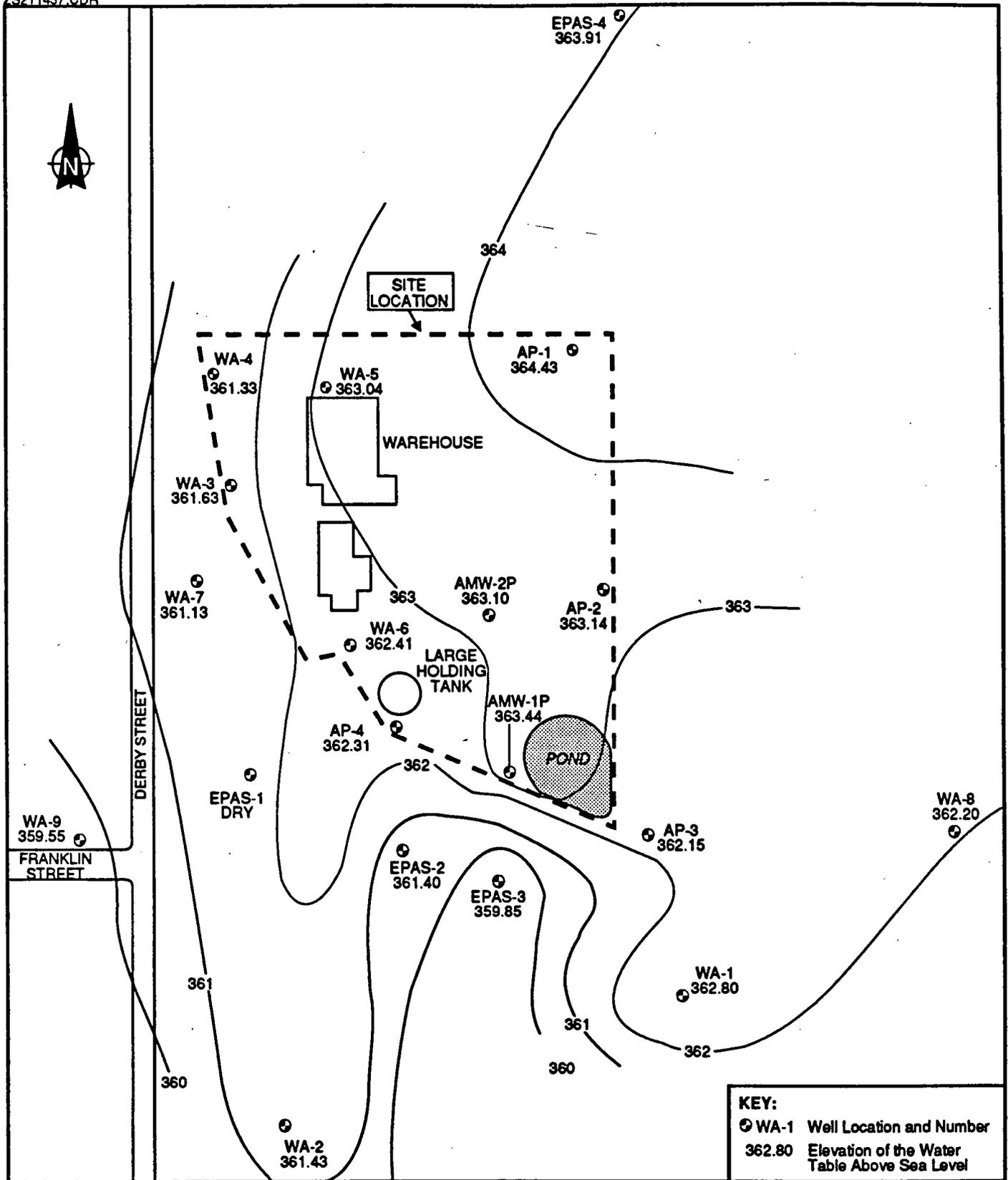


Figure 3-6
WATER TABLE ELEVATION, A-ZONE, APRIL 1992
BROWN AND BRYANT, ARVIN



SOURCE: Ecology and Environment, Inc. 1993.

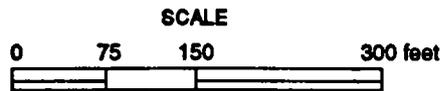
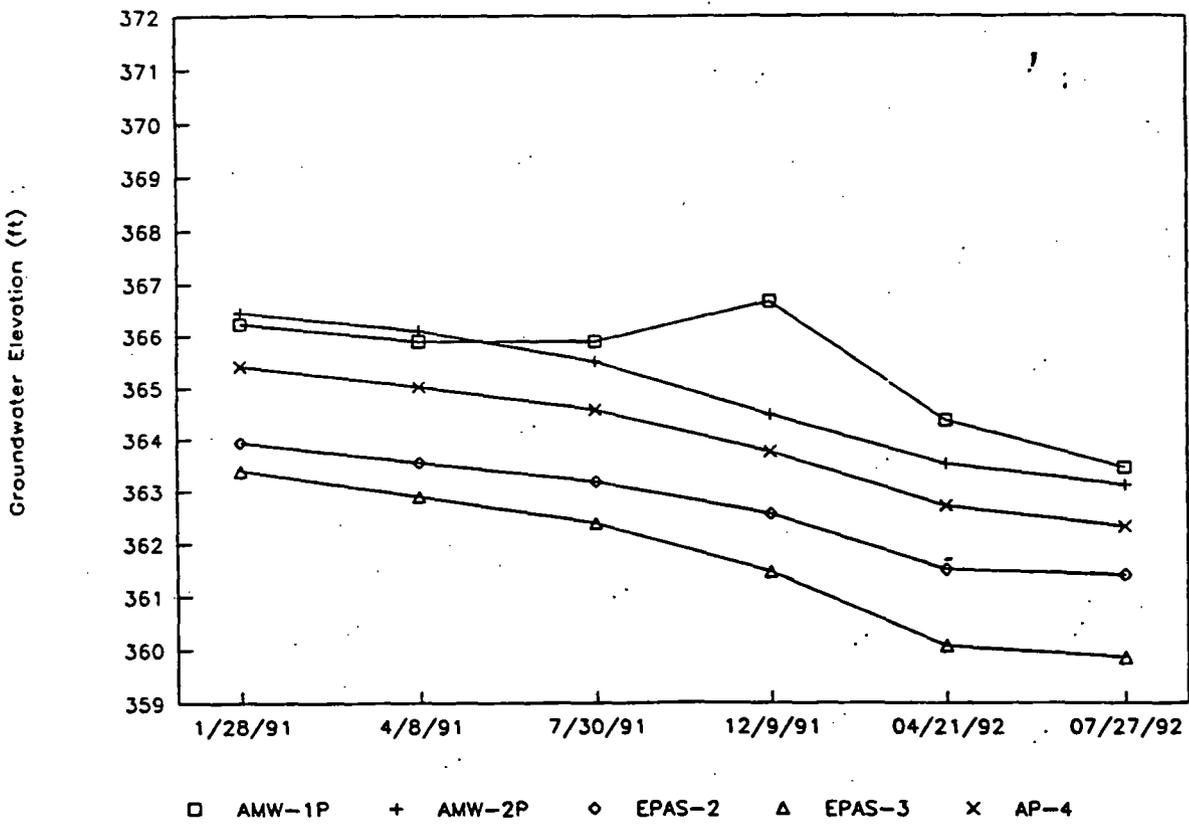
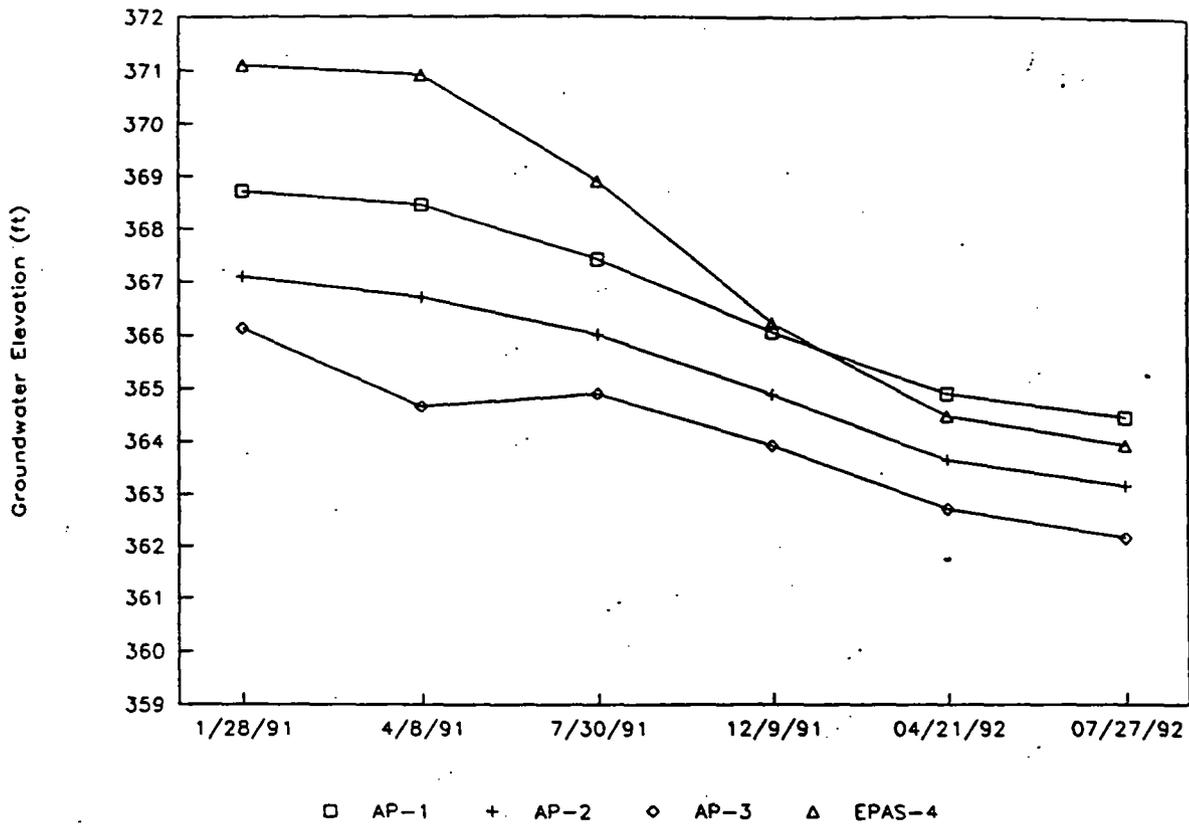


Figure 3-7
WATER TABLE ELEVATION, A-ZONE, JULY 1992
BROWN AND BRYANT, ARVIN

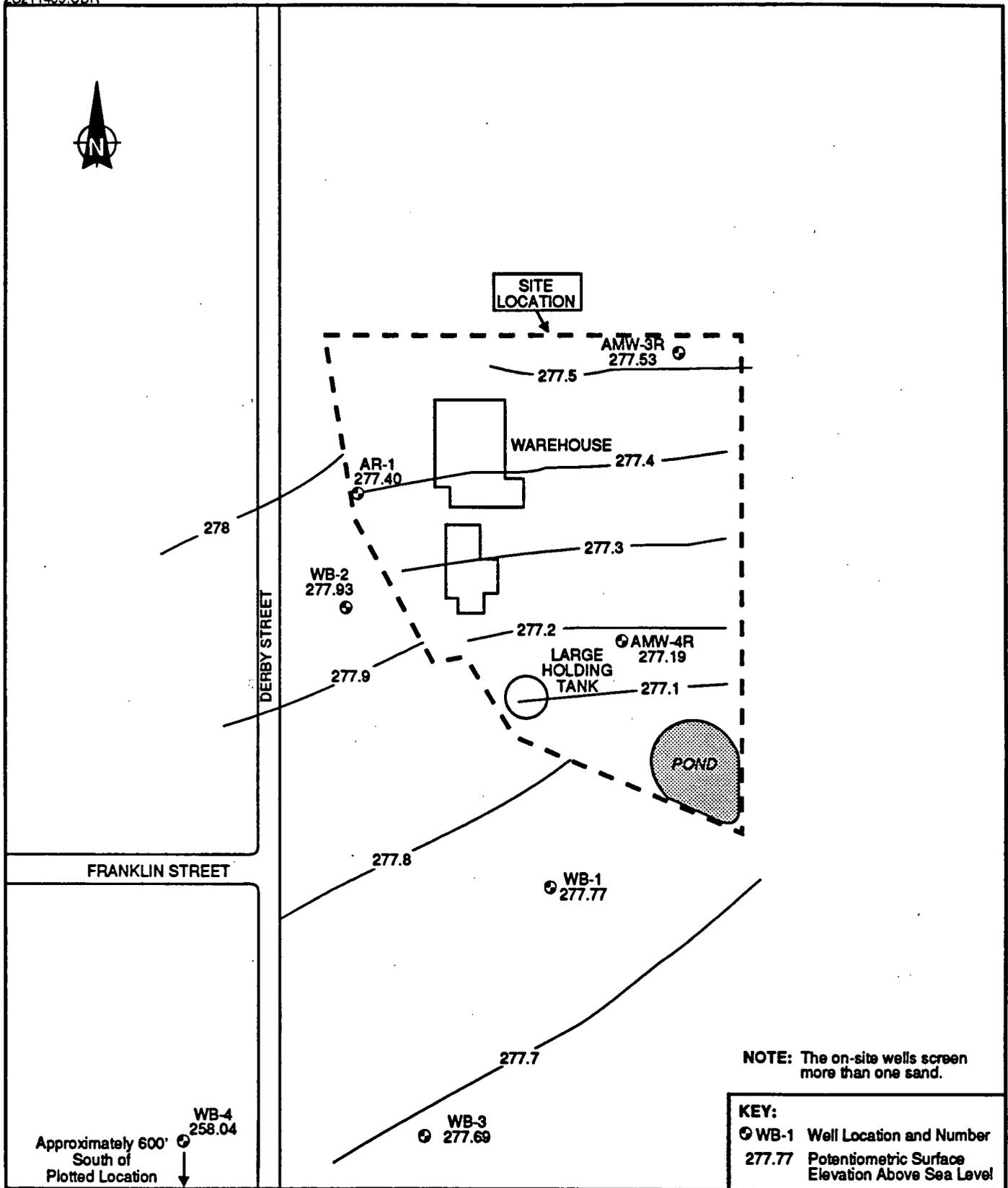
A-ZONE WELLS



Brown & Bryant, Arvin Calif.

Figure 3.8

WATER TABLE TRENDS, A-ZONE



SOURCE: Ecology and Environment, Inc. 1993.

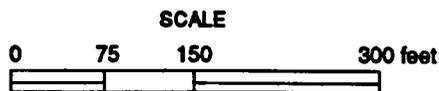
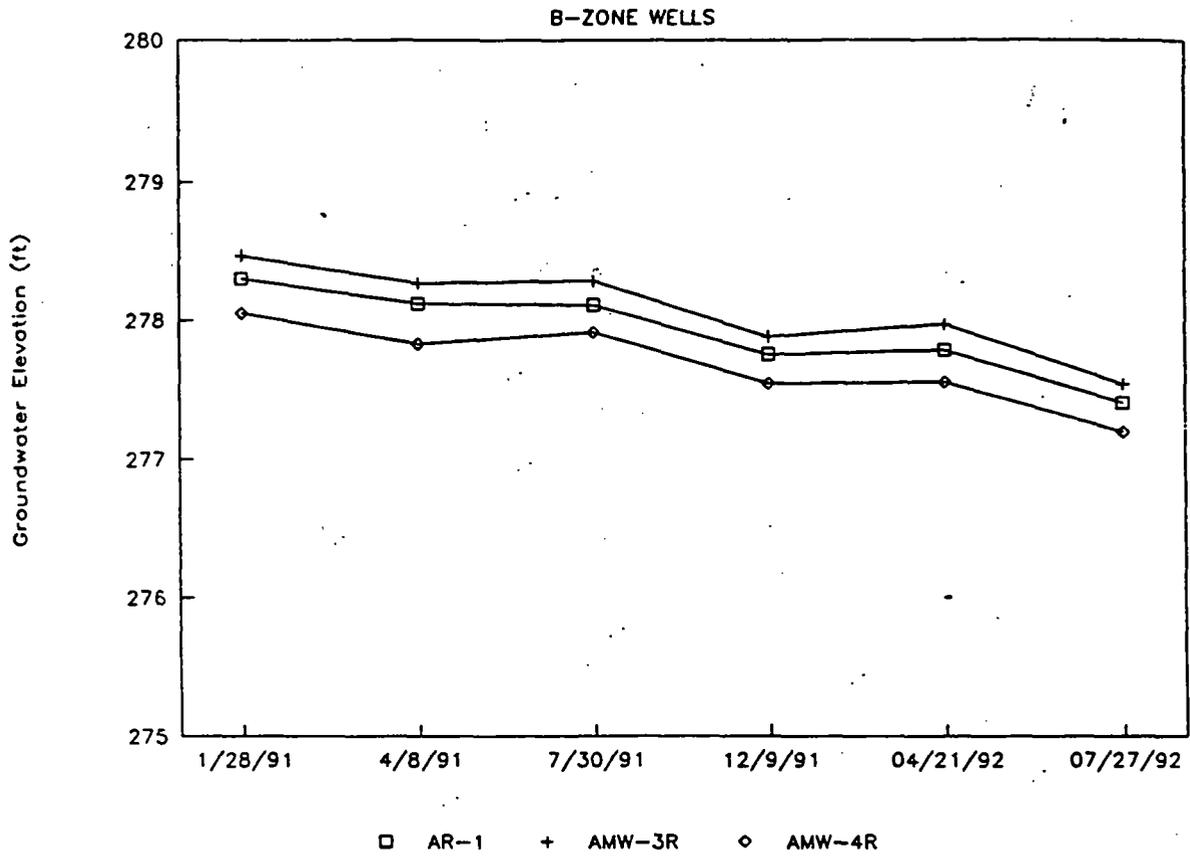


Figure 3-9
POTENTIOMETRIC SURFACE ELEVATION, B-ZONE, JULY 1992
BROWN AND BRYANT, ARVIN



Brown & Bryant, Arvin Calif.

Figure 3.10

WATER TABLE TRENDS, B-ZONE

SECTION 4: NATURE AND EXTENT OF CONTAMINATION

This section presents the results of field investigations conducted during the RI/FS that provided data on the nature and extent of contamination in the media of concern at the site. Presented below are the findings for surface soils, subsurface soils, and groundwater units sampled during the RI/FS. For each media specific section below, only the results of sampling conducted by EPA or its contractor are presented. The data collected by the PRPs' contractor, Kennedy/Jenks (K/J), is outside of the scope of this RI/FS and is not presented here.

For each media discussed below, all chemicals that were detected during the RI/FS are listed along with the highest detected result in each media. These lists of chemicals are then screened to identify the most important contaminants for determining the extent of contamination. In all cases, the extent of contamination is only discussed for those chemicals that were detected at greater than 5% frequency; in some cases, this list is further screened using existing health-based action levels or for other reasons discussed below that suggest that the chemical is not a significant contamination threat. The intent is to focus only on those chemicals that will be determining factors in selecting and specifying the site remediation, which is discussed in the Feasibility Study.

4.1 Source Areas

Historical sources of contamination at the site have all been removed with the closure of the site in the late 1980s. Based on the facility operations history (see section 1.2.2) the primary historical source areas are the tank area in the center of the site, the wash pad and sump area just south of the tanks, the dinoseb storage area where a spill occurred (along the east fence line), the waste pond, and the area between the pond and the large storage tank (see Figure 1.3). Of these areas, all have shown significant levels of contamination in the surface and/or subsurface soils except for the tank area in the center of the site.

These historical source areas have in the past served as points for potential direct exposure to contamination and sources of groundwater contamination. Despite clean-up actions taken to date (see section 1), contamination remains within the vadose zone and continues to pose a potential threat to groundwater quality, and contamination remains in the surface soil and poses potential risks from direct exposure. In addition to these soil source areas, the A-zone groundwater is highly contaminated and appears to be the most significant and largest reservoir of remaining contamination in any portion of the site. The A-zone groundwater contamination as well as the soils contamination are described and discussed in detail in the sections below.

Aside from the above more significant source areas for site contamination, contamination is also found distributed over much of the site at lower concentrations.

4.2 Surface Soil Contamination

To examine the nature and extent of contamination in surface soils, data was compiled from fifty surface soil samples and 191 sample analyses (see section 2 and Figure 2.3). (For the purpose of identifying chemicals of potential concern in surface soils, only the results of the surface soil samples collected with a trowel from the top one foot were used. To determine the extent of contamination for the chemicals of potential concern, soil boring data from the surface were also used. A total of seven organic compounds were detected in surface soils during the RI/FS, including three volatile organic compounds, three semivolatile organic compounds, and dinoseb (all hits in surface soil samples are included in Appendix F). The chemicals are listed in Table 4.1; for each chemical the total number of hits, the frequency of detection, and the highest result detected are also presented. Of the seven organic chemicals detected, four chemicals were detected at a greater than 5% frequency, and of these four chemicals, only dinoseb is a chemical of concern for risk assessment (see section 6.1). The extent of dinoseb contamination is discussed below in section 4.2.1.

Based on historical data for the chemicals used at B&B, metals have not been considered a likely contamination threat, and this was found to be true with respect to surface soils. During the RI/FS, a total of nineteen samples were analyzed for a routine list of hazardous and nonhazardous metals. Table 4.2 summarizes the results of these analyses. The table includes a list of all metals detected in subsurface soils, and, for each metal detected, the highest and average concentrations and the frequency of detection are also presented. Average concentrations are provided for both on-site samples and background samples (two background samples were collected from location SS06). No significant differences were observed between the background and on-site averages; the difference between the two averages is always less than an order of magnitude and in many cases the differences are significantly smaller. In fact, the background average is frequently higher than the on-site average. Based on this data, no further evaluation of the metals results in surface soils is provided.

4.2.1 Extent of Dinoseb Contamination in Surface Soils

Dinoseb is found throughout the site and is more widely distributed in soil than any other site contaminant. Dinoseb was detected in thirty surface soil samples and eighteen soil boring samples taken from the surface. Table 4.3 lists all the results for surface soil and soil boring samples for dinoseb within the

top one foot of soil, and Figure 4.1 includes all these locations. A total of twenty-one samples from the top one foot were non-detect for dinoseb, and the detection frequency for dinoseb in surface soil samples was 70%.

A health-based clean-up level for dinoseb in surface soils has been established at 80 mg/kg (see the FS Report). Eight surface soil sample locations had detected dinoseb concentrations greater than 80 mg/kg. The eight sample locations are surface soil samples 23, 105, 106, 110, 411, and soil boring locations C, U and X (see Figure 4.1). From these samples, four areas for potential clean-up are identified: the dinoseb spill area along the east fence line (which had the highest dinoseb concentration on-site of 7,400 mg/kg), the northeast corner of the site, a second location along the east fence line (at location 105), and an area to the east of the large storage tank (at location 110). To further identify areas for potential clean-up, Figure 4.1 also identifies the locations of eight other samples with concentrations of dinoseb between 8 mg/kg and 80 mg/kg. These samples are in the same general locations as the samples with results above 80 mg/kg.

Based on the data collected, it is difficult to determine the exact extent of each area exceeding the clean-up level. Table 4.3 segregates the dinoseb results for each of the four areas identified above and includes the average and standard deviation for the results from three of these areas and for the site overall. In general it appears that there are isolated hot spots with concentrations in excess of 80 mg/kg. In three of the four areas with concentrations in excess of 80 mg/kg, only one sample in each area had concentrations above this level. In the dinoseb spill area, five locations were above 80 mg/kg.

The extent of dinoseb contamination from 1 to 7 feet bgs was also investigated. Seven feet is the extent of a possible construction zone and is based on sewer line data from the City of Arvin. The risk from construction worker exposure to contamination in this zone was evaluated in section 6. Dinoseb was the only contaminant of concern in this depth interval, and only two samples from one soil boring location were detected at concentrations of dinoseb greater than 80 mg/kg. These samples were from soil boring C at 2 feet bgs (4,300 mg/kg) and 5 feet bgs (5,800 mg/kg). Soil boring C is located in the dinoseb spill area.

4.3 Subsurface Soil Contamination

To examine the nature and extent of contamination in the subsurface soils, data was compiled from fifty-seven soil borings and 2107 sample analyses (see section 2). Appendix F includes a listing of all the detected concentrations of chemicals found in each soil boring. Discussed below in section 4.3.1 is the

nature of contaminants in the subsurface. This section summarizes the chemicals that have been detected during the RI/FS to arrive at a list of chemicals that have been detected most frequently at the site and which appear to pose the most significant contaminant threat. The extent and distribution of these chemicals are then discussed in section 4.3.2. That section primarily focuses on those chemicals which, due to their presence in subsurface soils, may travel through the vadose zone into the A-zone groundwater and eventually pose a potential contamination threat to the B-zone groundwater. Unlike the A-zone groundwater, the B-zone groundwater is a potential drinking water source, though it is currently not being used for drinking water (see discussion in FS Report).

4.3.1 The Nature of Contamination in Subsurface Soils

The total number of different organic chemicals detected in subsurface soils during the RI/FS include nineteen volatile organic compounds, seventeen semivolatile organic compounds, five herbicides, and eleven organochlorine pesticides. (These totals do not include compounds which were tentatively identified from GC/MS analyses.) No organophosphorus, carbamate or urea pesticides were detected in any soil samples. The chemicals are listed in Table 4.4; for each chemical the total number of hits, the frequency of detection, and the highest result detected are presented. Of the fifty-two organic chemicals detected, twelve chemicals were detected at greater than 5% frequency. Of these twelve, four chemicals were never detected in groundwater; these are carbon disulfide, bis(2-ethylhexyl)phthalate, heptachlor, and 4,4'-DDE. Because these chemicals have not been found in either the A- or B-zone groundwaters despite their presence in soils for some years, it is apparent that their low concentration and relative immobility pose no potential threat to the B-zone groundwater. The eight remaining organic chemicals are discussed in more detail in the next section.

As mentioned above, metals have not been considered a likely contaminant threat at B&B, and with respect to the subsurface soils, this was found to be true. During the RI/FS, a total of 126 samples were analyzed for a routine list of hazardous and nonhazardous metals. Table 4.5 summarizes the results of these analyses. The table includes a list of all metals detected in subsurface soils, and for each metal detected, the highest and average concentrations and the frequency of detection are also presented. Average concentrations are provided for both on-site samples and background samples. (Soil borings SB406 and SB00 provided background data.) The results are similar to what was observed for surface soils. No significant differences were observed between the background and on-site averages; the differences between the two averages is always less than an order of magnitude and in many cases the differences are significantly smaller. Again, as in the surface soils, many of the background

averages are higher than the on-site averages. It was also noted that many of the highest detected results were in background samples. Based on this data, no further evaluation of the metals results in subsurface soils is provided.

4.3.2 The Extent of Contamination in Subsurface Soils

Identified in the previous section were eight organic chemicals which were detected at the greatest frequencies in subsurface soils and which may also pose a contamination threat to the B-zone groundwater. The extent of these contaminants are discussed below.

Toluene, though relatively common at the site, was not detected at particularly high concentrations. Of the seventy-one detected concentrations of toluene in subsurface soils, all but two were below 100 ug/kg. The highest result was 910 ug/kg, and the next highest result was 120 ug/kg. Both of these results were from the E&E-TAT soil boring I (Figure 4.2). Toluene was also never found above drinking water maximum contaminant levels (MCLs) in either the A- or B-zone groundwaters. However, it was one of only eight volatile organic compounds detected in the B-zone groundwater, and it appears to have migrated consistently deeper in soils than many of the other contaminants. Eight detected concentrations of toluene were found in the B-zone soils, including a sample result of 120 ug/kg from 90 feet below ground surface (bgs). Only three other chemicals were found at greater frequencies in the B-zone soils (1,2-DCP, 1,2,3-TCP, and DBCP).

Dichloroprop was also not found at particularly high concentrations in the subsurface soils. The highest result was 170 ug/kg, and twelve out of the fourteen detected concentrations were below 100 ug/kg. In the A-zone groundwater the highest detected result was 8 ug/l. While the chemical was not detected in significantly high levels in either soil or groundwater, it was found to be widely distributed throughout the site. It was detected at least once in the following soil borings: SB-403, 407, 408, 410, 411, 416, 417, 418, 423, and 424 (Figure 2.4).

The remaining six chemicals detected at high frequencies in subsurface soils are also detected in relatively high concentrations in the A-zone groundwater. These chemicals and chloroform were the contaminants focused on during the emergency response investigation. Tables 4.6 (for dinoseb) and 4.7a-g (for VOCs) list all the detected concentrations for each of the six chemical, from highest to lowest detected concentration, for eight depth intervals from the surface to the 150 feet bgs. Appendix G lists the results (detected and nondetected) for each of the six chemicals for each soil boring.

The extent of contamination from these six chemicals is discussed in detail below. This discussion will focus on three source areas where contamination was found at the highest concentrations and to the greatest areal extent. These areas are the dinoseb spill area, the sump and wash pad area, and the pond and area between the pond and the storage tank. The pond and the area adjacent to the pond were combined into one large source area because this entire area is subject to the ponding of rain water during the winter. Figure 4.2 delineates each area and the soil borings contained in each area. In the discussions below, average concentrations for the six chemicals of potential concern were calculated for one or more of these areas at discrete depth intervals.

The concentrations detected for the six chemicals are also compared below against multiples of the MCL for a relative measure of the potential significance of contamination in soils. The concentrations in soil were compared to drinking water MCLs. A-zone soil concentrations were compared to 100 times the MCL and B-zone soil concentrations were compared to 10 times MCL. While MCLs are concentrations in water, they provide a simple bench mark for comparing concentrations over the site in soil, and they provide a relative measure for comparing concentrations in soil for different chemicals. The purpose here in using the MCL is to establish a method for identifying the principal source areas on-site and to compare concentrations over the site and at depth; these levels are not intended as clean-up levels. In section 5, the vadose zone modeling provides a prediction of the impact to groundwater that may occur due to soil contamination in the vadose zone. The multipliers added to the MCL are intended to take into account attenuation factors that come into play when accessing the impact that soil contamination will have on groundwater; in this context they are only being used to screen out areas for further analysis with vadose zone modeling.

4.3.2.1 The Extent of Dinoseb Contamination in Subsurface Soils

Dinoseb concentrations in the subsurface soil were compared to 700 ug/kg (100 times MCL) for the A-zone soils and to 70 ug/kg (10 times MCL) for the B-zone soils.

A total of sixty-eight soil samples collected below 1 foot depth in the A-zone were detected at concentrations equal to or greater than 700 ug/kg. Of these, forty-four samples were located within the dinoseb spill area, fourteen samples were located in the pond and adjacent area, five samples were located in the sump and wash pad area, and five more samples were scattered both on and off site. Only six of the sixty-eight samples were detected at greater than 40 feet bgs. In the B-zone there was one sample, collected from boring DD at 100 feet bgs, which was detected at concentrations greater than or equal to 70 ug/kg; the concentration in this sample was 1300 ug/kg.

A summary of dinoseb concentration distributions within the three source areas is presented in Table 4.8. Figures 4.3a and 4.3b present the distribution of dinoseb contamination in separate maps, one for 1-20 feet and another for 21-40 feet; a map is not provided for below 40 feet because of the low frequency of detected concentrations above the screening concentration. As expected, dinoseb concentrations are significantly higher in the dinoseb spill area. In this area the concentrations are highest at and near the surface and decrease with depth, especially after 30 feet bgs. However, with only two samples taken in the 31 to 40 foot interval, this interval is not well characterized.

In the other two source areas, the dinoseb concentrations are significantly less than those in the dinoseb spill area. Concentrations in the sump and wash pad area are the lowest of the three source areas. In the pond and adjacent area, concentrations of dinoseb are highest between 21 and 40 feet bgs.

4.3.2.2 The Extent of Volatile Organic Contamination in Subsurface Soils

The extent of the five most commonly detected volatile organic compounds in subsurface soil are discussed in detail here. Of these five chemicals, the most commonly detected compound is 1,2-dichloropropane (34% detection frequency), followed by 1,2,3-trichloropropane (24% detection frequency), dibromochloropropane (15% detection frequency), 1,3-dichloropropane (15% detection frequency), and ethylene dibromide (9% detection frequency).

To evaluate the potential impact of contamination from different portions of the site and to identify areas on-site with the greatest potential to impact groundwater, the concentrations in soil were compared to 100 times health based levels for drinking water (usually the MCL) for A-zone soils and 10 times health based levels for B-zone soils (see the discussion in section 4.3.2 for the rationale in using this screening approach). The health based levels are listed below; since there is no health based levels for 1,3-dichloropropane (1,3-DCP), a cut off of 1000 ug/kg in A-zone soil and 100 ug/kg in B-zone soil was used to identify areas where this chemical is in highest concentration.

Target Concentrations for Assessing Relative Impacts

Chemical	Health Level (HL)	100x HL	10x HL
1,2-dichloropropane (1,2-DCP)	5 ug/l ¹	500 ug/kg	50 ug/kg
1,2,3-trichloropropane (TCP)	40 ug/l ²	4000 ug/kg	400 ug/kg
dibromochloropropane (DBCP)	0.2 ug/l ¹	20 ug/kg	2 ug/kg
ethylene dibromide (EDB)	0.05 ug/l ¹	5 ug/kg	0.5 ug/kg
1,3-dichloropropane (1,3-DCP)	none	1000 ug/kg ³	100 ug/kg ³
¹ EPA MCL ² Lifetime Health Advisory Level ³ Not Health Based Levels (see text)			

For each of these compounds, the following number of samples were detected in A-zone soils at 100 times the health based levels or greater and in the B-zone at 10 times health based levels or greater.

Number of Samples Exceeding Target Concentrations

Chemical	No. of Samples >100x HL in A-Zone Soil	No. of Samples ≥10x HL in B-Zone Soil
1,2-DCP	103	31
1,3-DCP	4	0
TCP	14	4
DBCP	82	21
EDB	63	2

Of the two hundred and sixty-six results from the A-zone that were greater than or equal to the target levels indicated above, 59% were from the sump and wash pad area and half of these were from a single borehole, soil boring I. Thirty percent of the results for the A-zone were from the pond and adjacent area, and 11% were from other portions of the site. The other boreholes with concentrations greater than or equal to the target levels were soil borings 402, C, E, O, P, U, V, X, and NN. Only one to three results were from each of these bore holes, except for soil boring E.

In the B-zone, fifty-eight results were greater than or equal to the target levels. The locations of these concentrations generally correspond to the location of higher concentrations in the A-zone groundwater. Most of these results were located downgradient from the sump and pond areas.

Figures 4.4 - 4.6 present distribution for 1,2-DCP, EDB, and DBCP in separate maps, one for 0-30 feet and another for 31-65 feet for each chemical. The figures present the highest concentrations for each depth interval. On the figures, the symbol "o" denotes a concentration from 100 to 1,000 times MCL, "♦" denotes a concentration from 1,000 to 10,000 times MCL, and "*" denotes concentrations greater than 10,000 times the MCL. In general the pattern of distribution of results within these concentration ranges is not significantly different for the three chemicals. Nearly all of the samples are located in either the sump or pond areas. The pattern of distribution for each chemical is also not markedly different between the two depth intervals.

A more detailed summary of concentration distributions within the sump and wash pad area and within the pond and adjacent area is presented in Tables 4.9 and 4.10, respectively. These tables show a more distinct pattern of contaminant distribution than the figures. In general, the concentrations of volatile contaminants in the sump and wash pad area are significantly higher than in the pond and adjacent area. Especially high concentrations were observed in the sump and wash pad area at the 21 to 30 foot depth interval. Average concentration were frequently greater than the target levels throughout much of the A-zone soil profile in the sump and wash pad area. However, it does not appear that 1,3-DCP is a significant contamination problem anywhere at the site. It should also be noted that for the sump and wash pad area, there were generally very few samples taken below 65 feet.

In the pond and adjacent area, concentrations reached their peaks at deeper depths, usually in the depth interval just above the A-zone groundwater. This supports other data indicating that contaminant transport may have been faster in this portion of the site. Average concentrations were also frequently greater than the target levels, especially for EDB and DBCP.

4.4 Groundwater Contamination

To examine the nature and extent of contamination in groundwater, data was compiled from eighteen A-zone wells, seven B-zone wells, and two drinking water wells, and from 859 sample analyses (see section 2). Appendix H includes a listing of all the detected concentrations of chemicals found in each well. Discussed below in separate sections is the nature and extent of groundwater contamination for each groundwater unit sampled

during the RI/FS. Also presented are the results of water quality analyses, including the concentrations of major cations and anions in each well. The results for the B-zone are not intended to provide conclusive data on the extent of contamination in this zone due to the inadequate number of wells. The second operable unit RI/FS is intended to accomplish this objective.

As in the case of the soils contamination, the results are evaluated based on the frequency of detection and a comparison of concentrations to health-based standards. Whenever available, a current or proposed EPA MCL was used for this comparison. In the absence of an EPA MCL, a California MCL was used or the most conservative health advisory level was used, which was generally the lifetime chronic exposure level; MCLs are rarely established at levels below the lifetime chronic exposure levels.

4.4.1 A-Zone Groundwater Contamination

4.4.1.1 The Nature of Contamination in the A-Zone

A total of fifty-two different organic chemicals (excluding tentatively identified compounds) were detected in the A-zone groundwater during the six groundwater sampling rounds conducted during the RI/FS. These chemicals included twenty-two volatile organic compounds, twelve semivolatile organic compounds, six herbicides, and twelve carbamate and urea pesticides; no organophosphorus pesticides, organochlorine pesticides or PCBs were detected. The chemicals are listed in Table 4.11; for each chemical, the total number of hits, the frequency of detection, the highest result detected, and, if available, the drinking water MCL (or other health based levels) is presented. Of the fifty-two organic chemicals detected, thirty-nine were detected at greater than 5% frequency. Of these, fifteen chemicals were also detected at least once at levels above the MCL or other health-based level listed, and twenty-four chemicals did not have health-based levels available for comparison. The extent of contamination from these fifteen chemicals is discussed in the following section. Of the twenty-four chemicals without health-based levels, 1,3-dichloropropane is also discussed in more detail below because it is a very commonly detected compound in A-zone groundwater.

4.4.1.2 The Extent of Contamination in the A-Zone

In the previous section, fifteen organic chemicals were identified as having been detected at greater than 5% frequency and as having been detected at least once at concentrations greater than published health-based levels for drinking water. Among these chemicals, six stand out as being the most commonly detected chemicals and also occurring at relatively high concentrations: dinoseb, 1,2-DCP, TCP, EDB, DBCP and chloroform.

The results for these chemicals are presented in Table 4.12; this table also includes the average concentration and the maximum and minimum concentration detected for each chemical at each A-zone well (for the newest wells only the average concentration is presented because of the small data set). These six chemicals are discussed in more detail later in this section.

The remaining nine organic compounds were detected either less frequently or less often above health-based levels. The results for these chemicals and for 1,3-DCP are discussed below. Appendix H includes all of the detected concentrations for these chemicals.

1,1,2-Trichloroethane was detected in six wells: AMW-1P, AMW-2P, EPAS-2, EPAS-3, WA-6 and WA-7. All of the detected concentrations were near the EPA MCL of 5 ug/l except in well EPAS-3, where the concentrations ranged from 15 ug/l to 24 ug/l.

1,1-Dichloroethane was detected in seven wells: AMW-1P, AMW-2P, AP-4, EPAS-2, EPAS-3, WA-6 and WA-7. The detected results were generally below the California MCL of 5 ug/l in all wells except for AMW-2P, WA-6 and WA-7. All results are less than an order of magnitude above the State MCL (the highest result detected was 36 ug/l in well WA-6).

Benzene was detected in the same seven wells as was 1,1-Dichloroethane. The detected results were below the EPA MCL in wells AMW-1P, AP-4, and EPAS-2P and above the MCL in wells AMW-2P, EPAS-3, WA-6 and WA-7. All except two results were less than an order of magnitude above the EPA MCL of 5 ug/l; the exceptions were in wells EPAS-3 (52 ug/l) and WA-6 (62 ug/l).

Methylene chloride was detected in the same seven wells above plus well WA-2. All detected results were between 9 ug/l and 1 ug/l in each well except for wells AMW-2P and WA-6. The concentrations in well AMW-2P ranged from 23 ug/l to 50 ug/l, and the two concentrations detected in well WA-6 were 53 ug/l and 44 ug/l. The EPA MCL is 5 ug/l.

Pentachlorophenol (PCP) was detected in wells AMW-1P, AMW-2P, and EPAS-3. No analyses for PCP have been performed on the new wells. The detected results range from 3 ug/l to 12 ug/l. The EPA MCL is 1 ug/l.

1,3-DCP was detected in the following seven A-zone wells: AMW-1P, AMW-2P, AP-4, EPAS-2, EPAS-3, WA-6, and WA-7. Average concentrations were below 100 ug/l in all wells except AMW-1P (avg = 514 ug/l) and EPAS-3 (avg = 196 ug/l). The results for 1,3-DCP are also included in Table 4.12.

Two carbamate pesticides (carbofuran, and diuron) were detected at greater than 5% frequency and above health-based

drinking water standards. Carbofuran was only detected in one round of sampling (Jan, 1991). In that round it was detected in seven wells, and the highest concentration was 147 ug/l in well AMW-1P. The EPA MCL is 40 ug/l. Diuron was detected in three wells (AMW-1P, AMW-2P, and EPAS-3). Two results were above the lifetime non-cancer health advisory of 10 ug/l: one in well AMW-1P (100 ug/l) and one in well AMW-2P (30 ug/l) (a duplicate sample result of 21 ug/l was also reported).

The remaining six compounds identified above are discussed in more detail below (see also Table 4.12). All of these chemicals were detected at concentrations greater than an order of magnitude above the health-based drinking water levels, and four chemicals (dinoseb, 1,2-DCP, EDB and DBCP) were detected at concentrations greater than three orders of magnitude above the health-based levels.

Chloroform

Chloroform was detected in twelve of the eighteen A-zone wells; it was never detected in wells AP-1, EPAS-4, WA-1, WA-4, WA-5 and WA-8. Average concentrations were above the MCL of 100 ug/l in four wells: AMW-2P (avg = 822 ug/l), WA-2 (avg = 293 ug/l), WA-6 (avg = 1,005 ug/l), and WA-7 (avg = 185 ug/l). Concentrations in well AMW-2P have declined from approximately 1,000 ug/l to 500 ug/l over the 18 month sampling period, while the concentrations have generally been consistent over time in all other wells.

1,2,3-Trichloropropane (TCP)

TCP was detected in twelve of the eighteen A-zone wells; it was never detected in wells AP-1, EPAS-4, WA-1, WA-4, WA-5 and WA-9. Average concentrations were above the non-cancer lifetime health advisory level of 40 ug/l in the following seven wells: AMW-1P (avg = 8,057 ug/l), AMW-2P (avg = 2,980 ug/l), AP-4 (avg = 464 ug/l), EPAS-2 (avg = 513 ug/l), EPAS-3 (avg = 2,340 ug/l), WA-6 (avg = 2,500 ug/l), and WA-7 (avg = 590 ug/l). Concentrations have remained fairly consistent over the 18 month sampling period in all wells except for in well AMW-2P where concentrations have declined over time from 3,600 ug/l to 1,700 ug/l.

While not presented in a figure, the distribution of contamination from TCP in the A-zone is similar to DBCP and 1,2-DCP (see Figures 4.8 & 4.9).

Dinoseb

Dinoseb was the most commonly detected chemical in soils at B&B. In the A-zone groundwater, it was detected in all A-zone wells except for wells WA-3, WA-4, WA-5, WA-8, and WA-9. Average

concentrations equaled or exceeded the MCL of 7 ug/l in the following nine wells: AMW-1P (avg = 22,607 ug/l), AMW-2P (avg = 168 ug/l), AP-1 (avg = 11 ug/l), AP-2 (avg = 62 ug/l), AP-3 (avg = 37 ug/l), EPAS-2 (avg = 558 ug/l), EPAS-3 (avg = 759 ug/l), WA-6 (avg = 390 ug/l), and WA-7 (avg = 7 ug/l).

Three anomalies were observed among the data and may have been the result of a laboratory or field error that could not be detected during data validation. These anomalies were the unusually high result for the April 1991 sample for well AP-2 (310 ug/l), the high result from December 1991 for well AP-3 (230 ug/l), and the non-detected result for the January 1991 sample for well EPAS-2. Without these results the average concentration in well AP-2 would be below the MCL, the average concentration in well AP-3 would be equal to the MCL, and the average concentration in well EPAS-2 would be slightly higher. Dinoseb was also detected once in the background well at a concentration of 0.2 ug/l (J). This concentration was below the quantitation limit and may also have been an anomaly.

In wells AMW-1P, AMW-2P, EPAS-2 and EPAS-3 an overall increase was observed in dinoseb concentrations over the 18 month sampling period, though up and down fluctuations were observed from one sampling round to another. In each of these wells the concentration at least doubled over the 18 month sampling period (see Figure 4.10a).

Figure 4.7 shows the extent of contamination from dinoseb in the A-zone groundwater for average concentrations from 1992 sampling rounds. The outer line represents 70 ug/l, or ten times the MCL, and the second contour is 700 ug/l. The highest concentrations correlate with the source areas identified above and the direction of contaminant migration is generally consistent with the direction of groundwater flow.

1,2-Dichloropropane (1,2-DCP)

1,2-DCP was the most widely detected compound in the A-zone groundwater. It was detected in all but two A-zone wells (AP-1 and WA-2). Average concentrations equaled or exceeded the MCL of 5 ug/l in thirteen of these wells: AMW-1P (avg = 22,828 ug/l), AMW-2P (avg = 72,600 ug/l), AP-2 (avg = 12 ug/l), AP-3 (39 ug/l), AP-4 (avg = 10,380 ug/l), EPAS-2 (avg = 6,067 ug/l), EPAS-3 (avg = 35,200 ug/l), WA-1 (avg = 6 ug/l), WA-3 (avg = 40 ug/l), WA-4 (only sample = 5 ug/l), WA-6 (avg = 95,500 ug/l), WA-7 (avg = 28,000 ug/l), and WA-9 (20 ug/l). Concentrations remained generally consistent over time in each well, with slight increases or decreases observed over time in some wells; in particular a decline was noted in well AMW-2P, which also consistently had the highest results (see Figure 4.10a). In the last two sampling rounds, 1,2-DCP was detected at near the detection limit in the background well EPAS-4. This well will be

monitored over time to determine whether these are anomalous values or whether there is in fact low levels of 1,2-DCP up gradient from the site.

Figure 4.8 shows the extent of contamination from 1,2-DCP in the A-zone groundwater for 1992. The outer line represents 50 ug/l, or ten times the MCL. The approximate area within the ten times MCL estimated boundary is 5.6 acres. The other three contour lines are for 500 ug/l, 5,000 ug/l and 50,000 ug/l. As in the case of the dinoseb contamination, the concentration distribution is consistent with the source areas identified, and the direction of contaminant migration is generally consistent with the direction of groundwater flow. The significantly high concentrations observed in well EPAS-3 as compared with well EPAS-2 may be related to the closer proximity of well EPAS-3 to the pond, or it may also reflect localized differences in groundwater flow patterns.

Ethylene dibromide (EDB)

EDB was detected in the following seven A-zone wells, all above the MCL of 0.05 ug/l: AMW-1P (avg = 931 ug/l), AMW-2P (avg = 8 ug/l), AP-3 (avg = 2 ug/l), AP-4 (avg = 0.49 ug/l), EPAS-2 (avg = 36 ug/l), EPAS-3 (avg = 33 ug/l), and WA-6 (avg = 8 ug/l). Concentrations in well AMW-1P have been consistently higher than in any other well; however, these concentrations have also steadily declined over the 18 month sampling period from an initial high of 1,300 ug/l in the first two sampling rounds to a low of 330 ug/l in the last sampling round (see Figure 4.10b). In other wells the concentrations have been generally consistent over time, except for a general increase at well EPAS-2. The only anomaly observed in the data was the result of 67 ug/l in April 1991 for well AMW-2P; this result is thirty times higher than any other result measured in this well.

The distribution of EDB contamination is not presented in a figure; however, a review of the data shows that EDB contamination is more localized as compared with the other contaminants discussed here. Most of the elevated concentrations were found near the pond at wells AMW-1P, EPAS-2 and EPAS-3, and unlike the other key contaminants, the concentrations observed near the sump in wells AMW-2P and WA-6 were fairly low.

Dibromochloropropane (DBCP)

DBCP was detected in the following eleven wells: AMW-1P, AMW-2P, AP-1, AP-2, AP-3, AP-4, EPAS-2, EPAS-3, WA-1, WA-6, and WA-7. Average concentrations exceeded the MCL of 0.2 ug/l in eight of these wells: AMW-1P (avg = 241 ug/l), AMW-2P (avg = 344 ug/l), AP-3 (avg = 12 ug/l), AP-4 (avg = 28 ug/l), EPAS-2 (avg = 73 ug/l), EPAS-3 (avg = 4,560 ug/l), WA-6 (avg = 165 ug/l), and WA-7 (avg = 31 ug/l). The concentrations detected in well EPAS-

3 have always been significantly higher than concentrations in any other well by more than an order of magnitude difference. Over time concentrations have declined somewhat in wells AMW-1P and AMW-2P, especially in well AMW-2P, while concentrations have stayed the same or increased slightly in the other wells (see Figure 4.10b). No unusual anomalies were observed in the data.

Figure 4.9 shows the extent of contamination from DBCP in the A-zone groundwater for 1992. The outer line represents 2 ug/l (or 10 times MCL) and each line towards the center of the contamination is a ten fold increase from the previous contour, up to 2,000 ug/l. The distribution of contamination is similar to the distribution for 1,2-DCP, except that the highest concentrations are just below the pond around well EPAS-3 instead near the sump.

General Trends

Organic contamination at the site consistently occurs at significant concentrations in the following seven wells: AMW-1P, AMW-2P, AP-4, EPAS-2, EPAS-3, WA-6 and WA-7. AMW-1P had the highest average concentrations for four of the seven chemicals discussed above (dinoseb, EDB, TCP, and 1,3-DCP). WA-6, with only two sampling rounds, had the highest average concentration for 1,2-DCP and chloroform. EPAS-3 had the highest average concentration for DBCP. AMW-2P had the second highest average concentration for chloroform, 1,2-DCP, TCP, and DBCP. EPAS-2P also consistently showed high concentrations as did wells AP-4 and WA-7, though less so than any of the other wells.

In well AMW-2P the concentrations of the six volatiles discussed above all decreased over the sampling period (see Figure 4.11a). This might be expected since this well is located near the center of the former sump, which appears to be the furthest up-gradient significant source area for volatile organic compounds. Dinoseb concentrations, on the other hand, have generally increased in well AMW-2P; this may be related to an increasing influence of contamination moving from the dinoseb spill area, which is somewhat up-gradient from this well.

Concentrations of volatile contaminants have also declined somewhat in well AMW-1P over the sampling period, while dinoseb concentrations have increased. No other similar trends have been observed in other wells. As the plume advances, concentrations are likely to rise in periphery wells such as WA-7 and WA-9.

4.4.1.3 Results of Metals and Water Quality Analyses for A-Zone Groundwater

Table 4.13 and Table 4.14 includes a summary of the results of metals analyses and water quality parameters, respectively. Table 4.13 includes the result and location of the highest

detected concentration for each metal analyzed. These results are compared to health-based action levels for drinking water and to the average concentration in background well EPAS-4.

As discussed previously in this section, metals contamination at B&B has not been suspected as a concern at B&B, and in the soils there were no concentrations detected at levels significantly above those found in background samples. In the A-zone groundwater, the highest results exceeded health-based levels for aluminum, antimony, arsenic, beryllium, cadmium, chromium, nickel, selenium, and vanadium. All of these metals, except for antimony, exhibit patterns of contamination that suggest that the contamination is probably not site related. The following observations, in addition to the observations made from soil samples, have been made to support this conclusion:

Concentrations of beryllium, cadmium, and selenium were found at or above health-based levels in three or fewer samples out of a total of 60 samples.

Concentrations of chromium consistently exceed the MCL in well AP-1 and background well EPAS-4; however, the average concentration in AP-1 (avg=308 ug/l) was less than the background average (538 ug/l).

High levels of aluminum are expected in the A-zone groundwater due to the presence of suspended sediment in the samples which would be expected to contain aluminum silicate.

High levels of arsenic were only observed in a single well, AMW-2P (avg=425 ug/l).

Average nickel concentration was observed to exceed the MCL in five wells (AMW-1P, WA-2, WA-4, WA-7 and WA-8); of these, the averages for all except wells WA-8 and WA-7 were less than twice the background average of 87 ug/l, and the averages for wells WA-7 and WA-8 were less than three times background.

Average vanadium concentration was less than twice the background average for all wells except for well AMW-2P (avg=120 ug/l), which was less than three times background.

Concentrations of antimony above the MCL were more widely distributed than any of the nine metals. Detected concentrations exceeded the MCL of 6 ug/l in ten wells (AP-1, AP-2, AP-3, AP-4, AMW-1P, AMW-2P, EPAS-2, EPAS-3, WA-6 and WA-7); however, the analytical detection level also exceeded the MCL. In the absence of any clear soils contamination from antimony and without a historical connection to the processes at the site, it is concluded that these concentrations are probably related to

natural conditions.

While it is not concluded here that B&B activities directly resulted in contamination from metals, it is possible that site conditions increased the solubility of certain metals. It is also possible that these metals may complicate some of the treatment and disposal options for the site. These factors may require additional evaluation.

The water quality data included in Table 4.14 includes the average concentrations for major cations and anions sampled from groundwater wells as well as averages for pH and total dissolved solids (TDS); cation and anion average concentrations are also presented in milliequivalents per liter for comparison between the different cations and anions. Overall, the dominant cation is calcium and the dominant anion is bicarbonate; common exceptions to this are sodium and chloride as dominant cation and anion, respectively. The overall average TDS for the A-zone wells is 2230 mg/l.

AMW-1P exhibits a unique cation/anion distribution with sulfate and nitrate as dominant anions and calcium and magnesium as the dominant cations. This well also showed the highest concentrations of dissolved salts of any well; the TDS is approximately twice the average concentration of the next highest well. The high concentrations of nitrate are probably related to the fertilizer operations at the site and the disposal of waste water from these operations to the pond.

A general pattern that can be observed is that the anion and cation concentrations are highest at wells that exhibit the highest levels of groundwater contamination. This is likely the result of increased solubility of these salts as a result of the presence of site contamination. This observation also supports the conclusion that increased metals concentrations in some wells are the result of the influence of site contamination on the solubility of the metals. As a weak acid, dinoseb may contribute to increasing the solubility of some metals and salts. The five wells with the highest cation and anion concentrations are (in order from the highest) AMW-1P, WA-6, EPAS-3, AMW-2P, and WA-7.

4.4.2 B-Zone Groundwater Contamination

A total of eleven different organic chemicals have been detected in the B-zone groundwater during the six groundwater sampling rounds conducted for the RI/FS. These chemicals include nine volatile organic compounds, one semivolatile organic compound (butylbenzylphthalate), and dinoseb. All of the detected results for these chemicals are presented in Table 4.15. These chemicals include the six chemicals identified as being most common and at highest concentrations in the A-zone groundwater. All of the other chemicals are also relatively common in the A-zone groundwater except for butylbenzylphthalate,

which was only detected once in any groundwater sample. Five of the eleven chemicals were detected at least once at concentrations equal to or greater than the health-based drinking water levels (TCP, 1,2-DCP, DBCP, EDB, and dinoseb).

In evaluating the results from B-zone wells, it is important to take into account the differences between the newer wells (all "WB" wells) and the older wells installed prior to the RI/FS. As discussed in section 3.5.3, it appears that wells AMW-3R and AMW-4R were screened over more than one B-zone water bearing unit, and the screened interval for well AR-01 is unknown. All of the "WB" wells were screened in water bearing unit B-2. As a result of these differences, the concentrations in the "WB" wells cannot be directly compared with those in the older wells. It is expected that concentrations in at least the two deeper, older wells could possibly be diluted as a result of cleaner water bearing units mixing with more contaminated water bearing units.

1,2-DCP was detected at least once in each of the seven B-zone wells. Concentrations equal to or greater than the MCL were detected in four out of the seven wells; the highest concentration detected in the B-zone (1,700 ug/l in well WB2-1) is more than 300 times higher than the MCL. Average concentrations were above the MCL of 5 ug/l in well WB2-1 (avg = 1,365 ug/l), WB2-2 (avg = 43 ug/l), and AR-01 (avg = 8 ug/l). The concentrations detected in well AMW-4R were equal to or greater than the MCL in two sampling rounds (December 1991 and July 1992); however, the average concentration was less than the MCL (avg = 3 ug/l). 1,2-DCP was detected once (0.3 ug/l), at near the detection limit, in the furthest down-gradient off-site well, WB-2-4. This well is significant because it is intended to serve as an early detection well for contamination that may enter City Well 1. At 0.3 ug/l, the concentrations in the B-zone would not significantly impact the City Well because this concentration is below the MCL and because any B-zone groundwater entering City Well 1 would be diluted significantly by the volume of water in City Well 1. Monitoring of all B&B wells and City Well 1 will continue for the foreseeable future at a semiannual frequency.

The only other volatile chemical detected above MCLs was DBCP. DBCP was detected in only two wells. Average concentrations in these wells were 29 ug/l and 7 ug/l for wells WB2-1 and WB2-2, respectively; the MCL is 0.2 ug/l.

Dinoseb was the only other organic chemical detected above MCLs. Dinoseb was detected in only two wells, WB2-1 and WB2-2, and only once at concentrations above the MCL of 7 ug/l (8 ug/l in well WB2-2).

An analysis of the extent of contamination in the B-zone is not provided in this report. The second RI will address this concern.

4.4.2.1 Results of Metals and Water Quality Analyses for B-Zone Groundwater

From Table 4.13, only two metals, antimony and vanadium, were ever detected in the B-zone at concentrations above the health-based levels. Vanadium was detected twice in well WB2-2 at concentrations above the health-based level and antimony was detected twice in wells WB2-2 and AR-1 and once in AMW-3R and AMW-4R at concentrations above the MCL. For the reasons discussed above for the A-zone, this contamination is not believed to be site related.

The pattern of cation and anion concentrations in the B-zone is similar to the A-zone. As in the A-zone, the highest contaminated B-zone wells also have the highest dissolved salt concentrations. Also like the A-zone, the dominant cations are calcium and sodium, and the dominant anions are chloride and bicarbonate; however, in the B-zone, calcium and chloride are the highest cation and anion, respectively, in every well except for WB2-4. The average TDS for the B-zone is 774 mg/l.

4.4.3 Results of Analyses from Arvin Drinking Water Wells

Two City Wells were sampled during the RI/FS. These were City Well 5, which is up-gradient from the site, and City Well 1, which is the closest City Well down-gradient from the site. These wells were sampled routinely to insure that contamination from the site was not being detected in the City drinking water. City Well 1 was sampled during each quarterly monitoring round, while City Well 5 was sampled for only the first four quarterly rounds so as to establish background concentrations for the drinking water aquifer.

Organic chemicals were only detected in City Well 1 during one sampling round (December 1991). Five volatile organic chemicals were detected during this sampling round; these are listed in Table 4.16. 1,2-DCP was detected at 0.3 ug/l. This value is at the detection limit for this chemical and is considered possibly an anomaly since it has never be detected during the other five sampling rounds. The other four chemicals are all trihalomethanes, which are typically byproducts from the chlorination of drinking water; these results are not considered site related. EPA will continue to monitor City Well 1 for the foreseeable future.

As with the B-zone, antimony and vanadium were the only metals detected above health-based levels, although arsenic is consistently detected at concentrations near the MCL. Antimony was detected once at concentrations above the MCL while vanadium was detected in every sample at concentrations above the long-term health advisory level. The vanadium would appear to be

related to the regional geology since it is found at similar levels in both wells which are approximately a mile apart from each other.

4.5 Tables and Figures

Table 4.1: Organic Chemicals Detected in Surface Soils

Table 4.2: Metals Detected in Surface Soils

Table 4.3: Dinoseb Concentrations in Surface Soils

Table 4.4: Organic Chemicals Detected in Subsurface Soils

Table 4.5: Metals Detected in Subsurface Soils

Table 4.6: Detected Concentrations of Dinoseb in Soil Boring Samples

Table 4.7a-g: Detected Concentrations of Selected Volatile Organic Compounds in Soil

Table 4.8: Dinoseb Contaminant Distribution in Source Areas

Table 4.9: VOC Depth Profile - Pond and Adjacent Area

Table 4.10: VOC Depth Profile - Sump and Wash Pad Area

Table 4.11: Organic Chemicals Detected in A-Zone Groundwater

Table 4.12: Concentrations of Selected Organic Chemicals in A-Zone Groundwater

Table 4.13: Highest Concentrations of Metals in Groundwater

Table 4.14: Average Concentrations of pH, TDS and Major Cations and Anions in Groundwater Wells

Table 4.15: Organic Chemicals Detected in B-Zone Groundwater and City Wells

Figure 4.1: Dinoseb Concentrations in the Top Foot of Soil

Figure 4.2: Source Areas of Soil Contamination

Figure 4.3a & b: Dinoseb Concentrations in the Top 20 feet and from 20 to 40 feet

Figure 4.4a & b: 1,2-DCP Concentrations in the Top 30 feet and from 30 to 65 feet

Figure 4.5a & b: DBCP Concentrations in the Top 30 feet and from 30 to 65 feet

Figure 4.6a & b: EDB Concentrations in the Top 30 feet and from 30 to 65 feet

Figure 4.7: Dinoseb Concentrations in A-Zone Groundwater

Figure 4.8: 1,2-DCP Concentrations in A-Zone Groundwater

Figure 4.9: DBCP Concentrations in A-Zone Groundwater

Figure 4.10a & b: Trends in A-Zone Groundwater Contamination for Selected Wells (Dinoseb, 1,2-DCP, DBCP & EDB)

Figure 4.11a & b: Trends in A-Zone Groundwater Contamination by Well (AMW-1P, AMW-2P, EPAS-2 & EPAS-3)

TABLE 4.1
ORGANIC CHEMICALS DETECTED IN SURFACE SOIL SAMPLES
 (concentrations in ug/kg)

SAMPLE LOCATION	SAMPLE ID #	CHEMICAL	HIGHEST RESULT	TOTAL HITS	TOTAL ANALYSES	FREQUENCY DETECTED
		<u>VOLATILE ORGANICS</u>				
104	SS 04 D001 E05 A	Chloroform	350 LJ	1	24	4%
113	SS 13 D001 E05 A	1,2-Dichloropropane	1000 LJ	2	24	8%
424	SS 24 D000 E04 A	Toluene	16 LJ	3	24	13%
		<u>SEMIVOLATILE ORGANICS</u>				
110	SS 10 D001 E05 R	Fluoranthene	830	1	32	3%
113	SS 13 D001 E05 A	Hexachlorobenzene	2000	2	32	6%
105	SS 05 D001 E05 A	Phenanthrene	2400	1	32	3%
		<u>HERBICIDES</u>				
110	SS 10 D001 E05 A	Dinoseb	5200000 J	36	50	72%

TABLE 4.2
METALS DETECTED IN SURFACE SOIL SAMPLES
 (concentrations in ug/kg)

CHEMICAL	HIGHEST RESULT	LOCATION	TOTAL HITS	FREQUENCY DETECTED	BACKGROUND AVERAGE	ON-SITE AVERAGE
Aluminum	17100.00	111	19	100%	13700	12919
Arsenic	37.20	110	19	100%	8	11
Barium	259.00	104	19	100%	218	184
Beryllium	0.52 LJ	105	12	63%	0.4	0.4
Cadmium	18.30	113	15	21%	4	4
Calcium	17400.00	107	19	100%	7660	5514
Chromium	102.00	105	19	100%	49	35
Cobalt	8.90 LJ	104	19	100%	7	7
Copper	34.20	112	19	100%	19	20
Iron	24900.00	111	19	100%	20450	20800
Lead	153.00 J	112	19	100%	17	36
Magnesium	7440.00	104	19	100%	6710	5788
Manganese	390.00	111	19	100%	311	260
Mercury	1.50	113	6	10%	0.06	0.4
Nickel	15.30	113	19	100%	7	7
Potassium	7760.00	104	19	100%	5735	5888
Selenium	0.25 LJ	113	1	7%	0.25	0.25
Sodium	0.76 LJ	106	19	100%	312	250
Thallium	94.90	105	19	44%	0.6	0.5
Vanadium	4600.00	105	19	100%	57	45
Zinc	1310.00	124	126	100%	1585	733

*A total of 19 metals analyses were performed.

TABLE 4.3
DINOSEB RESULTS for TOP FOOT of SOIL
 (concentrations in ug/kg)

NORTHEAST CORNER		
LOCATION	RESULT	
SS 11	35000	J
SS 11	34000	J
SS 12	240	J
SS 13	620	J
SS 102	120	U
SS 103	680	
SS 411	450000	
SS 411	510000	

AVERAGE	128833	
STD DEVIATION	203777	

EAST FENCE LINE		
LOCATION	RESULT	
SB B	17000	
SS 105	560000	J

AVERAGE	288500	

DINOSEB SPILL AREA		
LOCATION	RESULT	
SS 21	5800	
SS 22	6200	
SS 23	88000	
SS 106	130000	J
SS 106	300000	J
SB C	7400000	
SB X	110000	
SB U	89000	
SB W	12000	
SB D	4100	
SB V	2310	
SB Y	23.8	
SB Z	3	J
SB AA	54.8	

AVERAGE	581964	
STD DEVIATION	1892718	

REMAINDER OF SITE		
LOCATION	RESULT	
SS 101	110	U
SS 104	110	U
SS 113	980	J
SS 114	110	U
SS 115	1200	J
SS 116	450	
SS 117	110	U
SS 401	2800	
SS 402	5300	
SS 406 BCKGRND	200	U
SS 410	200	U
SS 413	5000	U
SS 414	2500	U
SS 415	1000	
SS 416	200	U
SS 417	200	U
SS 418	110	U
SS 423	220	
SS 424	200	U
SS 424	200	U
SB S	7000	
SB T	650	
SB R	360	
SB N	360	
SB N	270	
SB CC	25.2	J
SB NN	11	UJ
SB BB	10.8	UJ
SB G	10	U
SB Q	10	U
SB MM	10	UJ
SB OO	10	UJ
SB O	10	U

AVERAGE	907	
STD DEVIATION	1685	

POND AREA		
LOCATION	RESULT	
SS 107	1000	J
SS 108	260	
SS 109	140	
SS 110	3500000	J
SS 110	5200000	J
SS 111	180	
SS 112	400	
SS 403	41000	
SS 405	14000	
SS 407	19000	
SS 408	1000	U
SB EE	470	J
SB FF	42.6	

AVERAGE	675192	
STD DEVIATION	1602060	

SITE SUMMARY	
TOTAL DETECTS	48
TOTAL NON-DETECTS	21
DETECTION FREQUENCY	70%

TABLE 4.4
ORGANIC CHEMICALS DETECTED IN SOIL BORING SAMPLES
 (concentrations in ug/kg)

BOR LOC	SAMPLE ID #	CHEMICAL	HIGHEST RESULT	DEPTH	TOTAL HITS	TOTAL ANALYSES	FREQUENCY DETECTED
		<u>VOLATILE ORGANICS</u>					
EE	SB E D040 ES1 A	1,1,1-Trichloroethane	5.00 J	40.00	3	294	1%
403	SB 03D040 E04 A	1,1,2-Trichloroethane	13.00	40.00	4	294	1%
I	SB _I D030 ES1 A	1,2,3-Trichloropropane	190000.00	30.00	190	795	24%
401	SB 01D063 E04 A	1,2-Dichloroethane	56.00 LJ	63.00	5	294	2%
I	SB _I D030 ES1 F	1,2-Dichloropropane	200000.00	30.00	267	795	34%
I	SB _I D020 ES1 F	1,3-Dichloropropane	3600.00	20.00	122	795	15%
GG	SB G D050 ES1 A	2-Butanone	12.00 J	50.00	1	294	<1%
418	SB 18D001 E04 A	Acetone	110.00 J	1.00	6	294	2%
I	SB _I D030 ES1 A	Benzene	340.00 J	30.00	4	294	1%
I	SB _I D030 ES1 A	Carbon Disulfide	1600.00	30.00	42	294	14%
I	SB _I D030 ES1 A	Chlorobenzene	5900.00	30.00	7	294	2%
M	SB _ D030 ES1 F	Chloroform	2600.00	30.00	17	795	2%
I	SB _I D030 ES1 A	Dibromochloropropane	690000.00	30.00	123	795	15%
I	SB _I D030 ES1 A	Ethyl Benzene	41000.00	30.00	6	294	2%
I	SB _I D030 ES1 F	Ethylene Dibromide	36000.00	30.00	70	765	9%
I	SB _I D030 ES1 A	Methylene Chloride	400.00 J	30.00	6	294	2%
DD	SB D D020 ES1 A	Tetrachloroethene	1.00 J	20.00	1	294	<1%
I	SB _I D030 ES1 A	Toluene	910.00 J	30.00	71	294	24%
I	SB _I D030 ES1 A	Xylenes (Total)	120000.00	30.00	9	294	3%
		<u>SEMIVOLATILE ORGANICS</u>					
I	SB _I D030 ES1 A	1,2,4-Trichlorobenzene	180.00 J	30.00	2	257	1%
I	SB _I D030 ES1 A	1,2-Dichlorobenzene	3500.00	30.00	3	257	1%
I	SB _I D030 ES1 A	1,4-Dichlorobenzene	1600.00	30.00	4	257	2%
I	SB _I D030 ES1 A	2-Methylnaphthalene	26000.00	30.00	9	257	4%
I	SB _I D018 ES1 A	Benzo(a)anthracene	73.00 J	18.00	1	257	<1%
GG	SB G D035 ES1 A	bis(2-ethylhexyl)phthalate	4400.00	35.00	17	257	7%
I	SB _I D030 ES1 A	Chrysene	960.00	30.00	7	257	3%
423	SB 23D033 E04 R	Diethylphthalate	67.00 LJ	33.00	1	257	<1%
408	SB 08D065 E04 A	Di-n-octylphthalate	260.00 LJ	65.00	5	257	2%
I	SB _I D030 ES1 A	Fluoranthene	260.00 J	30.00	5	257	2%

TABLE 4.4
ORGANIC CHEMICALS DETECTED IN SOIL BORING SAMPLES
 (concentrations in ug/kg)

BOR LOC	SAMPLE ID #	CHEMICAL	HIGHEST RESULT	DEPTH	TOTAL HITS	TOTAL ANALYSES	FREQUENCY DETECTED
I	SB_I D015 ES1 A	Fluorene	710.00	15.00	2	257	1%
I	SB_I D030 ES1 A	Hexachlorobenzene	42000.00	30.00	6	257	2%
I	SB_I D030 ES1 A	Naphthalene	5300.00	30.00	4	257	2%
I	SB_I D018 ES1 A	N-nitrosodiphenylamine	850.00	18.00	1	257	<1%
424	SB 24 D025 E04 A	Pentachloronitrobenzene	1000.00	25.00	2	257	1%
I	SB_I D030 ES1 A	Phenanthrene	4900.00	30.00	8	257	3%
I	SB_I D030 ES1 A	Pyrene	1100.00	30.00	8	257	3%
		<u>HERBICIDES</u>					
C	SB _ D000 ES1 T	Dinoseb	7400000.00	0.00	195	434	45%
424	SB 24 D025 E04 A	Dichloroprop	170.00 J	25.00	14	117	12%
402	SB 02 D055 E04 A	2,4-DB	140.00 J	55.00	2	117	2%
424	SB 24 D020 E04 A	2,4,5-TP	26.00 J	20.00	5	117	4%
408	SB 08 D014 E04 A	2,4,5-T	25.00 J	14.00	4	117	4%
		<u>ORGANOCHLORINE PESTICIDES</u>					
405	SB 05 D010 E04 A	Methoxychlor	2.00 LJ	10.00	2	108	2%
424	SB 24 D035 E04 A	Heptachlor	4.00	35.00	7	108	7%
424	SB 24 D030 E04 A	Gamma chlordane	0.60 LJ	30.00	1	108	1%
410	SB 10 D043 E04 R	Endrin	3.00 LJ	43.00	4	108	4%
407	SB 07 D033 E04 A	Endosulfan I	1.00 LJ	33.00	3	108	3%
410	SB 10 D043 E04 R	Dieldrin	3.00 LJ	43.00	4	108	4%
407	SB 07 D033 E04 A	Beta BHC	1.00 LJ	33.00	1	108	1%
424	SB 24 D050 E04 A	Aldrin	1.00 LJ	50.00	2	108	2%
424	SB 24 D025 E04 A	4,4'-DDT	9.00	25.00	4	108	4%
418	SB 18 D001 E04 A	4,4'-DDE	10.00	1.00	6	108	6%
424	SB 24 D025 E04 A	4,4'-DDD	2.00 LJ	25.00	1	108	1%

TABLE 4.5
METALS DETECTED IN SOIL BORING SAMPLES
 (concentrations in ug/kg)

CHEMICAL	HIGHEST RESULT	DEPTH	LOCATION	TOTAL # OF HITS*	FREQUENCY DETECTED	BACKGROUND AVERAGE	ON-SITE AVERAGE
Aluminum	33100.00	40.00	SB 406	126	100%	15486	12693
Antimony	9.20 LJ	15.00	SB _X	8	6%	ND	6
Arsenic	50.60	50.00	SB 406	126	100%	16	11
Barium	514.00	60.00	SB 424	126	100%	200	177
Beryllium	31.00 LJ	50.00	SB 424	80	63%	1	1
Cadmium	1.80 J	3.00	SB 415	27	21%	0.6	1
Calcium	147000.00	48.00	SB 423	126	100%	20899	11608
Chromium	111.00	25.00	SB 424	126	100%	19	16
Cobalt	21.50	40.00	SB OO	126	100%	11	8
Copper	1040.00 J	50.00	SB DD	126	100%	17	30
Iron	55000.00	25.00	SB 406	126	100%	26695	20727
Lead	106.00	15.00	SB 424	126	100%	5	5
Magnesium	16900.00	40.00	SB 406	126	100%	6330	6631
Manganese	1330.00 J	60.00	SB 424	126	100%	411	362
Mercury	0.26 J	43.00	SB 423	13	10%	0.2	0.1
Nickel	18.60	40.00	SB OO	126	100%	9	7
Potassium	12400.00	25.00	SB 406	126	100%	6301	5593
Selenium	1.80 J	2.00	SB OO	9	7%	2	1
Silver	3.80	40.00	SB OO	38	30%	2	2
Sodium	1790.00	18.00	SB 413	126	100%	550	304
Thallium	1.00 LJ	50.00	SB 403	55	44%	0.5	0.5
Vanadium	114.00	25.00	SB 424	126	100%	52	41
Zinc	1310.00	25.00	SB 424	126	100%	69	77

*A total of 126 metals analyses were performed.

TAB 1.6

DETECTED CONCENTRATIONS of DINOSEB In SOIL BORING SAMPLES
(concentrations in ug/kg)

0 - 10FT			(Total ND = 72)	0 - 10FT (cont'd)			11 - 20FT			(Total ND = 51)
SITE ID # *		RESULT		SITE ID #		RESULT	SITE ID #		RESULT	
SB_C D000 ES1 T		7400000.00		SB_R D000 ES1 A		360.00	SB_D D014 ES1 T		58000.00	
SB_C D010 ES1 T		5100000.00		SB_W D010 ES1 A		274.00	SB_C D015 ES1 T		53000.00	
SB_C D002 ES1 T		4300000.00		SB_N D000 ES1 T		270.00	SB_C D015 ES1 T		47000.00	
SB_C D005 ES1 T		580000.00		SB_T D002 ES1 T		170.00	SB_X D020 ES1 A		42100.00 J	
SB_X D000 ES1 A		110000.00		SB_Y D005 ES1 A		100.00	SB_U D020 ES1 A		20100.00	
SB_U D000 ES1 A		89000.00		SB 10 D008 E04 R		98.00 J	SB_V D015 ES1 A		18600.00	
SB_V D005 ES1 A		30800.00		SB_Y D002 ES1 A		76.60 J	SB_I D018 ES1 T		18000.00	
SB_U D005 ES1 A		21500.00		SB CC D010 ES1 A		72.10	SB_V D020 ES1 A		9300.00	
SB_B D000 ES1 T		17000.00		SB_G D002 ES1 T		59.00	SB_X D015 ES1 A		5650.00	
SB BB D005 ES1 A		16600.00		SB AA D000 ES1 A		54.80	SB_W D015 ES1 A		5020.00	
SB_U D002 ES1 A		14200.00		SB FF D000 ES1 A		42.60	SB_D D019 ES1 T		4800.00	
SB_W D000 ES1 A		12000.00		SB CC D005 ES1 A		41.80	SB_W D020 ES1 A		3300.00	
SB_X D005 ES1 A		11300.00 J		SB EE D005 ES1 A		36.00 J	SB_U D015 ES1 A		2300.00	
SB_X D002 ES1 A		9960.00		SB FF D010 ES1 A		28.30 J	SB FF D020 ES1 A		1600.00	
SB_D D009 ES1 T		8700.00		SB 13 D003 E04 A		26.00 J	SB_I D018 ES1 T		1500.00	
SB_S D000 ES1 A		7000.00		SB CC D000 ES1 A		25.20 J	SB 24 D015 E04 A		980.00 J	
SB_D D004 ES1 T		5700.00		SB_G D005 ES1 T		25.00	SB DD D020 ES1 A		970.00 J	
SB_W D002 ES1 A		5260.00		SB_Y D000 ES1 A		23.80	SB_I D018 ES1 T		410.00	
SB_X D010 ES1 A		4540.00		SB BB D002 ES1 A		23.10 J	SB 24 D020 E04 A		400.00 J	
SB_A D002 ES1 T		4100.00		SB 24 D010 E04 A		17.00 J	SB GG D015 ES1 A		340.00 J	
SB_D D000 ES1 T		4100.00		SB FF D005 ES1 A		15.40 J	SB_J D015 ES1 T		110.00	
SB_V D002 ES1 A		2870.00		SB_T D010 ES1 T		12.00	SB FF D015 ES1 A		95.00 J	
SB_V D010 ES1 A		2510.00		SB FF D002 ES1 A		6.80 J	SB_S D015 ES1 A		81.30 J	
SB_V D000 ES1 A		2310.00		SB CC D002 ES1 A		6.20 J	SB BB D020 ES1 A		39.20 J	
SB_T D005 ES1 T		2300.00		SB EE D002 ES1 A		5.50 J	SB_G D015 ES1 T		25.00	
SB 07 D010 E04 A		2300.00 J		SB_Y D010 ES1 A		3.10 J	SB_S D020 ES1 A		22.40 J	
SB_W D005 ES1 A		1880.00		SB_Z D000 ES1 A		3.00 J	SB_L D015 ES1 T		14.00	
SB_U D010 ES1 A		1570.00		SB OO D010 ES1 A		2.40 J	SB CC D015 ES1 A		13.60	
SB_L D010 ES1 T		1500.00		SB_Z D005 ES1 A		1.60 J	SB_P D015 ES1 T		12.00	
SB HH D010 ES1 A		1140.00 J					SB BB D015 ES1 A		11.90 J	
SB_T D000 ES1 T		650.00					SB_Y D020 ES1 A		11.80 J	
SB EE D000 ES1 A		470.00 J					SB_Y D015 ES1 A		7.70 J	
SB_N D000 ES1 T		360.00					SB CC D020 ES1 A		2.30 J	

*See Section 1.3.1 for explanation of location codes.

TABLE 4.6 (cont'd)

21 - 30FT		(Total ND = 31)	31 - 40FT		(Total ND = 27)	41 - 65FT		(Total ND = 45)
SITE ID #		RESULT	SITE ID #		RESULT	SITE ID #		RESULT
SB_C	D025 ES1 T	120000.00	SB 07	D033 E04 A	12000.00 J	SB DD	D050 ES1 A	1900.00
SB 07	D025 E04 A	15000.00 J	SB 05	D040 E04 A	3300.00 J	SB GG	D060 ES1 A	1400.00
SB_V	D030 ES1 A	14100.00	SB DD	D040 ES1 A	1700.00	SB DD	D060 ES1 A	1400.00
SB DD	D030 ES1 A	5000.00	SB_C	D035 ES1 T	1400.00	SB_G	D045 ES1 T	1100.00
SB_X	D030 ES1 A	4560.00	SB_K	D035 ES1 T	300.00	SB 08	D045 E04 R	510.00 J
SB_W	D030 ES1 A	3370.00	SB FF	D040 ES1 A	230.00 J	SB 05	D065 E04 A	440.00 J
SB FF	D030 ES1 A	1300.00 J	SB_J	D035 ES1 T	140.00	SB_C	D044 ES1 T	240.00
SB 24	D030 E04 A	1100.00 J	SB GG	D035 ES1 A	84.00 J	SB 10	D043 E04 R	220.00 J
SB 10	D029 E04 A	700.00 J	SB_J	D040 ES1 T	79.00	SB AA	D050 ES1 A	189.00 J
SB_K	D030 ES1 T	330.00	SB GG	D040 ES1 A	58.00 J	SB 10	D043 E04 R	180.00 J
SB_D	D029 ES1 T	280.00	SB 24	D035 E04 A	43.00 J	SB 05	D050 E04 A	170.00 J
SB_D	D024 ES1 T	240.00	SB 10	D033 E04 A	34.00 J	SB 24	D060 E04 A	110.00 J
SB 24	D025 E04 A	240.00 J	SB 24	D040 E04 A	33.00 J	SB CC	D050 ES1 A	89.30
SB_J	D030 ES1 T	140.00	SB HH	D040 ES1 A	32.00	SB 08	D065 E04 A	71.00 J
SB_U	D025 ES1 A	91.50	SB 08	D032 E04 A	27.00 J	SB FF	D060 ES1 A	58.00 J
SB GG	D025 ES1 A	75.00 J	SB_G	D035 ES1 T	25.00	SB 01	D063 E04 A	48.00 J
SB 09	D030 E04 R	33.00 J	SB_P	D035 ES1 T	22.00	SB GG	D050 ES1 A	46.00
SB EE	D030 ES1 A	24.80 J	SB_U	D040 ES1 A	8.00 J	SB BB	D050 ES1 A	43.00 J
SB 09	D030 E04 R	24.00 J	SB_S	D040 ES1 A	7.60 J	SB_X	D050 ES1 A	39.90
SB CC	D030 ES1 A	20.20 J	SB 03	D040 E04 A	5.00 J	SB_W	D050 ES1 A	37.30 J
SB 01	D025 E04 R	19.00 J				SB 08	D045 E04 R	37.00 J
SB 01	D025 E04 R	16.00 J				SB 08	D060 E04 R	34.00 J
SB_K	D025 ES1 T	12.00				SB 07	D045 E04 R	32.00 J
SB_U	D030 ES1 A	10.90 J				SB 01	D045 E04 A	25.00 J
SB EE	D025 ES1 A	6.20 J				SB HH	D050 ES1 A	24.40
SB_Y	D030 ES1 A	5.40 J				SB_M	D055 ES1 T	24.00
SB BB	D030 ES1 A	1.50 J				SB_J	D055 ES1 T	21.00
SB AA	D030 ES1 A	1.30 J				SB 07	D059 E04 A	18.00 J
SB_Z	D030 ES1 A	1.20 J				SB 23	D048 E04 A	14.00 J
						SB EE	D050 ES1 A	13.60
						SB 07	D045 E04 R	13.00 J
						SB FF	D050 ES1 A	11.10 J
						SB 01	D055 E04 A	8.00 J
						SB 03	D050 E04 R	7.00 J
						SB 11	D058 E04 A	5.00 J
						SB OO	D050 ES1 A	3.20 J
						SB_U	D060 ES1 A	1.20 J

TABLE 4. (cont'd)

66 - 85FT (Total ND = 16)			>85FT (Total ND = 25)		
SITE ID #		RESULT	SITE ID #		RESULT
SB GG D085	ES1 A	890.00	SB DD D100	ES1 A	1300.00
SB DD D070	ES1 A	570.00	SB DD D090	ES1 A	45.00
SB GG D075	ES1 A	82.00 J	SB FF D090	ES1 A	40.00
SB FF D070	ES1 A	69.00 J	SB GG D090	ES1 A	8.80 J
SB GG D070	ES1 A	46.00 J	SB _U D095	ES1 A	1.70 J
SB 24 D067	E04 A	23.00 J			
SB DD D080	ES1 A	9.50 J			
SB _U D070	ES1 A	5.30 J			
SB _U D075	ES1 A	1.50 J			

TABLE 4.7a
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 0 - 10 FOOT DEPTH
 (concentrations in ug/kg)

1,2-DCP LOCATION *	TOTAL ND 179 CONC
SB_H D004 ES1 F	11000.00
SB_J D010 ES1 F	690.00
SB_H D002 ES1 F	550.00 J
SB_H D010 ES1 F	400.00
SB_H D008 ES1 F	320.00
SB_H D000 ES1 F	320.00
SB_M D010 ES1 F	220.00
SB_I D005 ES1 A	110.00
SB 24 D005 E04 A	100.00
SB 03 D010 E04 A	81.00
SB_I D005 ES1 A	70.00 J
SB_U D000 ES1 A	52.00
SB_E D000 ES1 A	41.00 J
SB 01 D005 E04 R	27.00
SB 24 D010 E04 A	23.00
SB_U D000 ES1 F	23.00
SB_E D000 ES1 F	16.00
SB_K D010 ES1 F	12.00
SB EE D002 ES1 F	9.60
SB_N D000 ES1 A	9.00 J
SB 13 D008 E04 A	7.00 LJ
SB EE D005 ES1 F	6.00
SB 01 D005 E04 R	5.00 LJ
SB 24 D000 E04 R	4.00 LJ
SB 24 D000 E04 R	2.00 LJ

1,3-DCP LOCATION	TOTAL ND 136 CONC
SB_J D010 ES1 F	14.00

1,2,3-TCP LOCATION	TOTAL ND 108 CONC
SB_E D000 ES1 A	400.00
SB_E D000 ES1 F	330.00 J
SB_J D010 ES1 F	220.00
SB_H D008 ES1 F	120.00
SB_H D010 ES1 F	110.00
SB_E D000 ES1 F	100.00 J
SB_U D000 ES1 A	89.00
SB_H D006 ES1 F	86.00
SB_M D010 ES1 F	86.00
SB_C D010 ES1 F	70.00
SB_H D000 ES1 F	68.00
SB_X D000 ES1 F	66.00
SB_F D005 ES1 F	52.00

1,2,3-TCP (cont'd) LOCATION	CONC
SB_P D010 ES1 F	49.00
SB_F D000 ES1 F	40.00
SB_P D003 ES1 F	32.00
SB_U D000 ES1 F	30.00
SB_P D001 ES1 F	30.00
SB_I D005 ES1 A	28.00
SB_P D005 ES1 F	22.00
SB_C D000 ES1 F	20.00
SB_C D002 ES1 F	19.00 J
SB_C D002 ES1 F	16.00
SB_Z D002 ES1 F	14.00
SB_E D005 ES1 F	13.00 J
SB_I D005 ES1 F	12.00
SB EE D002 ES1 F	11.00
SB_C D004 ES1 A	9.00 J
SB_F D000 ES1 F	6.40

EDB LOCATION	TOTAL ND 156 CONC
SB_U D000 ES1 A	45.00 J
SB_M D010 ES1 F	26.00
SB_U D000 ES1 F	16.00
SB_H D010 ES1 F	11.00
SB_C D002 ES1 F	11.00
SB_E D000 ES1 A	7.00 J
SB_P D010 ES1 F	6.60
SB_I D005 ES1 A	5.00 J
SB 07 D010 E04 A	3.00 LJ
SB 24 D005 E04 A	2.00 LJ

DBCP LOCATION	TOTAL ND 155 CONC
SB_E D000 ES1 F	910.00 J
SB_E D005 ES1 F	570.00 J
SB_E D000 ES1 A	330.00
SB_X D000 ES1 F	180.00
SB_E D000 ES1 F	170.00 J
SB_U D000 ES1 A	110.00
SB_C D005 ES1 F	62.00 J
SB 24 D010 E04 A	15.00
SB 24 D005 E04 A	14.00
SB_U D000 ES1 F	9.00
SB 07 D010 E04 A	6.00 LJ

ND = non detect

*See Section 1.3.1 for explanation of location codes.

TABLE 4.7b
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 11 - 20 FOOT DEPTH
 (concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 99 CONC
SB_I D016 ES1 F	33000.00
SB_I D020 ES1 F	27000.00
SB_I D016 ES1 A	23000.00
SB_I D016 ES1 A	22000.00
SB_I D020 ES1 A	21000.00
SB_I D020 ES1 A	21000.00
SB_I D015 ES1 A	20000.00
SB_I D015 ES1 A	17000.00
SB_I D015 ES1 F	12000.00
SB 24 D015 E04 A	3200.00 J
SB_I D018 ES1 A	1300.00
SB_I D018 ES1 A	1100.00
SB_I D018 ES1 F	1100.00
SB_H D012 ES1 F	820.00
SB 03 D020 E04 A	670.00 J
SB_L D020 ES1 F	480.00
SB_M D015 ES1 F	330.00
SB_J D015 ES1 F	220.00
SB_J D020 ES1 F	170.00
SB_L D020 ES1 A	140.00
SB_K D020 ES1 F	140.00
SB_M D020 ES1 F	130.00
SB_H D018 ES1 F	94.00
SB_L D020 ES1 A	79.00 J
SB_K D015 ES1 A	62.00
SB 01 D015 E04 A	28.00
SB 24 D020 E04 A	19.00
SB_H D020 ES1 F	18.00
SB_K D015 ES1 F	12.00
SB 05 D020 E04 A	9.00 LJ
SB_L D015 ES1 F	8.10
SB DD D020 ES1 F	7.10

1,3-DCP LOCATION	TOTAL ND 83 CONC
SB_I D020 ES1 F	3600.00
SB_I D015 ES1 F	1500.00
SB_I D020 ES1 A	1100.00
SB_I D016 ES1 F	710.00
SB_I D016 ES1 A	430.00
SB_L D020 ES1 F	5.50

1,2,3-TCP LOCATION	TOTAL ND 59 CONC
SB_I D020 ES1 A	49000.00
SB_I D020 ES1 F	38000.00
SB_I D015 ES1 A	27000.00
SB_I D015 ES1 F	20000.00
SB_I D018 ES1 A	11000.00

1,2,3-TCP(CONT'D) LOCATION	CONC
SB_H D020 ES1 F	65.00
SB_F D015 ES1 F	65.00
SB_J D015 ES1 F	51.00
SB_E D015 ES1 F	50.00 J
SB_K D020 ES1 F	46.00
SB_A D015 ES1 F	45.00
SB_H D018 ES1 F	36.00
SB_P D020 ES1 F	30.00
SB_A D020 ES1 F	18.00
SB_O D020 ES1 F	17.00
SB EE D020 ES1 F	14.00
SB_A D015 ES1 F	13.00
SB_L D015 ES1 F	12.00
SB_K D015 ES1 A	12.00 J
SB_J D020 ES1 F	12.00
SB_P D015 ES1 F	11.00
SB EE D020 ES1 A	10.00 J
SB_I D016 ES1 A	4600.00
SB_I D016 ES1 F	3100.00
SB_I D018 ES1 F	1500.00
SB_L D020 ES1 F	290.00
SB_M D015 ES1 F	200.00
SB_H D012 ES1 F	150.00 J
SB_M D020 ES1 F	110.00
SB_L D020 ES1 A	91.00

EDB LOCATION	TOTAL ND 90 CONC
SB_I D020 ES1 F	11000.00
SB_I D015 ES1 F	4100.00
SB_I D020 ES1 A	2000.00
SB_I D016 ES1 F	1600.00
SB_I D016 ES1 A	1500.00
SB_I D015 ES1 A	860.00 J
SB_I D018 ES1 F	370.00
SB_I D018 ES1 A	310.00 J
SB 24 D015 E04 A	99.00
SB_L D020 ES1 F	21.00
SB EE D020 ES1 A	15.00 J
SB EE D020 ES1 F	12.00
SB 03 D020 E04 A	7.00 LJ
SB 24 D020 E04 A	2.00 LJ

ND = non detect

Continued on the next page.

TABLE 4.7b(cont'd)
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 11 - 20 FOOT DEPTH
 (concentrations in ug/kg)

DBCP	TOTAL ND 85
LOCATION	CONC
SB _I D020 ES1 F	130000.00
SB _J D020 ES1 A	110000.00
SB _I D015 ES1 F	47000.00
SB _I D015 ES1 A	44000.00
SB _I D018 ES1 A	32000.00
SB _J D018 ES1 F	3700.00
SB _I D016 ES1 A	2100.00
SB _I D016 ES1 F	1800.00
SB 24 D015 E04 A	830.00 J
SB _E D015 ES1 F	650.00 J
SB _L D020 ES1 F	280.00
SB 24 D020 E04 A	180.00
SB _E D015 ES1 F	150.00
SB _E D020 ES1 F	120.00
SB _K D015 ES1 A	120.00
SB _E D020 ES1 F	110.00
SB _L D020 ES1 A	94.00
SB 03 D020 E04 A	24.00
SB 01 D015 E04 A	10.00 LJ

TABLE 4.7c
DETECTED CONCENTRATIONS of SELECTED VOLATILE
ORGANIC COMPOUNDS in SOIL, 21 - 30 FOOT DEPTH
(concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 97 CONC
SB _I D030 ES1 F	200000.00
SB _I D030 ES1 A	190000.00
SB _I D030 ES1 A	180000.00
SB _I D025 ES1 F	83000.00
SB _I D025 ES1 A	30000.00
SB _I D025 ES1 A	27000.00
SB 01 D028 E04 A	11000.00 J
SB _M D030 ES1 F	9300.00
SB 01 D025 E04 R	8200.00 J
SB 01 D025 E04 R	6400.00 J
SB _L D030 ES1 A	4700.00
SB _L D030 ES1 A	4400.00
SB 24 D030 E04 A	3800.00 J
SB _L D030 ES1 F	3700.00
SB _J D030 ES1 A	2100.00
SB 24 D025 E04 A	1800.00 J
SB _J D030 ES1 A	1600.00
SB _H D026 ES1 F	1300.00
SB _M D025 ES1 F	1200.00
SB _K D030 ES1 F	1100.00
SB _J D030 ES1 F	1100.00
SB _K D025 ES1 F	940.00
SB _L D025 ES1 F	520.00
SB _J D025 ES1 A	400.00
SB _J D025 ES1 F	300.00
SB _J D025 ES1 A	270.00
SB _H D022 ES1 F	200.00
SB 10 D023 E04 A	150.00
SB _H D022 ES1 F	130.00
SB _H D024 ES1 F	91.00
SB DD D030 ES1 A	60.00
SB 08 D025 E04 A	44.00
SB 07 D025 E04 A	38.00 LJ
SB 03 D030 E04 R	27.00
SB 02 D025 E04 A	24.00
SB 13 D023 E04 A	21.00
SB 03 D030 E04 R	17.00
SB _U D030 ES1 A	9.00
SB _F D021 ES1 F	5.10
SB 05 D030 E04 L	3.00 LJ

1,3-DCP LOCATION	TOTAL ND 66 CONC
SB _I D025 ES1 A	1400.00
SB _J D030 ES1 F	520.00
SB _M D025 ES1 F	48.00
SB _J D030 ES1 A	13.00 J
SB _J D025 ES1 A	4.00 J

1,2,3-TCP LOCATION	TOTAL ND 43 CONC
SB _I D030 ES1 A	190000.00
SB _I D030 ES1 F	120000.00
SB _I D025 ES1 A	54000.00
SB _I D025 ES1 F	20000.00
SB _M D030 ES1 F	4600.00
SB _M D025 ES1 F	1800.00
SB _L D030 ES1 F	1500.00
SB _L D030 ES1 A	1200.00
SB _L D025 ES1 F	660.00
SB _K D030 ES1 F	460.00
SB _K D025 ES1 F	430.00
SB _J D030 ES1 A	370.00
SB _H D024 ES1 F	320.00
SB _H D026 ES1 F	270.00
SB _J D030 ES1 F	220.00
SB _H D022 ES1 F	190.00
SB _J D025 ES1 A	150.00
SB _J D025 ES1 F	110.00
SB _H D022 ES1 F	88.00
SB _H D028 ES1 F	72.00
SB _H D030 ES1 F	46.00
SB _P D030 ES1 F	31.00
SB _F D026 ES1 F	18.00
SB _P D025 ES1 F	18.00
SB _E D026 ES1 F	15.00
SB _O D030 ES1 F	15.00
SB _O D025 ES1 F	14.00
SB _F D021 ES1 F	5.10

EDB LOCATION	TOTAL ND 76 CONC
SB _I D030 ES1 F	36000.00
SB _I D030 ES1 A	6600.00
SB _I D025 ES1 F	3400.00
SB _I D025 ES1 A	3200.00
SB 07 D025 E04 A	930.00
SB _J D030 ES1 F	410.00
SB 24 D025 E04 A	140.00
SB _M D025 ES1 F	130.00
SB _H D022 ES1 F	49.00
SB 24 D030 E04 A	22.00
SB _K D025 ES1 F	16.00
SB _H D022 ES1 F	12.00
SB _L D025 ES1 F	6.60
SB 08 D025 E04 A	3.00 LJ

ND = NON DETECT

Continued on the next page.

TABLE 4.7c(cont'd)
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 21 - 30 FOOT DEPTH
 (concentrations in ug/kg)

DBCP				TOTAL ND 66
LOCATION				CONC
SB _J	D030	ES1	A	690000.00
SB _J	D030	ES1	F	420000.00
SB _I	D025	ES1	A	92000.00
SB _J	D025	ES1	F	44000.00
SB 24	D025	E04	A	4300.00 J
SB _M	D025	ES1	F	1200.00
SB 24	D030	E04	A	800.00 J
SB 01	D025	E04	R	560.00
SB 01	D025	E04	R	510.00
SB _L	D025	ES1	F	380.00
SB 01	D028	E04	A	290.00
SB _L	D030	ES1	A	180.00
SB _K	D025	ES1	F	120.00
SB _E	D026	ES1	F	120.00
SB _J	D030	ES1	A	56.00
SB 07	D025	E04	A	56.00 LJ
SB 02	D025	E04	A	54.00
SB _E	D026	ES1	F	28.00
SB 03	D030	E04	R	24.00
SB 08	D025	E04	A	20.00
SB 03	D030	E04	R	18.00
SB _O	D025	ES1	F	5.70
SB _J	D025	ES1	A	5.00 J
SB 10	D023	E04	A	1.00 LJ

TABLE 4.7d
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 31 - 40 FOOT DEPTH
 (concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 49 CONC
SB _I D032 ES1 F	19000.00
SB 24 D035 E04 A	17000.00
SB _M D040 ES1 A	13000.00
SB _M D035 ES1 F	10000.00
SB _I D040 ES1 F	8700.00
SB _M D040 ES1 A	8600.00
SB _L D035 ES1 F	4500.00
SB _K D035 ES1 F	3900.00
SB 24 D040 E04 A	3700.00
SB _M D040 ES1 F	3500.00 J
SB _J D040 ES1 F	3400.00
SB _J D035 ES1 F	2400.00
SB _K D040 ES1 F	2400.00
SB 03 D040 E04 A	1900.00 J
SB _I D032 ES1 A	1500.00
SB _H D040 ES1 F	1400.00
SB _I D032 ES1 A	1300.00
SB _M D035 ES1 A	880.00
SB _I D040 ES1 A	810.00
SB _I D040 ES1 A	800.00
SB _M D035 ES1 A	740.00
SB _L D040 ES1 F	710.00
SB _H D032 ES1 F	580.00
SB _J D040 ES1 A	440.00
SB _J D040 ES1 A	410.00
SB 02 D035 E04 A	180.00
SB 08 D032 E04 A	160.00
SB GG D040 ES1 A	120.00
SB 05 D040 E04 A	57.00
SB GG D040 ES1 F	43.00
SB GG D035 ES1 F	37.00
SB DD D040 ES1 F	33.00
SB FF D040 ES1 F	15.00
SB GG D040 ES1 A	8.00
SB GG D035 ES1 A	5.00 J
SB _U D040 ES1 A	3.00 J
SB 10 D033 E04 A	2.00 LJ
SB 23 D033 E04 R	1.00 LJ

1,3-DCP LOCATION	TOTAL ND 47 CONC
SB _I D032 ES1 F	450.00
SB _M D040 ES1 A	40.00
SB _I D032 ES1 A	22.00 J
SB _J D040 ES1 F	21.00
SB _M D035 ES1 A	7.00 J

1,2,3-TCP LOCATION	TOTAL ND 80 CONC
SB _I D032 ES1 F	8300.00
SB _I D040 ES1 F	5700.00
SB _M D035 ES1 F	4000.00
SB _M D040 ES1 A	3400.00
SB _I D032 ES1 A	2600.00
SB _L D035 ES1 F	2200.00
SB _K D035 ES1 F	2000.00
SB _M D035 ES1 A	1400.00
SB _M D040 ES1 F	990.00 J
SB _K D040 ES1 F	960.00
SB _L D040 ES1 F	880.00
SB _J D040 ES1 F	690.00
SB _J D035 ES1 F	540.00
SB _H D040 ES1 F	420.00
SB _J D040 ES1 A	240.00
SB _I D040 ES1 A	200.00
SB DD D040 ES1 F	65.00
SB _O D035 ES1 F	50.00
SB GG D040 ES1 F	36.00
SB GG D040 ES1 A	25.00
SB _G D035 ES1 F	14.00
SB _O D040 ES1 F	13.00

EDB LOCATION	TOTAL ND 59 CONC
SB _I D032 ES1 F	820.00
SB _L D035 ES1 F	54.00
SB _J D040 ES1 F	41.00
SB 03 D040 E04 A	23.00
SB 07 D033 E04 A	22.00
SB _L D040 ES1 F	17.00
SB _I D032 ES1 A	16.00 J
SB 08 D032 E04 A	5.00 LJ
SB 05 D040 E04 A	3.00 LJ

ND = non detect

Continued on the next page.

TABLE 4.7d(cont'd)
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL,31 - 40 FOOT DEPTH
 (concentrations in ug/kg)

DBCP	TOTAL ND 51		
LOCATION	CONC		
SB_I D032 ES1 A	11000.00		
SB_I D032 ES1 F	8700.00		
SB_I D040 ES1 F	2100.00		
SB_M D035 ES1 F	1200.00		
SB 24 D035 E04 A	240.00 LJ		
SB 02 D035 E04 A	220.00 J		
SB 03 D040 E04 A	110.00		
SB 08 D032 E04 A	100.00		
SB_L D035 ES1 F	43.00		
SB_L D040 ES1 F	43.00		
SB_M D040 ES1 A	33.00		
SB_J D040 ES1 F	32.00		
SB_M D035 ES1 A	27.00		
SB_O D035 ES1 F	22.00		
SB_J D040 ES1 A	19.00 J		
SB_O D040 ES1 F	6.60		
SB 07 D033 E04 A	3.00 LJ		

TABLE 4.7e
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 41 - 65 FOOT DEPTH
 (concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 84 CONC
SB_H D065 ES1 A	10000.00
SB_H D065 ES1 A	9600.00
SB 01 D045 E04 A	5500.00 J
SB 02 D045 E04 A	3600.00 J
SB_M D055 ES1 A	2600.00
SB_I D050 ES1 A	2500.00
SB 08 D065 E04 A	2300.00 J
SB 01 D055 E04 A	2100.00 J
SB_L D055 ES1 F	2000.00
SB_M D055 ES1 A	1900.00
SB_I D050 ES1 A	1800.00
SB_H D045 ES1 F	1700.00
SB_H D065 ES1 F	1600.00
SB 01 D063 E04 A	1600.00 J
SB 08 D060 E04 R	1600.00 J
SB_H D050 ES1 F	1600.00
SB 05 D060 E04 A	1500.00
SB 05 D065 E04 A	1300.00 J
SB_I D045 ES1 A	1300.00
SB 24 D050 E04 A	1100.00
SB DD D050 ES1 F	1000.00 J
SB_M D055 ES1 F	1000.00 J
SB 08 D045 E04 R	790.00
SB 05 D050 E04 A	760.00
SB_J D055 ES1 F	750.00
SB_I D045 ES1 A	720.00
SB_I D060 ES1 F	720.00
SB_I D060 ES1 A	660.00
SB 08 D045 E04 R	610.00
SB 24 D060 E04 A	500.00
SB_H D060 ES1 F	410.00
SB GG D050 ES1 A	370.00
SB_I D045 ES1 F	370.00
SB 03 D060 E04 A	370.00
SB_I D060 ES1 A	350.00
SB 10 D043 E04 R	330.00
SB_H D055 ES1 F	240.00
SB GG D060 ES1 F	200.00
SB FF D060 ES1 F	200.00
SB 10 D043 E04 R	180.00
SB DD D050 ES1 A	150.00
SB_I D050 ES1 F	140.00
SB DD D050 ES1 A	140.00
SB GG D050 ES1 F	97.00
SB 07 D065 E04 A	46.00
SB NN D060 ES1 F	44.00
SB 07 D059 E04 A	43.00 LJ
SB DD D060 ES1 A	32.00
SB FF D050 ES1 F	29.00

1,2-DCP(cont'd) LOCATION	CONC
SB 07 D045 E04 R	29.00 LJ
SB FF D060 ES1 A	27.00
SB 07 D045 E04 R	16.00 LJ
SB 03 D050 E04 R	12.00
SB_T D060 ES1 F	9.20
SB FF D050 ES1 A	8.00
SB_B D060 ES1 A	7.00 J
SB 02 D055 E04 A	1.00 LJ

1,3-DCP LOCATION	TOTAL ND 66 CONC
SB_I D050 ES1 F	34.00
SB_H D065 ES1 A	12.00 J
SB DD D050 ES1 F	5.70

1,2,3-TCP LOCATION	TOTAL ND 44 CONC
SB_H D065 ES1 F	2000.00
SB_M D055 ES1 F	980.00 J
SB_I D050 ES1 A	890.00
SB_H D065 ES1 A	890.00
SB_H D045 ES1 F	820.00
SB_I D050 ES1 F	600.00
SB DD D060 ES1 F	550.00
SB_L D055 ES1 F	520.00
SB_H D050 ES1 F	420.00
SB_I D045 ES1 F	390.00
SB_I D045 ES1 A	340.00
SB_I D060 ES1 A	340.00
SB_M D055 ES1 A	340.00
SB_H D060 ES1 F	240.00
SB GG D060 ES1 F	92.00
SB_H D055 ES1 F	84.00
SB DD D050 ES1 F	78.00
SB_J D055 ES1 F	68.00 J
SB GG D050 ES1 F	68.00
SB DD D050 ES1 A	50.00
SB_V D050 ES1 F	44.00
SB_I D060 ES1 F	38.00
SB_V D050 ES1 A	27.00
SB FF D060 ES1 F	27.00
SB_O D055 ES1 F	7.50

ND = non detect

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TABLE 4.7e(cont'd)
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL, 41 - 65 FOOT DEPTH
 (concentrations in ug/kg)

EDB	TOTAL ND 86
LOCATION	CONC
SB 07 D045 E04 R	1500.00 J
SB 07 D045 E04 R	560.00
SB _H D065 ES1 F	360.00
SB _M D055 ES1 F	310.00 J
SB 08 D065 E04 A	290.00
SB 07 D059 E04 A	270.00
SB 05 D060 E04 A	170.00
SB 05 D065 E04 A	170.00
SB 08 D060 E04 R	73.00
SB 05 D050 E04 A	60.00
SB _H D045 ES1 F	47.00
SB _I D060 ES1 A	42.00
SB 07 D065 E04 A	36.00
SB 08 D045 E04 R	27.00 LJ
SB 08 D045 E04 R	23.00 LJ
SB 03 D060 E04 A	22.00 LJ
SB DD D050 ES1 F	22.00
SB DD D050 ES1 A	12.00 J

DBCP	TOTAL ND 87
LOCATION	CONC
SB _H D065 ES1 F	2600.00
SB 02 D045 E04 A	610.00 J
SB 08 D045 E04 R	200.00
SB 08 D045 E04 R	160.00
SB 08 D060 E04 R	120.00
SB 05 D065 E04 A	96.00
SB 07 D059 E04 A	86.00
SB _I D050 ES1 F	72.00
SB 01 D063 E04 A	48.00 LJ
SB 24 D060 E04 A	27.00 LJ
SB 10 D043 E04 R	27.00 LJ
SB _V D050 ES1 A	26.00
SB 07 D065 E04 A	23.00
SB 10 D043 E04 R	17.00 LJ
SB DD D050 ES1 A	14.00 J
SB 03 D050 E04 R	11.00
SB 10 D058 E04 A	3.00 LJ

TABLE 4.7f
DETECTED CONCENTRATIONS of SELECTED VOLATILE
ORGANIC COMPOUNDS in SOIL, 66 - 85 FOOT DEPTH
(concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 20 CONC
SB 01 D066 E04 L	12000.00 J
SB GG D075 ES1 F	5700.00
SB _I D070 ES1 F	2600.00
SB NN D080 ES1 A	2100.00
SB NN D080 ES1 F	1700.00
SB GG D085 ES1 F	1500.00
SB 03 D067 E04 A	1500.00
SB GG D070 ES1 A	1300.00
SB 24 D067 E04 A	1200.00 LJ
SB GG D070 ES1 F	430.00
SB GG D075 ES1 A	390.00
SB _I D070 ES1 A	370.00
SB 10 D066 E04 A	370.00
SB _I D070 ES1 A	370.00
SB FF D080 ES1 A	340.00
SB MM D080 ES1 A	320.00
SB DD D080 ES1 A	230.00
SB 02 D066 E04 A	220.00
SB FF D080 ES1 F	150.00
SB DD D070 ES1 A	140.00
SB _T D070 ES1 A	130.00
SB _T D070 ES1 F	94.00
SB DD D080 ES1 A	56.00
SB FF D070 ES1 F	39.00
SB MM D080 ES1 F	16.00
SB GG D085 ES1 A	9.00
SB NN D070 ES1 F	5.90

1,3-DCP LOCATION	TOTAL ND 32 CONC
SB NN D080 ES1 F	14.00

1,2,3-TCP LOCATION	TOTAL ND 11 CONC
SB GG D075 ES1 F	1200.00
SB GG D085 ES1 F	820.00
SB DD D080 ES1 F	750.00 J
SB DD D070 ES1 F	710.00
SB _I D070 ES1 F	200.00
SB FF D080 ES1 F	170.00
SB DD D070 ES1 A	130.00
SB FF D080 ES1 A	100.00
SB DD D080 ES1 A	85.00
SB NN D080 ES1 F	78.00
SB NN D080 ES1 A	71.00
SB MM D080 ES1 A	37.00
SB _T D070 ES1 F	34.00
SB NN D070 ES1 F	30.00
SB _I D070 ES1 A	27.00

1,2,3-TCP(cont'd) LOCATION	CONC
SB _D D070 ES1 F	26.00
SB _T D070 ES1 A	25.00
SB _U D070 ES1 F	20.00
SB MM D080 ES1 F	15.00
SB FF D070 ES1 F	15.00
SB MM D070 ES1 F	14.00
SB _U D070 ES1 A	8.00 J

EDB LOCATION	TOTAL ND 38 CONC
SB 10 D066 E04 A	140.00
SB DD D080 ES1 A	55.00
SB FF D080 ES1 A	7.00 J

DBCP LOCATION	TOTAL ND 28 CONC
SB GG D075 ES1 F	1800.00
SB GG D085 ES1 F	1200.00
SB FF D080 ES1 F	280.00
SB FF D080 ES1 A	260.00
SB 10 D066 E04 A	120.00 J
SB DD D080 ES1 A	90.00
SB DD D070 ES1 A	87.00
SB 01 D066 E04 L	79.00
SB 03 D067 E04 A	68.00 J
SB NN D080 ES1 A	21.00 J
SB MM D080 ES1 A	11.00 J
SB _T D070 ES1 F	5.70
SB NN D080 ES1 F	5.20

ND = non detect

TABLE 4.7g
DETECTED CONCENTRATIONS of SELECTED VOLATILE
ORGANIC COMPOUNDS in SOIL,>85 FOOT DEPTH
(concentrations in ug/kg)

1,2-DCP LOCATION	TOTAL ND 28 CONC
SB _I D090 ES1 A	3100.00
SB _I D090 ES1 A	2900.00
SB _I D090 ES1 F	2900.00
SB DD D100 ES1 A	2000.00
SB _T D093 ES1 A	1300.00
SB GG D100 ES1 F	1200.00
SB DD D090 ES1 A	310.00
SB MMD120 ES1 F	280.00
SB _T D110 ES1 F	260.00
SB GG D090 ES1 F	230.00
SB DD D090 ES1 A	220.00
SB GG D110 ES1 A	200.00
SB GG D100 ES1 A	200.00
SB FF D090 ES1 A	200.00
SB MM D090 ES1 F	190.00
SB _T D093 ES1 A	170.00
SB GG D110 ES1 F	160.00
SB GG D130 ES1 F	120.00
SB _T D110 ES1 A	120.00
SB _T D093 ES1 F	120.00
SB FF D090 ES1 F	110.00
SB GG D090 ES1 A	110.00
SB FF D100 ES1 A	100.00
SB GG D090 ES1 A	92.00
SB GG D130 ES1 A	90.00
SB FF D110 ES1 A	90.00
SB DD D090 ES1 F	87.00
SB MMD110 ES1 F	83.00
SB _T D130 ES1 F	78.00
SB GG D120 ES1 F	66.00
SB _T D100 ES1 F	61.00
SB FF D100 ES1 F	43.00
SB GG D120 ES1 A	33.00
SB _T D100 ES1 A	30.00
SB _T D130 ES1 A	29.00
SB FF D090 ES1 A	27.00
SB NN D130 ES1 F	27.00
SB DD D100 ES1 A	26.00
SB FF D110 ES1 F	24.00
SB FF D120 ES1 F	19.00
SB MMD120 ES1 A	19.00 J
SB _Q D090 ES1 F	19.00
SB NN D090 ES1 A	17.00 J
SB NN D120 ES1 F	14.00
SB MM D090 ES1 A	6.00 J
SB MM D090 ES1 F	5.10
SB NN D090 ES1 A	4.00 J
SB NN D110 ES1 A	1.00 J

1,3-DCP LOCATION	TOTAL ND 57 CONC
SB DD D100 ES1 A	20.00 J

1,2,3-TCP LOCATION	TOTAL ND 27 CONC
SB DD D100 ES1 F	1000.00 J
SB _I D090 ES1 F	900.00
SB DD D100 ES1 A	520.00
SB GG D100 ES1 F	410.00
SB DD D090 ES1 F	310.00 J
SB _T D093 ES1 A	190.00
SB _I D090 ES1 A	170.00
SB DD D090 ES1 A	110.00
SB _T D093 ES1 F	87.00
SB GG D090 ES1 F	57.00
SB _T D110 ES1 F	54.00
SB GG D110 ES1 F	44.00
SB GG D110 ES1 A	36.00
SB FF D090 ES1 F	35.00
SB FF D110 ES1 A	31.00
SB FF D100 ES1 A	30.00
SB GG D130 ES1 F	27.00
SB _T D100 ES1 F	25.00
SB MM D090 ES1 F	25.00
SB GG D120 ES1 F	23.00
SB _T D100 ES1 A	21.00 J
SB _T D130 ES1 F	21.00
SB GG D090 ES1 A	20.00 J
SB FF D110 ES1 F	18.00
SB _T D110 ES1 A	17.00 J
SB GG D120 ES1 A	14.00 J
SB GG D130 ES1 A	12.00 J
SB _T D130 ES1 A	11.00 J
SB MM D090 ES1 F	9.90
SB _Q D090 ES1 F	9.60
SB FF D090 ES1 A	7.00 J

EDB LOCATION	TOTAL ND 56 CONC
SB DD D090 ES1 A	270.00
SB DD D090 ES1 F	210.00 J

ND = non detect

Continued on the next page.

TABLE 4.7g(cont'd)
 DETECTED CONCENTRATIONS of SELECTED VOLATILE
 ORGANIC COMPOUNDS in SOIL,>85 FOOT DEPTH
 (concentrations in ug/kg)

DBCP LOCATION	TOTAL ND 37 CONC
SB DD D100 ES1 A	840.00
SB GG D100 ES1 F	590.00
SB DD D100 ES1 F	410.00 J
SB DD D090 ES1 F	180.00 J
SB GG D090 ES1 F	110.00
SB DD D090 ES1 A	97.00
SB FF D100 ES1 A	75.00
SB GG D110 ES1 A	62.00
SB GG D090 ES1 A	45.00
SB FF D090 ES1 F	31.00
SB _T D093 ES1 A	27.00
SB GG D120 ES1 A	23.00 J
SB GG D130 ES1 F	22.00
SB FF D110 ES1 A	21.00 J
SB _T D110 ES1 F	15.00
SB GG D120 ES1 F	15.00
SB _T D093 ES1 F	15.00
SB GG D110 ES1 F	14.00
SB _T D100 ES1 A	6.00 J
SB _T D100 ES1 F	5.50
SB _T D130 ES1 F	2.90

**Table 4.8
Dinoseb Depth Profile**

Dinoseb Spill Area

Depth Interval	Average	Total Hits	Total NDs	Highest Result	Location
1-10ft	38,8511	21	5	5,100,000	C-10ft
11-20ft	14,957	14	4	58,000	D-14ft
21-30ft	12,969	11	0	120,000	D-25ft
31-40ft	704	2	0	1,400	C-35ft
41-65ft	61	5	4	189	AA-50ft
66-85ft	3.4	2	1	5.3J	U-70ft
>85ft	1.7	1	1	1.7J	U-95ft

Sump and Wash Pad Area

Depth Interval	Average	Total Hits	Total NDs	Highest Result	Location
1-10ft	158	2	8	1,500	L-10ft
11-20ft	1,652	7	6	18,000	I-16ft
21-30ft	152	6	5	1,100J	424-30ft
31-40ft	60	5	6	300	K-35ft
41-65ft	24	6	6	110J	424-60ft
66-85ft	13	2	1	23J	424-67ft
>85ft	--	0	1	--	--

Pond Area

Depth Interval	Average	Total Hits	Total NDs	Highest Result	Location
1-10ft	195	7	6	2,300J	407-10ft
11-20ft	237	4	9	1,600	FF-20ft
21-30ft	2,045	11	2	15,000	407-25ft
31-40ft	1,480	10	2	12,000J	407-33ft
41-65ft	278	19	4	1,900	DD-50ft
66-85ft	210	6	2	890	GG-85ft
>85ft	180	4	4	1,300	DD-100ft

Table 4.9
VOC Depth Profile - Pond and Adjacent Area (conc. in ug/kg)

0-10ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	14	15	10	17	18
Total Hits	8	0	4	2	1
Avg Conc	582	(11)	39	8	10
High Conc Location	11,000 H - 04ft	---	120 H - 08ft	11 H - 10ft	6LJ 407-10ft
11-20ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	12	14	7	13	14
Total Hits	6	0	7	3	2
Avg Conc	119	(9)	30	9	17
High Conc Location	820 H-12ft	---	46 K-20ft	15 J EE-20ft	120 K-15ft
21-30ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	10	13	5	14	15
Total Hits	13	0	8	5	6
Avg Conc	182	(9)	148	70	43
High Conc Location	1,300 H-26ft	---	460 K-30ft	930 407-40ft	120 K-25ft
31-40ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	5	8	4	11	12
Total Hits	33	0	6	5	3
Avg Conc	486	(179)	325	502	183
High Conc Location	3,900 K-35ft	---	2,000 K-35ft	820 I-32	110 403-40ft
41-65ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	7	13	12	16	12
Total Hits	33	2	3	16	20
Avg Conc	936	32	360	126	126
High Conc Location	5,500J 401-45ft	12J H-65ft	2,000 H-65ft	1,500J 407-45ft	2,600 H-65ft

Table 4.9
 VOC Depth Profile - Pond and Adjacent Area (conc.in ug/kg)

66-85ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	4	11	2	10	12
Total Hits	14	0	9	3	20
Avg Conc	685	(52)	38	61	126
High Conc Location	5,700 GG-75ft	-----	200 GG-75ft	140 410-66ft	2,600 H-65ft
>85ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	2	12	7	11	6
Total Hits	14	1	6	2	7
Avg Conc	226	26	177	61	143
High Conc Location	2,000 DD-100ft	20J DD-100ft	1,000 DD-100ft	270 DD-90ft	840 DD-100ft

Table 4.10
VOC Depth Profile - Sump and Wash Pad Area (conc. in ug/kg)

0-10ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	2	4	1	9	10
Total Hits	10	1	4	3	2
Avg Conc	106	16	71	10	16
High Conc Location	690 J - 10ft	14 J - 10ft	220 J - 10ft	26 M - 10ft	15 424-10ft
11-20ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	0	9	0	8	6
Total Hits	22	6	15	9	11
Avg Conc	8,883	677	10,331	1,221	20,671
High Conc Location	33,000 I-16ft	3,600 I-20ft	49,000 I-20ft	11,000 I-20ft	130,000 I-20ft
21-30ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	0	8	0	9	4
Total Hits	23	5	13	9	14
Avg Conc	33,513	915	30,355	2,894	69,797
High Conc Location	200,000 I-30ft	1,400 I-25ft	190,000 I-30ft	36,000 I-30ft	690,000 I-30ft
31-40ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	1	9	1	11	5
Total Hits	21	5	13	5	11
Avg Conc	4,828	197	2,225	502	1,574
High Conc Location	19,000 I-32ft	450 I-32ft	8,300 I-32ft	820 I-32	11,000 I-32ft
41-65ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	0	10	0	13	12
Total Hits	19	1	10	2	2
Avg Conc	1,453	----	450	82	77
High Conc Location	10,000 H-65ft	34 I-50ft	890 I-55ft	310J M-55ft	72 I-50ft

Table 4.10
VOC Depth Profile - Sump and Wash Pad Area (conc. in ug/kg)

66-85ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	0	2	0	4	3
Total Hits	5	0	2	0	2
Avg Conc	3,308	(59)	113	(419)	423
High Conc Location	12,000J 401-66ft	----	200 I-70ft	----	120J 410-66ft
>85ft	1,2-DCP	1,3-DCP	TCP	EDB	DBCP
Total ND	0	2	0	2	2
Total Hits	3	0	2	0	0
Avg Conc	2,225	(252)	535	(133)	(263)
High Conc Location	3,100 I-90ft	----	900 I-90ft	----	----

TAB 11
 ORGANIC CHEMICALS DETECTED IN A-ZONE GROUNDWATER
 (concentrations in ug/L)

WELL LOCATION	SAMPLE ID #	CHEMICAL	HIGHEST RESULT	DATE SAMPLED	TOTAL HITS	TOTAL ANALYSES	FREQ DETECT	HEALTH-BASED ACTION LEVELS *
		<u>VOLATILES</u>						
AMW-2P	MW 02 D001 E05 A	1,1,2,2-Tetrachloroethane	3 LJ	11-Dec-9	3	63	5%	1 Cal MCL
EPAS-03	MW 23 D001 E05 A	1,1,2-Trichloroethane	24	12-Dec-9	18	63	29%	5
WA-6	MW 46 D001 E07 A	1,1-Dichloroethane	36	01-Apr-92	21	63	33%	5 Cal MCL
WA-6	MW 46 D001 E07 A	1,1-Dichloroethene	4 LJ	01-Apr-92	5	63	8%	7
AMW-1P	MW 01 D001 E03 A	1,2,3-Trichloropropane	11000	02-Aug-9	49	63	78%	40 non-cancer H.A. (lifetime)
EPAS-03	MW 23 D001 EW1 A	1,2-Dichlorobenzene	3 J	09-May-9	31	63	49%	10 proposed
WA-6	MW 46 D001 E07 A	1,2-Dichloroethane	140	01-Apr-92	25	63	40%	5
WA-6	MW 46 D001 E07 A	1,2-Dichloropropane	100000	01-Apr-92	45	63	71%	5
AMW-1P	MW 01 D001 E03 A	1,3-Dichloropropane	670	02-Aug-9	33	63	52%	None
WA-6	MW 46 D001 E07 A	Benzene	62	01-Apr-92	24	63	38%	5 (1 for Cal)
WA-2	MW 42 D001 E07 A	Bromodichloromethane	4 LJ	01-Apr-92	3	63	5%	100
AMW-2P	MW 02 D001 E05 A	Carbon Tetrachloride	2 LJ	11-Dec-9	5	63	8%	5 (0.5 Cal)
EPAS-03	MW 23 D001 EW1 A	Chlorobenzene	40	09-May-9	23	63	37%	100 (30 Cal)
WA-6	MW 46 D001 E07 A	Chloroform	1200	01-Apr-92	36	63	57%	100
EPAS-03	MW 23 D001 E02 A	Dibromochloropropane	30000 J	13-Apr-91	61	126	48%	0.2
EPAS-03	MW 23 D001 EW1 A	Ethyl Benzene	4 J	09-May-9	5	63	8%	30 proposed
AMW-1P	MW 01 D001 E02 R	Ethylene Dibromide	6300 J	12-Apr-91	47	126	37%	0.05
WA-6	MW 46 D001 E07 A	Methylene Chloride	53	01-Apr-92	24	63	38%	5
WA-6	MW 46 D001 E07 A	Tetrachloroethene	4 LJ	01-Apr-92	8	63	13%	5
AMW-2P	MW 02 D001 E03 A	Toluene	4 LJ	03-Aug-9	7	63	11%	40 proposed
WA-7	MW 47 D001 E07 L	Trichloroethene	2 LJ	01-Apr-92	3	63	5%	5
EPAS-03	MW 23 D001 EW1 A	Xylenes (Total)	14	09-May-9	14	63	22%	20 proposed
		<u>SEMIVOLATILES</u>						
AMW-2P	MW 02 D001 E01 A	1,2,4-Trichlorobenzene	1 J	17-Jan-91	1	36	3%	70
AMW-2P	MW 02 D001 E03 R	1,2-Dichlorobenzene	2 J	03-Aug-9	2	36	6%	10 proposed
AMW-1P	MW 01 D001 E01 A	1,3-Dichlorobenzene	1 J	17-Jan-91	1	36	3%	600
AMW-2P	MW 02 D001 E01 A	1,4-Dichlorobenzene	2 J	17-Jan-91	1	36	3%	5 proposed
AMW-1P	MW 01 D001 E03 A	2,4-Dinitrophenol	47 J	02-Aug-9	1	36	3%	None
AMW-2P	MW 02 D001 E03 R	2-Methylnaphthalene	1 J	03-Aug-9	1	36	3%	None
AMW-1P	MW 01 D001 E01 A	4-Chloroaniline	4 J	17-Jan-91	1	36	3%	None

TABLE 4.11(cont'd)
 ORGANIC CHEMICALS DETECTED IN A-ZONE GROUNDWATER
 (concentrations in ug/L)

WELL LOCATION	SAMPLE ID #	CHEMICAL	HIGHEST RESULT	DATE SAMPLED	TOTAL HITS	TOTAL ANALYSES	FREQ DETECT	HEALTH-BASED ACTION LEVELS *
		<u>SEMIVOLATILES (cont'd)</u>						
EPAS-03	MW 23D001 E01 A	4-Nitrophenol	32 J	18-Jan-91	2	36	6%	None
AMW-2P	MW 02D001 E02 A	Benzoic Acid	250	11-Apr-91	2	36	6%	None
AMW-1P	MW 01D001 E02 A	Benzyl Alcohol	16 J	12-Apr-91	2	36	6%	None
EPAS-03	MW 23D001 E03 A	bis(2-chloroethyl)ether	1 J	31-Jul-91	1	36	3%	None
AMW-2P	MW 02D001 E03 R	Pentachlorophenol	12 J	03-Aug-9	6	36	17%	1
		<u>HERBICIDES</u>						
AMW-2P	MW 02D001 E03 R	2,4,5-T	5 J	03-Aug-9	3	36	8%	70 non-cancer H.A. (lifetime)
AMW-2P	MW 02D001 E01 A	2,4-D	1 J	17-Jan-91	2	36	6%	70
AMW-2P	MW 02D001 E01 A	2,4-DB	26 J	17-Jan-91	3	36	8%	None
AMW-2P	MW 02D001 E02 A	Dalaphon	11	11-Apr-91	1	36	3%	200
AMW-2P	MW 02D001 E01 A	Dichloroprop	8	17-Jan-91	3	36	8%	None
AMW-1P	MW 01D001 E05 A	Dinoseb	35000 J	10-Dec-9	41	63	65%	7
		<u>CARBAMATE & UREA PESTICIDES</u>						
AMW-1P	MW 01D001 E01 A	Aldicarb	96 J	17-Jan-91	2	33	6%	3
AMW-1P	MW 01D001 E01 A	Carbofuran	147 J	17-Jan-91	6	33	18%	40
AMW-2P	MW 02D001 E01 R	Chloroprotham	46	17-Jan-91	3	33	9%	350 Cal Action Level
AMW-1P	MW 01D001 E05 A	Diuron	100	10-Dec-9	5	33	15%	10 non-cancer H.A. (lifetime)
AMW-2P	MW 02D001 E01 R	Fenuron	85	17-Jan-91	2	33	6%	None
AMW-2P	MW 02D001 E01 R	Fluometuron	40	17-Jan-91	2	33	6%	90 non-cancer H.A. (lifetime)
EPAS-03	MW 23D001 E01 A	Linuron	3	18-Jan-91	1	33	3%	None
AMW-1P	MW 01D001 E01 A	Methicarb	2 J	17-Jan-91	2	33	6%	None
AMW-1P	MW 01D001 E01 A	Monuron	8 J	17-Jan-91	2	33	6%	None
EPAS-03	MW 23D001 E01 A	Protham	31	18-Jan-91	2	33	6%	100 non-cancer H.A. (lifetime)
AP-4	MW 14D001 E03 A	Propoxur	16	02-Aug-9	2	33	6%	None
AMW-2P	MW 02D001 E01 A	Siduron	8	17-Jan-91	1	33	3%	None

* - USEPA drinking water MCL Listed unless otherwise noted

TAB 4.12

CONCENTRATIONS of SELECTED ORGANIC CHEMICALS in A-ZONE GROUNDWATER
(concentrations in ug/L)

LOCATION	DATE	SID	Dinoseb	Chloroform	1,2-Dichloro Propane	1,3-Dichloro Propane	1,2,3-Trichloro Propane	Ethylene Dibromide	Dibromochloro Propane	
AMW-1P	Jan-91	MW 01 D001 E01 A	16350.00	120.00 UJ	29000.00	550.00	6800.00	1300.00	420.00 J	
	Apr-91	MW 01 D001 E02 A	17000.00	53.00	32000.00	500.00	6700.00	1300.00	430.00	
	Apr-91	MW 01 D001 E02 R	9200.00	50.00	31000.00	470.00	6000.00	1300.00	370.00	
	Aug-91	MW 01 D001 E03 A	6700.00	38.00	25000.00	670.00	11000.00	930.00	180.00	
	Dec-91	MW 01 D001 E05 A	35000.00 J	35.00	19000.00	600.00	9000.00	980.00	170.00	
	Apr-92	MW 01 D001 E07 A	34000.00 J	18.00	9800.00	390.00	6900.00	380.00	64.00	
	Jul-92	MW 01 D001 E08 A	40000.00	22.00	14000.00	420.00	10000.00	330.00	50.00	
			MAX	40000.00	53.00	32000.00	670.00	11000.00	1300.00	430.00
			MIN	6700.00	18.00	9800.00	390.00	6000.00	330.00	50.00
			AVG	22607.14 +	48.00	22828.57 +	514.29	8057.14 +	931.43 +	240.57 +
AMW-2P	Jan-91	MW 02 D001 E01 A	49.00 J	1000.00	78000.00	74.00	3600.00	1.50 *	340.00 J	
	Jan-91	MW 02 D001 E01 R	9.00 UJ	910.00	74000.00	67.00	3200.00	1.30 *	310.00 J	
	Apr-91	MW 02 D001 E02 A	13.00 U	1100.00	86000.00	73.00	4100.00	67.00 *	320.00	
	Aug-91	MW 02 D001 E03 A	15.00 J	1100.00	91000.00	81.00	4400.00	2.00 *	480.00	
	Aug-91	MW 02 D001 E03 R	27.00 J	1100.00	87000.00	75.00	1600.00	2.00 *	450.00	
	Dec-91	MW 02 D001 E05 A	440.00 J	840.00	80000.00	87.00	3800.00	2.00	480.00	
	Dec-91	MW 02 D001 E05 R	440.00 J	870.00	82000.00	82.00	4000.00	2.00	450.00	
	Apr-92	MW 02 D001 E07 A	240.00 J	450.00	48000.00	46.00	1700.00	1.00 LJ	210.00	
	Apr-92	MW 02 D001 E07 R	240.00 J	420.00	48000.00	44.00	1700.00	1.00 LJ	220.00	
	Jul-92	MW 02 D001 E08 A	190.00	430.00	52000.00	57.00	1700.00	1.00 LJ	180.00	
		MAX	440.00	1100.00	91000.00	87.00	4400.00	67.00 *	480.00	
		MIN	9.00	420.00	48000.00	67.00	1600.00	1.30 *	180.00	
		AVG	168.45 +	822.00 +	72600.00 +	68.60	2980.00 +	8.08 +	344.00 +	
AP-1	Jan-91	MW 11 D001 E01 A	0.80 UJ	5.00 U	5.00 U	5.00 U	5.00 U	0.05 U*	0.01 J*	
	Apr-91	MW 11 D001 E02 A	45.00	5.00 U	5.00 U	5.00 U	1.00 J	0.05 U*	0.05 U*	
	Aug-91	MW 11 D001 E03 A	0.30 LJ	5.00 U	5.00 U	5.00 U	5.00 U	0.05 U*	0.05 U*	
	Dec-91	MW 11 D001 E05 A	8.00	10.00 U	10.00 U	10.00 U	1.00 LJ	0.05 U*	0.05 U*	
	Apr-92	MW 11 D001 E07 A	RJ	10.00 U	10.00 U	10.00 U	10.00 U	0.05 U*	0.05 U*	
			MAX	45.00	ALL	ALL	ALL	1.00 J	ALL	0.01 J*
		MIN	0.30	ND	ND	ND	1.00 J	ND	0.01 J*	
		AVG	10.82 +				4.40		0.04	

TABLE 4.12(cont'd)
CONCENTRATIONS of SELECTED ORGANIC CHEMICALS in A-ZONE GROUNDWATER
 (concentrations in ug/L)

LOCATION	DATE	SID	Dinoseb	Chloroform	1,2-Dichloro Propane	1,3-Dichloro Propane	1,2,3-Trichloro Propane	Ethylene Dibromide	Dibromochloro Propane	
AP-2	Jan-91	MW 12 D001 E01 A	0.80 UJ	5.00 UJ	8.00	5.00 U	8.00	0.05 U*	1.80 *	
	Apr-01	MW 12 D001 E02 A	310.00	3.00 J	8.00	5.00 U	8.00	0.05 U*	3.00 J*	
	Aug-91	MW 12 D001 E03 A	2.00 UR	4.00 LJ	10.00	5.00 U	9.00	0.05 U*	1.00 *	
	Dec-91	MW 12 D001 E05 A	0.40 J	5.00 LJ	10.00 UJ	10.00 U	8.00 LJ	0.05 U*	2.00 *	
	Apr-92	MW 12 D001 E07 A	RJ	5.00 LJ	22.00	10.00 U	47.00	0.05 U*	1.00 *	
			MAX	310.00	5.00	22.00	ALL	47.00	ALL	3.00 J*
			MIN	0.40	3.00	8.00	ND	8.00	ND	1.00 *
		AVG	62.64 +	4.40	11.60 +		18.00		1.76 +	
AP-3	Jan-91	MW 13 D001 E01 A	9.00 UJ	5.00 U	38.00	5.00 U	16.00	4.70 *	7.80 *	
	Jan-91	MW 13 D001 E01 R	6.00 UJ	5.00 U	35.00	5.00 U	16.00	3.20 *	8.80 *	
	Apr-91	MW 13 D001 E02 A	1.00 U	5.00 U	22.00	5.00 U	16.00	0.80 J*	9.00 J*	
	Apr-91	MW 13 D001 E02 R	1.00 U	5.00 U	23.00	5.00 U	16.00	0.90 J*	10.00 J*	
	Aug-91	MW 13 D001 E03 A	23.00 J	5.00 U	28.00	5.00 U	16.00	0.90 *	3.00 *	
	Aug-91	MW 13 D001 E03 R	10.00 J	5.00 U	28.00	5.00 U	17.00	0.90 *	2.00 *	
	Dec-91	MW 13 D001 E05 A	230.00 J	10.00 U	48.00	10.00 U	33.00	6.00 J*	11.00	
Apr-92	MW 13 D001 E07 A	13.00 J	5.00 LJ	86.00	10.00 U	47.00	2.00	44.00		
		MAX	230.00	5.00 LJ	86.00	ALL	47.00	6.00 J*	44.00	
		MIN	1.00 U	5.00 LJ	22.00	ND	16.00	0.80 J*	2.00 *	
		AVG	36.63 +	5.63	38.50 +		22.13	2.43 +	11.95 +	
AP-4	Jan-91	MW 14 D001 E01 A	9.00 UJ	59.00 UJ	8700.00	11.00 J	390.00	0.05 U*	15.00 *	
	Apr-91	MW 14 D001 E02 A	1.00 U	75.00	9400.00	11.00 J	400.00	2.00 J*	42.00 J*	
	Aug-91	MW 14 D001 E03 A	1.00 LJ	86.00	9800.00	12.00	490.00	0.30 *	19.00	
	Dec-91	MW 14 D001 E05 A	18.00	110.00	13000.00	14.00	580.00	0.05 U*	24.00	
	Apr-92	MW 14 D001 E07 L	RJ	92.00	11000.00	15.00	460.00	0.05 U*	39.00	
			MAX	18.00	110.00	13000.00	15.00	580.00	2.00 J*	42.00 J*
		MIN	1.00	59.00 UJ	8700.00	11.00	390.00	0.05 U*	15.00	
		AVG	5.80	84.40	10380.00 +	12.60	464.00 +	0.49	27.80 +	

TABLE 3.12(cont'd)
CONCENTRATIONS of SELECTED ORGANIC CHEMICALS in A-ZONE GROUNDWATER
 (concentrations in ug/L)

LOCATION	DATE	SID	Dinoseb	Chloroform	1,2-Dichloro Propane	1,3-Dichloro Propane	1,2,3-Trichloro Propane	Ethylene Dibromide	Dibromochloro Propane	
EPAS-2	Jan-91	MW 22 D001 E01 A	3.00 UJ	50.00 UJ	9000.00	36.00 J	520.00	25.00 J	91.00 J	
	Apr-91	MW 22 D001 E02 A	310.00	38.00 J	7100.00	27.00	440.00	19.00 J	64.00 J	
	Aug-91	MW 22 D001 E03 L	140.00	42.00	7400.00	21.00	420.00	16.00	68.00	
	Dec-91	MW 22 D001 E05 L	800.00 J	51.00	9700.00	25.00	500.00	33.00	65.00	
	Apr-92	MW 22 D001 E07 A	1100.00 J	60.00	9600.00	33.00	580.00	58.00	70.00	
	Apr-92	MW 22 D001 E07 R	1000.00 J	59.00	9600.00	35.00	620.00	66.00	78.00	
			MAX	1100.00 J	60.00	9700.00	36.00 J	620.00	66.00	91.00
			MIN	3.00 UJ	38.00 J	7100.00 U	21.00	420.00	16.00	64.00
		AVG	558.83 +	50.00	8733.33 +	29.50	513.33 +	36.17 +	72.67 +	
EPAS-3	Jan-91	MW 23 D001 E01 A	411.00	50.00 UJ	34000.00	200.00	2100.00	33.00 J	4100.00 J	
	Apr-91	MW 23 D001 E02 A	604.00	22.00 J	33000.00	180.00	2200.00	28.00 J	4000.00	
	Aug-91	MW 23 D001 E03 A	680.00	26.00	38000.00	220.00	2700.00	36.00	5200.00	
	Dec-91	MW 23 D001 E05 A	1100.00 J	32.00	37000.00	200.00	2200.00	37.00	4400.00	
	Apr-92	MW 23 D001 E07 A	1000.00 J	31.00	34000.00	180.00	2500.00	32.00	5100.00	
			MAX	1100.00 J	32.00	38000.00	220.00	2700.00	37.00	5200.00
			MIN	411.00	22.00 J	33000.00	180.00	2100.00	28.00 J	4000.00
			AVG	759.00 +	32.20	35200.00 +	196.00	2340.00 +	33.20 +	4560.00 +
EPAS-4	Jan-91	MW 24 D001 E01 A	1.00 UJ	5.00 U	5.00 U	5.00 U	5.00 U	0.05 U*	0.05 U*	
	Apr-91	MW 24 D001 E02 A	0.20 J	5.00 U	5.00 U	5.00 U	5.00 U	0.05 U*	0.05 U*	
	Aug-91	MW 24 D001 E03 A	2.00 UJ	5.00 U	5.00 U	5.00 U	5.00 U	0.05 U*	0.05 U*	
	Aug-91	MW 24 D001 E05 A	0.20 UJ	10.00 U	2.00 LJ	10.00 U	10.00 U	0.05 U*	0.05 U*	
	Apr-92	MW 24 D001 E07 A	RJ	10.00 U	1.00 LJ	10.00 U	10.00 U	0.05 U*	0.05 U*	
			MAX	0.20 J	ALL	2.00 LJ	ALL	ALL	ALL	ALL
			MIN	0.20 UJ	ND	1.00 LJ	ND	ND	ND	ND
			AVG	0.68		3.60				
WA-1	Apr-92	MW 41 D001 E07 A	6.00 J	10.00 U	10.00 U	10.00 U	4.00 LJ	0.05 UJ	0.20 UJ	
	Aug-92	MW 41 D001 E08 A	0.70 UJ	10.00 U	2.00 LJ	10.00 U	7.00 LJ	0.05 U*	0.80 *	
			AVG	3.35	ALL ND	6.00 +	ALL ND	5.50	ALL ND	0.50 +

TABLE 4.12(cont'd)
 CONCENTRATIONS of SELECTED ORGANIC CHEMICALS in A-ZONE GROUNDWATER
 (concentrations in ug/L)

LOCATION	DATE	SID	Dinoseb	Chloroform	1,2-Dichloro Propane	1,3-Dichloro Propane	1,2,3-Trichloro Propane	Ethylene Dibromide	Dibromochloro Propane
WA-2	Apr-92	MW 42 D001 E07 A	0.70 RU	300.00	10.00 U	10.00 U	10.00 U	0.05 UJ	0.06 UJ
	Apr-92	MW 42 D001 E07 R	NA	250.00	10.00 U	10.00 U	10.00 U	NA	NA
	Jul-92	MW 42 D001 E08 A	0.70 UJ	330.00	10.00 U	10.00 U	10.00 U	0.05 U*	0.05 U*
		AVG	ALL ND	293.33 +	ALL ND	ALL ND	ALL ND	ALL ND	ALL ND
WA-3	Apr-92	MW 43 D001 E07 R	NA	1.00 LJ	41.00	10.00 U	6.00 LJ	0.05 UJ	0.09 UJ
	Apr-92	MW 43 D001 E07 A	0.70 RU	1.00 LJ	41.00	10.00 U	6.00 LJ	0.05 UJ	0.09 UJ
	Jul-92	MW 43 D001 E08 A	0.70 U	1.00 LJ	37.00	10.00 U	7.00 LJ	0.05 U*	0.08 UJ
		AVG	ALL ND	1.00	39.67 +	ALL ND	6.33	ALL ND	ALL ND
WA-4	Apr-92	MW 44 D001 E07 A	NA	NA	NA	NA	NA	NA	NA
	Jul-92	MW 44 D001 E08 A	0.70 U	10.00 U	5.00 LJ	10.00 U	10.00 U	0.05 U*	0.05 UJ
WA-5	Apr-92	MW 45 D001 E07 A	NA	NA	NA	NA	NA	NA	NA
	Jul-92	MW 45 D001 E08 A	0.70 UJ	10.00 U	2.00 LJ	10.00 U	10.00 U	0.05 U*	0.05 UJ
WA-6	Apr-92	MW 46 D001 E07 A	420.00 J	1200.00	100000.00	90.00	2500.00	5.00 LJ	200.00
	Jul-92	MW 46 D001 E08 A	360.00	810.00	91000.00	80.00	2500.00	10.00 U	130.00
		AVG	390.00 +	1005.00 +	95500.00 +	85.00	2500.00 +	7.50 +	165.00 +
WA-7	Apr-92	MW 47 D001 E07 A	7.00 J	180.00	24000.00	6.00 LJ	540.00	0.05 UJ	32.00
	Jul-92	MW 47 D001 E08 R	7.00	180.00	29000.00	5.00 LJ	560.00	0.05 U*	31.00
	Jul-92	MW 47 D001 E08 A	7.00	190.00	27000.00	5.00 LJ	620.00	0.05 U*	30.00
		AVG	7.00 +	185.00 +	28000.00 +	5.00	590.00 +	ALL ND	30.50 +
WA-8	Apr-92	MW 48 D001 E07 A	0.70 UR	10.00 U	4.00 LJ	10.00 U	14.00	0.05 U*	0.05 U*
	Jul-92	MW 48 D001 E08 A	0.70 U	10.00 U	3.00 LJ	10.00 U	15.00	0.05 U*	0.05 UJ
		AVG	ALL ND	ALL ND	3.50	ALL ND	14.50	ALL ND	ALL ND
WA-9	Apr-92	MW 49 D001 E07 A	0.70 UR	27.00	16.00	10.00 U	10.00 U	0.05 UJ	0.05 UJ
	Jul-92	MW 49 D001 E08 A	0.70 UJ	31.00	23.00	10.00 U	10.00 U	0.05 U*	0.05 U*
		AVG	ALL ND	29.00	19.50 +	ALL ND	ALL ND	ALL ND	ALL ND

+ - Average concentrations greater than or equal to health-based levels

* - Results by Method 504

TABLE 4.13
HIGHEST CONCENTRATIONS OF METALS DETECTED IN GROUNDWATER
(concentrations in ug/l)

SAMPLE ID NO.	CHEMICAL	HIGHEST RESULT	DATE SAMPLED	TOTAL # of HITS*	BACKGRD AVERAGE (A-Zone)	HEALTH-BASED ACTION LEVEL**
<u>A-ZONE</u>						
MW 23 D001 E05 A	Aluminum	53000	12-DEC-91	60	3734	10000 Cal. MCL
MW 01 D001 E03 A	Antimony	567	02-Aug-91	27	ND	6
MW 02 D001 E02 A	Arsenic	750	11-Apr-91	57	19	50
MW 23 D001 E05 A	Barium	758	12-Dec-91	54	153	2000
MW 13 D001 E03 A	Beryllium	8.4	02-Aug-91	15	ND	4
MW 02 D001 E01 A	Cadmium	6.1	17-Jan-91	5	ND	5
MW 01 D001 E01 A	Calcium	2010000	17-Jan-91	60	4700	
MW 24 D001 E05 A	Chromium	872	11-Dec-91	56	538	100
MW 01 D001 E05 A	Cobalt	44.2 LJ	10-Dec-91	21	15	
MW 02 D001 E05 R	Copper	105	11-Dec-91	49	29	1300 MCLG
MW 23 D001 E05 A	Iron	77000	12-Dec-91	60	11258	
MW 23 D001 E05 A	Lead	40.5 J	12-Dec-91	34	4.5	50
MW 01 D001 E05 A	Magnesium	629000	10-Dec-91	60	8646	
MW 23 D001 E05 A	Manganese	2210	12-Dec-91	60	131	
MW 46 D001 E07 A	Mercury	1.7 J	01-Apr-92	11	ND	2
MW 48 D001 E07 A	Nickel	403	01-Apr-92	60	87	100
MW 02 D001 E02 A	Potassium	39400 J	11-Apr-91	60	2250	
MW 46 D001 E07 A	Selenium	126 J	01-Apr-92	46	3	50
MW 01 D001 E03 A	Silver	30.4 LJ	02-Aug-91	20	ND	
MW 01 D001 E05 A	Sodium	467000 J	10-Dec-91	60	105780	
MW 02 D001 E03 A	Vanadium	205	03-Aug-91	54	28	20 LTHL***
MW 23 D001 E05 A	Zinc	208	12-Dec-91	55	36	
<u>B-ZONE</u>						
MW 54 D002 E07 A	Aluminum	202	01-Apr-92	6		10000 Cal. MCL
MW 31 D002 E03 L	Antimony	72	31-Jul-91	5		6
MW 52 D002 E07 A	Arsenic	14.7	01-Apr-92	17		50
MW 54 D002 E07 A	Barium	303	01-Apr-92	19		2000
MW 51 D002 E07 A	Calcium	164000	01-Apr-92	19		
MW 54 D002 E07 A	Chromium	88.5	01-Apr-92	13		100
MW 33 D002 E01 A	Copper	4.4 LJ	19-Jan-91	1		1300 MCLG
MW 54 D002 E07 A	Iron	574	01-Apr-92	15		
MW 51 D002 E07 A	Lead	1.0 LJ	01-Apr-92	1		50
MW 51 D002 E07 A	Magnesium	25000	01-Apr-92	19		
MW 53 D002 E07 A	Manganese	28.6	01-Apr-92	10		
MW 52 D002 E07 A	Mercury	0.2 J	01-Apr-92	2		2
MW 53 D002 E07 A	Nickel	33.6 LJ	01-Apr-92	2		100
MW 52 D002 E07 A	Potassium	7030	01-Apr-92	19		
MW 52 D002 E07 A	Selenium	30.4	01-Apr-92	19		50
MW 34 D002 E03 A	Silver	6.6 LJ	01-Aug-91	19		
MW 52 D002 E07 A	Vanadium	52.5	01-Apr-92	18		20 LTHL
MW 33 D002 E03 A	Zinc	53.2	30-Jul-91	14		

TABLE 4.13(cont'd)
HIGHEST CONCENTRATIONS OF METALS DETECTED IN GROUNDWATER
 (concentrations in ug/l)

SAMPLE ID NO.	CHEMICAL	HIGHEST RESULT	DATE SAMPLED	TOTAL # of HITS*	BACKGRD AVERAGE (A-Zone)	HEALTH-BASED ACTION LEVEL**
CITY WELLS						
DW 01 D003 E05 A	Aluminum	57.6 LJ	11-Dec-91	3		10000 Cal. MCL
DW 05 D003 E05 A	Antimony	19.5 LJ	11-Dec-91	1		6
DW 01 D003 E01 A	Arsenic	47.2	15-Jan-91	9		50
DW 01 D003 E05 A	Barium	43.7 LJ	11-Dec-91	9		2000
DW 01 D003 E05 A	Calcium	14600 J	11-Dec-91	9		
DW 01 D003 E07 A	Chromium	3.4 LJ	01-Apr-92	1		100
DW 05 D003 E05 A	Cobalt	5.5 LJ	11-Dec-91	3		1300 MCLG
DW 01 D003 E05 A	Iron	248.0 J	11-Dec-91	8		
DW 05 D003 E01 A	Lead	1.0 LJ	15-Jan-91	1		50
DW 05 D003 E01 A	Magnesium	1220 LJ	15-Jan-91	9		
DW 01 D003 E05 A	Manganese	5.7 LJ	11-Dec-91	2		
DW 01 D003 E07 A	Mercury	0.2 J	01-Apr-92	1		2
DW 05 D003 E01 A	Potassium	1810 LJ	15-Jan-91	9		
DW 05 D003 E02 A	Selenium	4.8 LJ	11-Apr-91	3		50
DW 01 D003 E03 A	Sodium	65700	31-Jul-91	9		
DW 01 D003 E03 A	Vanadium	53.2	31-Jul-91	9		20 LTHL
DW 01 D003 E07 A	Zinc	18.1 LJ	01-Apr-92	4		

*The total number of analyses for the A-zone, B-zone and City wells was 60, 19, and 9, respectively.

**Health-Based action levels are drinking water MCLs unless otherwise indicated.

***LTHL: Life-time Health Advisory Level (non-cancer)

TABLE 4.14
 AVERAGE CONCENTRATIONS OF pH, TOTAL DISSOLVED SOLIDS
 AND
 MAJOR CATIONS AND ANIONS IN GROUNDWATER WELLS

WELL LOCATION	ALKALINITY		CHLORIDE		NITRATE		SULFATE		pH CONC.	TDS CONC.	CALCIUM		MAGNESIUM	
	CONC. mg/l	EQUIV meq/l			CONC. mg/l	EQUIV meq/l	CONC. mg/l	EQUIV meq/l						
A-ZONE														
AMW-1P	506	8.3	460	13.0	1598	25.8	1814	36.8	6.5	12000	1695	84.6	528	43.4
AMW-2P	937	15.4	552	15.6	463	7.5	502	10.2	7.3	2299	64	3.2	38	3.1
AP-01	215	3.5	73	2.1	23	0.4	96	1.9	7.6	615	79	3.9	16	1.3
AP-02	240	3.9	107	3.0	42	0.7	180	3.7	7.3	973	150	7.5	28	2.3
AP-03	419	6.9	62	1.7	71	1.1	214	4.3	7.1	1290	166	8.3	38	3.1
AP-04	329	5.4	142	4.0	198	3.2	174	3.5	7	1768	268	13.4	56	4.6
EPAS-2	312	5.1	123	3.5	153	2.5	203	4.1	7.1	1528	207	10.3	43	3.5
EPAS-3	537	8.8	141	4.0	451	7.3	363	7.4	6.8	4946	805	40.2	142	11.7
EPAS-4	204	3.3	64	1.8	6	0.1	62	1.3	8	459	47	2.3	9	0.7
WA-1	221	3.6	69	1.9	26	0.4	113	2.3	7.4	684	77	3.8	31	2.6
WA-2	139	2.3	197	5.6	23	0.4	123	2.5	7.6	841	123	6.1	20	1.6
WA-3	164	2.7	236	6.7	61	1.0	396	8.0	7.5	1653	260	13.0	34	2.8
WA-4	185	3.0	126	3.6	26	0.4	154	3.1	7.8	843	139	6.9	20	1.6
WA-5	205	3.4	92	2.6	14	0.2	154	3.1	7.6	734	113	5.6	16	1.3
WA-6	552	9.0	728	20.5	520	8.4	516	10.5	6.7	6285	865	43.2	180	14.8
WA-7	153	2.5	350	9.9	190	3.1	184	3.7	7.5	2077	363	18.1	46	3.8
WA-8	227	3.7	89	2.5	78	1.3	243	4.9	7.7	1530	177	8.8	39	3.2
WA-9	220	3.6	379	10.7	29	0.5	114	2.3	7.4	1395	209	10.4	32	2.6
B-ZONE														
AR-1	124	2.0	205	5.8	34	0.5	100	2.0	7.8	846	142	7.1	21	1.7
AMW-3R	138	2.3	95	2.7	29	0.5	53	1.1	7.8	552	89	4.4	11	0.9
AMW-4R	114	1.9	106	3.0	28	0.5	53	1.1	7.8	529	91	4.5	15	1.2
WB2-1	92	1.5	184	5.2	74	1.2	63	1.3	7.6	1510	170	8.5	26	2.1
WB2-2	87	1.4	181	5.1	49	0.8	65	1.3	9.8	804	127	6.3	8	0.7
WB2-3	128	2.1	207	5.8	7	0.1	64	1.3	7.6	651	90	4.5	15	1.2
WB2-4	67	1.1	197	5.6	5	0.1	38	0.8	8.3	524	69	3.4	6	0.5
DRINKING WATER WELLS														
CW-1	85	1.4	35	1.0	3	0.0	30	0.6	8.4	232	13	0.6	1	0.1
CW-5	85	1.4	26	0.7	3	0.0	26	0.5	8.5	201	14	0.7	1	0.1

(continued on next page)

all averages over first four sampling rounds, except that all "WA" and "WB" wells were averaged over the last two sampling rounds.

TABLE 4.14(cont'd)
AVERAGE CONCENTRATIONS OF pH, TOTAL DISSOLVED SOLIDS
AND
MAJOR CATIONS AND ANIONS IN GROUNDWATER WELLS

WELL LOCATION	POTASIIUM		SODIUM		SUM OF ANIONS meq/l	SUM OF CATIONS meq/l
	CONC. mg/l	EQUIV meq/l	CONC. mg/l	EQUIV meq/l		
A-ZONE						
AMW-1P	11	0.3	387	16.8	84	145
AMW-2P	33	0.8	260	11.3	49	18
AP-01	5	0.1	107	4.7	8	10
AP-02	5	0.1	114	5.0	11	15
AP-03	7	0.2	178	7.7	14	19
AP-04	14	0.4	148	6.4	16	25
EPAS-2	8	0.2	144	6.3	15	20
EPAS-3	10	0.3	249	10.8	27	63
EPAS-4	23	0.6	105	4.6	7	8
WA-1	5	0.1	137	6.0	8	12
WA-2	2	0.1	100	4.4	11	12
WA-3	3	0.1	124	5.4	18	21
WA-4	4	0.1	99	4.3	10	13
WA-5	2	0.1	102	4.4	9	11
WA-6	10	0.3	382	16.6	48	75
WA-7	7	0.2	174	7.6	19	30
WA-8	8	0.2	253	11.0	12	23
WA-9	4	0.1	135	5.9	17	19
B-ZONE						
AR-1	4	0.1	77	3.3	10	12
AMW-3R	3	0.1	62	2.7	6	8
AMW-4R	3	0.1	60	2.6	6	8
WB2-1	3	0.1	84	3.7	9	14
WB2-2	9	0.2	100	4.4	9	12
WB2-3	3	0.1	98	4.3	9	10
WB2-4	2	0.1	87	3.8	8	8
DRINKING WATER WELLS						
CW-1	2	0.1	62	2.7	3	3
CW-5	2	0.1	54	2.3	3	3

all averages over first four sampling rounds, except that all "WA" and "WB" wells were averaged over the last two sampling rounds.

Table 4.15
Concentrations of Organic Chemicals Detected
in B-Zone Groundwater and City Wells

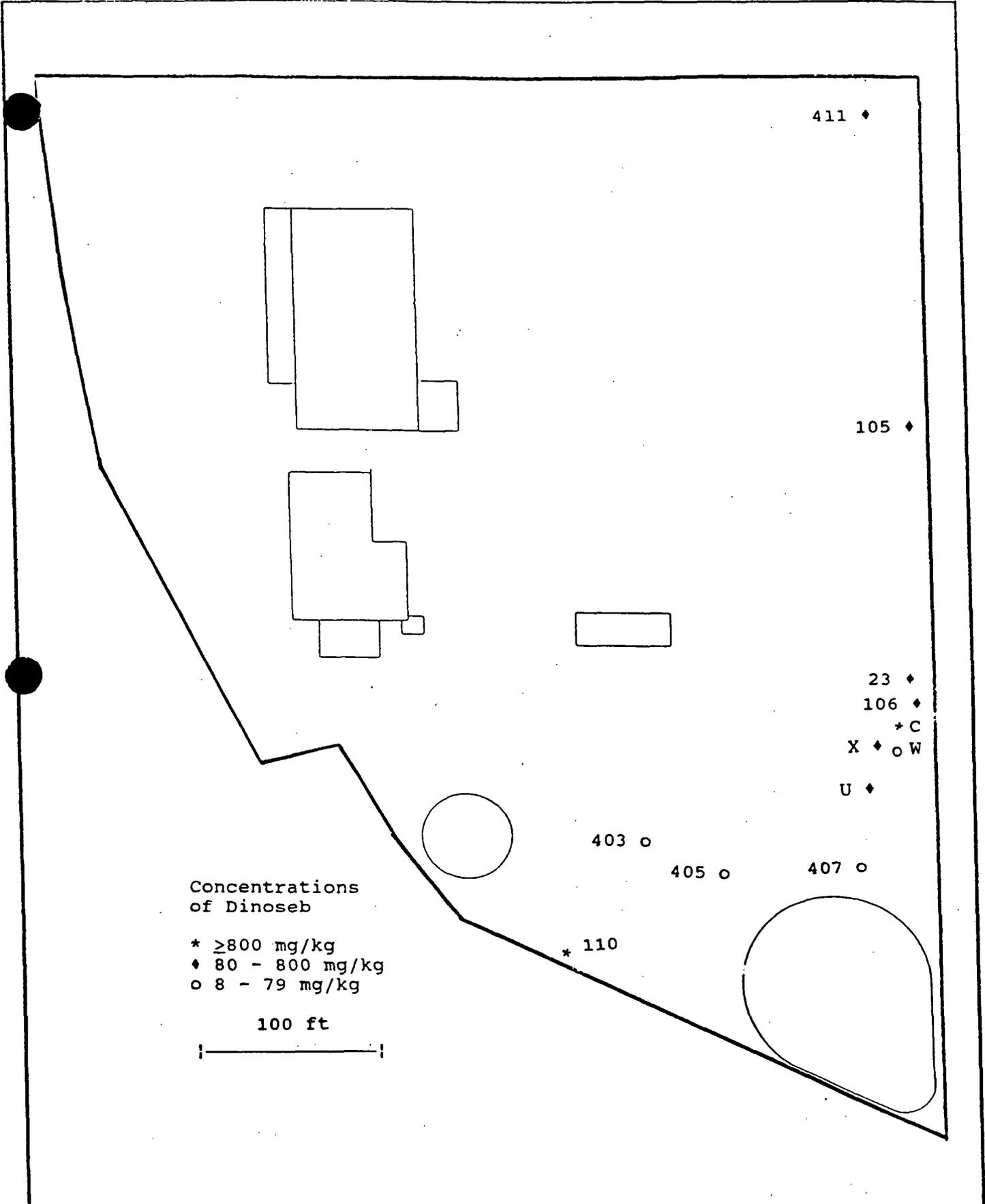
AR-01	ug/l	Date
1,2-Dichloropropane	12	Jan 1991
1,2-Dichloropropane	10	Apr 1991
1,2-Dichloropropane	8	Jul 1991
1,2-Dichloropropane	6	Dec 1991
1,2-Dichloropropane	5	Apr 1992
1,2-Dichloropropane	4	Jul 1992
Toluene	0.8 J	Apr 1991
Toluene	0.3 LJ	Dec 1991
AMW-3R		
1,2-Dichloropropane	0.7 J	Jan 1991
1,2-Dichloropropane	0.6 J	Apr 1991
1,2-Dichloropropane	0.9 LJ	Jul 1991
1,2-Dichloropropane	2	Dec 1992
1,2-Dichloropropane	1 LJ	Apr 1992
1,2-Dichloropropane	0.7 LJ	Jul 1992
Toluene	0.9 LJ	Apr 1991
Toluene	0.5 LJ	Dec 1991
AMW-4R		
1,2-Dichloropropane	1	Jan 1991
1,2-Dichloropropane	2	Apr 1991
1,2-Dichloropropane	3	Jul 1991
1,2-Dichloropropane	4	Dec 1991
1,2-Dichloropropane	1 LJ	Apr 1992
1,2-Dichloropropane	2	Apr 1992
1,2-Dichloropropane	5	Apr 1992
1,2-Dichloropropane	6	Jul 1992
Toluene	0.4 J	Apr 1991
Toluene	0.4 LJ	Dec 1991
Butylbenzylphthalate	2 J	Apr 1991

Table 4.15
Concentrations of Organic Chemicals Detected
in B-Zone Groundwater and City Wells

WB2-1	ug/l	Date
1,2,3-Trichloropropane	72	Apr 1992
1,2,3-Trichloropropane	58	Jul 1992
1,2,3-Trichloropropane	63	Jul 1992
1,1-Dichloroethane	0.3 LJ	Apr 1992
1,1-Dichloroethane	0.2 LJ	Jul 1992
1,1-Dichloroethane	0.2 LJ	Jul 1992
1,2-Dichloroethane	2	Apr 1992
1,2-Dichloroethane	1 LJ	Jul 1992
1,2-Dichloroethane	1 LJ	Jul 1992
1,2-Dichloropropane	1,700	Apr 1992
1,2-Dichloropropane	960	Jul 1992
1,2-Dichloropropane	820	Jul 1992
1,3-Dichloropropane	1 LJ	Apr 1992
1,3-Dichloropropane	1 LJ	Jul 1992
1,3-Dichloropropane	1 LJ	Jul 1992
Dibromochloropropane	30	Apr 1992
Dibromochloropropane	27	Jul 1992
Dibromochloropropane	27	Jul 1992
Ethylene dibromide	0.06 NC	Jul 1992
Dinoseb	5 J	Apr 1992
Dinoseb	3	Jul 1992
Dinoseb	4	Jul 1992
WB2-2		
1,2,3-Trichloropropane	19	Apr 1992
1,2,3-Trichloropropane	19	Jul 1992
1,2-Dichloropropane	47	Apr 1992
1,2-Dichloropropane	40	Jul 1992
Dibromochloropropane	7	Apr 1992
Dibromochloropropane	7	Jul 1992

Table 4.15
Concentrations of Organic Chemicals Detected
in B-Zone Groundwater and City Wells

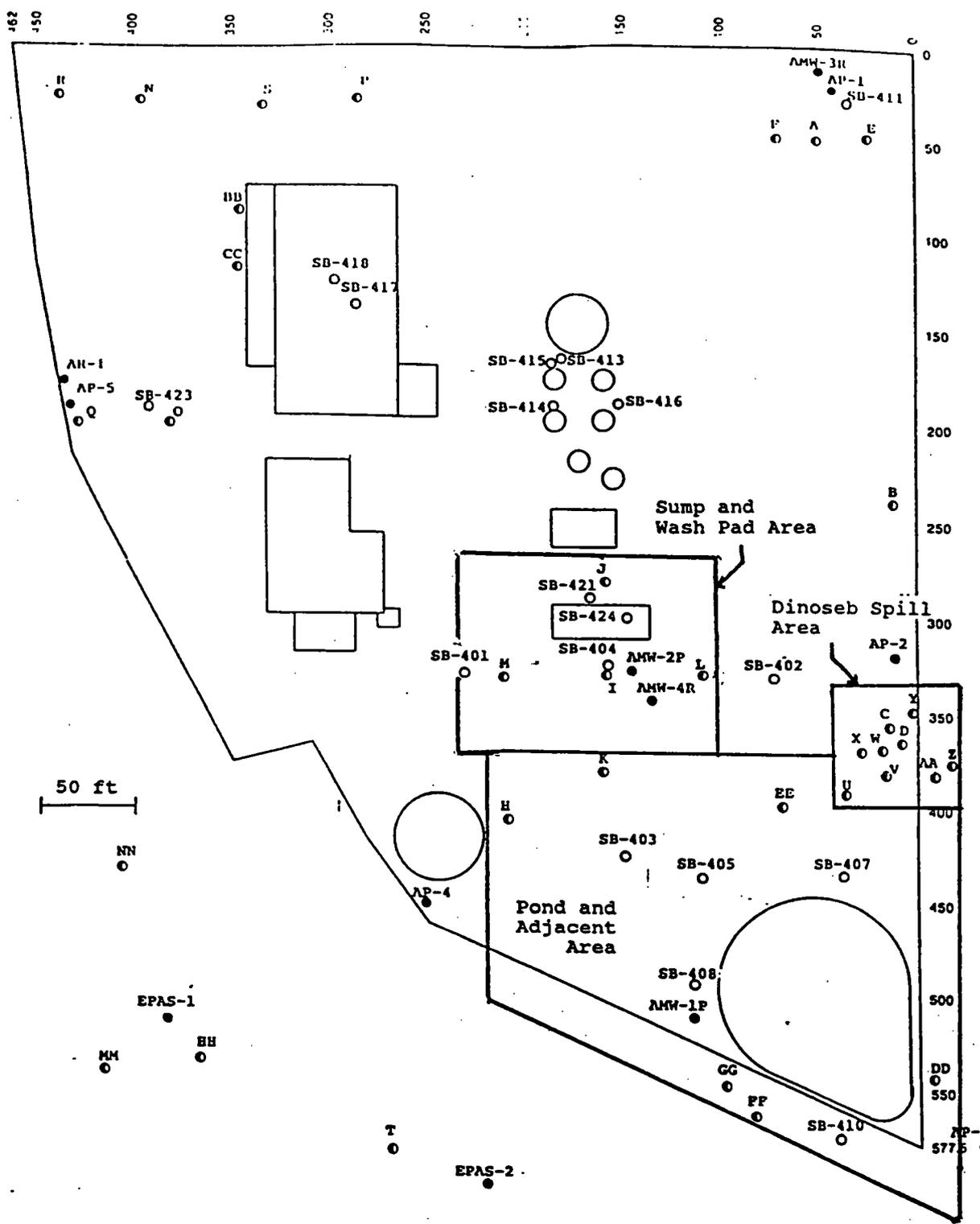
WB2-2 (cont'd)	ug/l	Date
Dinoseb	2 J	Apr 1992
Dinoseb	8 J	Jul 1992
WB2-3		
1,2-Dichloropropane	0.8 LJ	Apr 1992
1,2-Dichloropropane	0.8 LJ	Jul 1992
WB2-4		
1,2-Dichloropropane	0.3 LJ	Jul 1992
City Well #1		
1,2-Dichloropropane	0.3 LJ	Dec 1991
Bromodichloromethane	1 LJ	Dec 1991
Bromoform	0.8 LJ	Dec 1991
Chloroform	6 LJ	Dec 1991
Dibromochloromethane	0.7 LJ	Dec 1991



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Figure 4.1

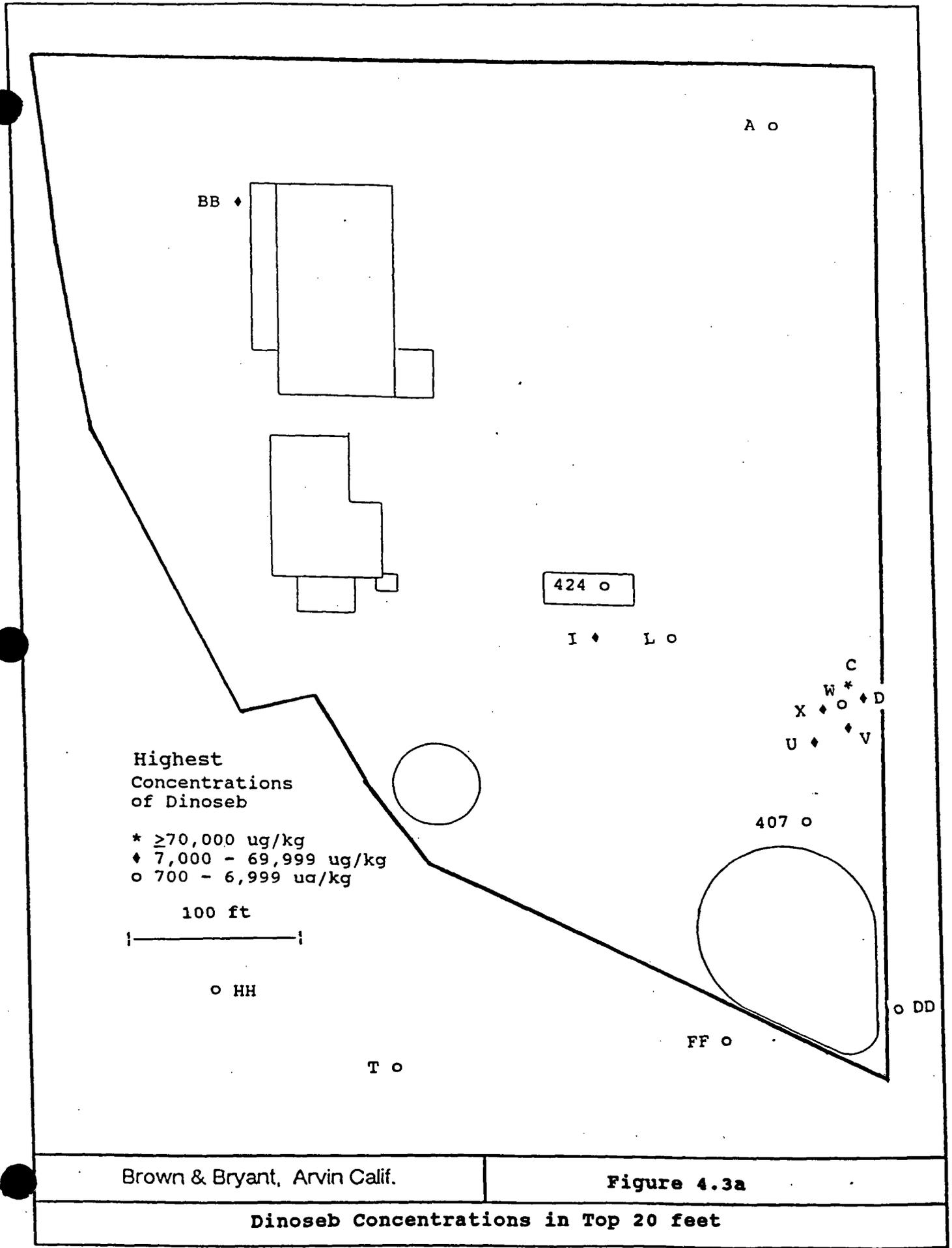
Dinoseb Concentrations in the Top Foot of Soil



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Figure 4.2

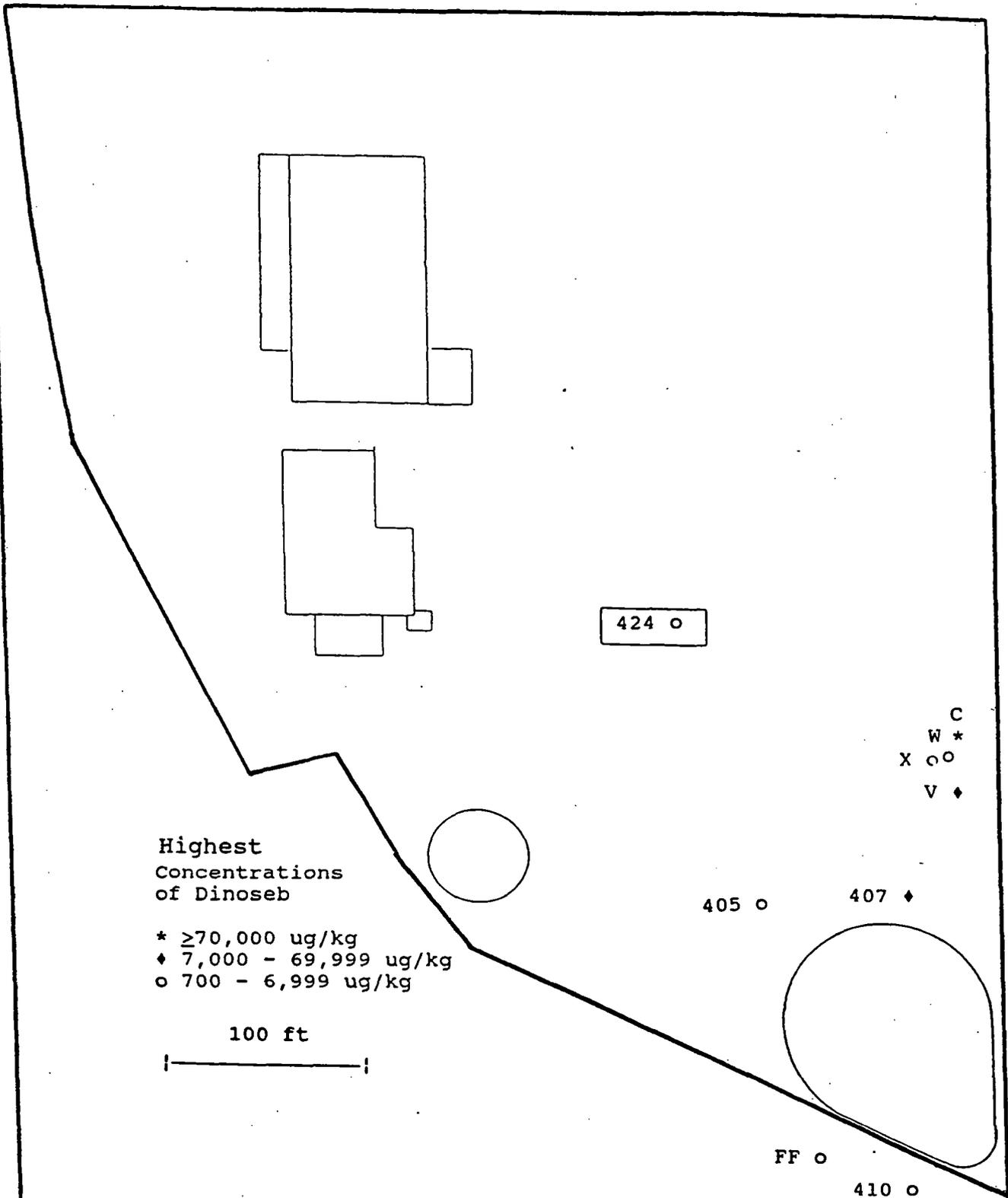
Source Areas of Soil Contamination



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Figure 4.3a

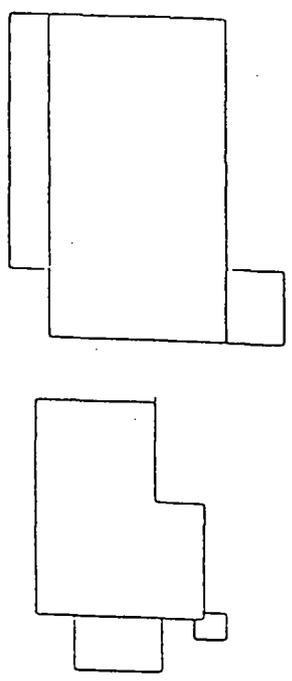
Dinoseb Concentrations in Top 20 feet



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Figure 4.3b

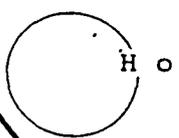
Dinoseb Concentrations from 20 to 40 feet



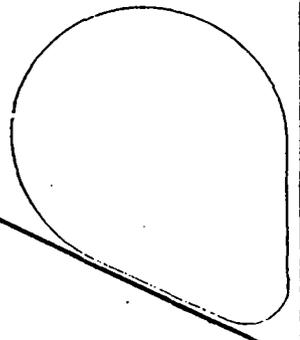
J ○
424 ○

401 ◆ ◆ M I * L ○

K ○



403 ○



Highest
Concentrations
of 1,2-DCP

- * $\geq 50,000$ ug/kg
- ◆ 5,000 - 49,999 ug/kg
- 500 - 4,999 ug/kg

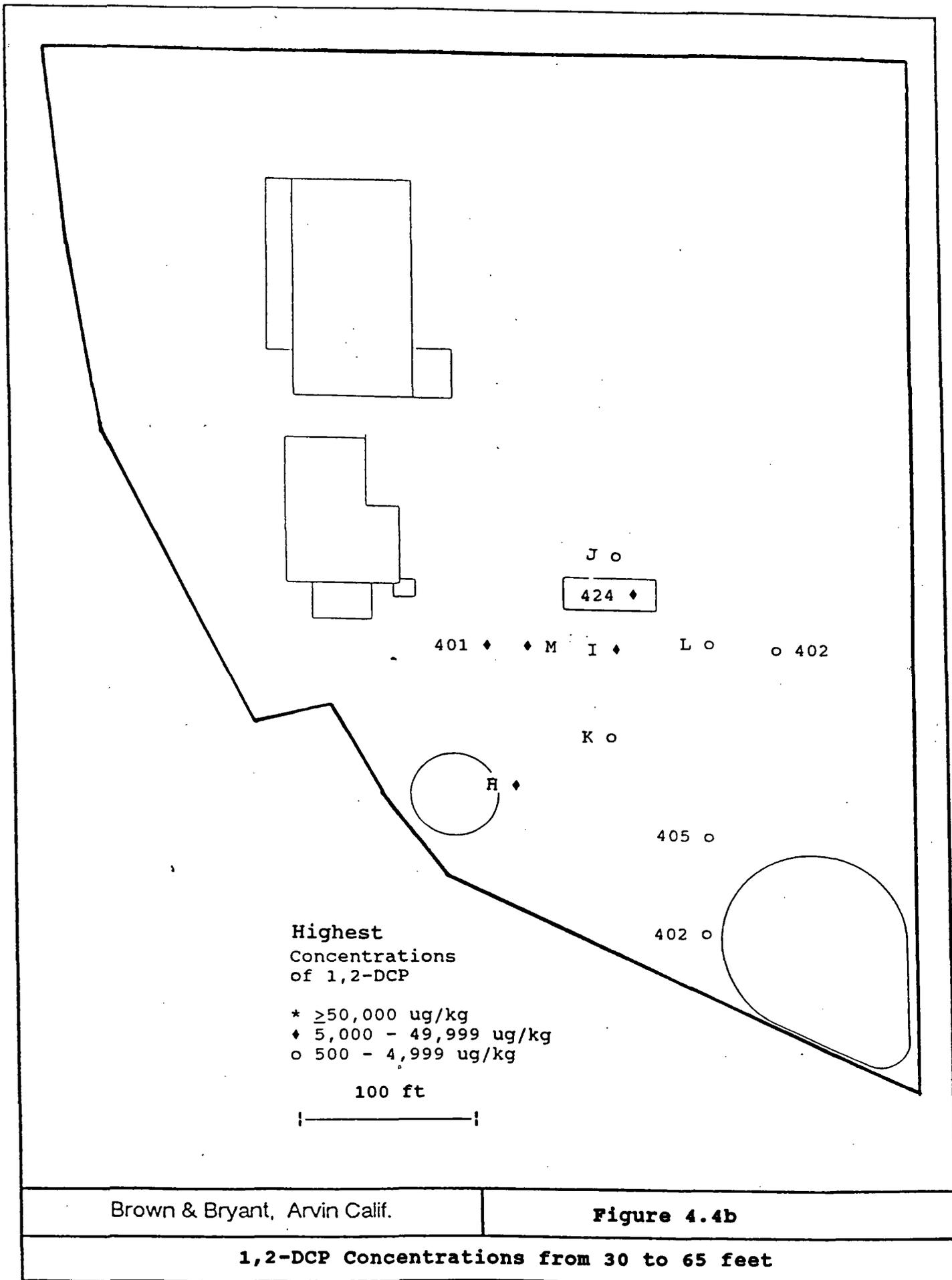
100 ft

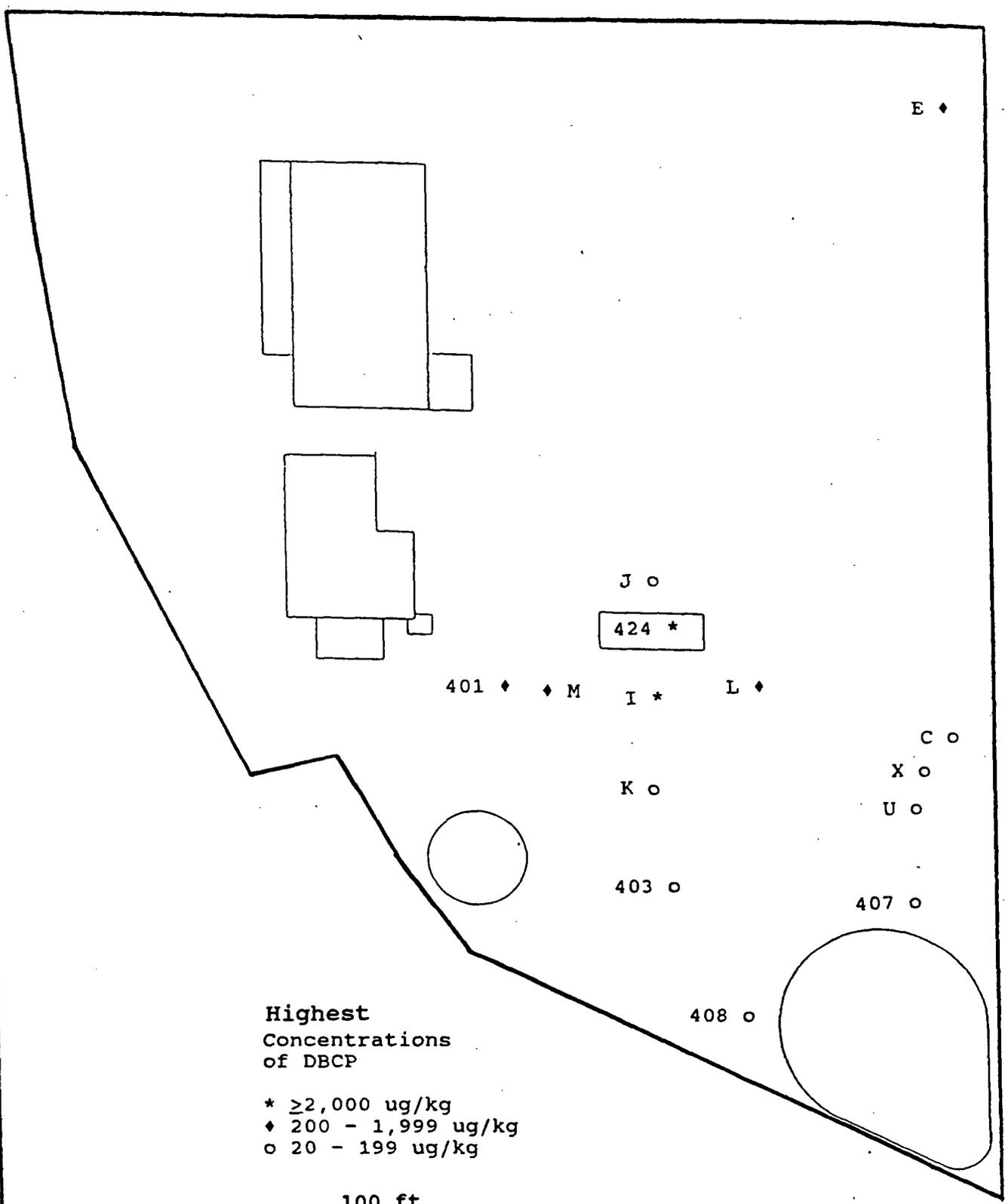


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Figure 4.4a

1,2-DCP Concentrations in Top 30 feet





Highest
Concentrations
of DBCP

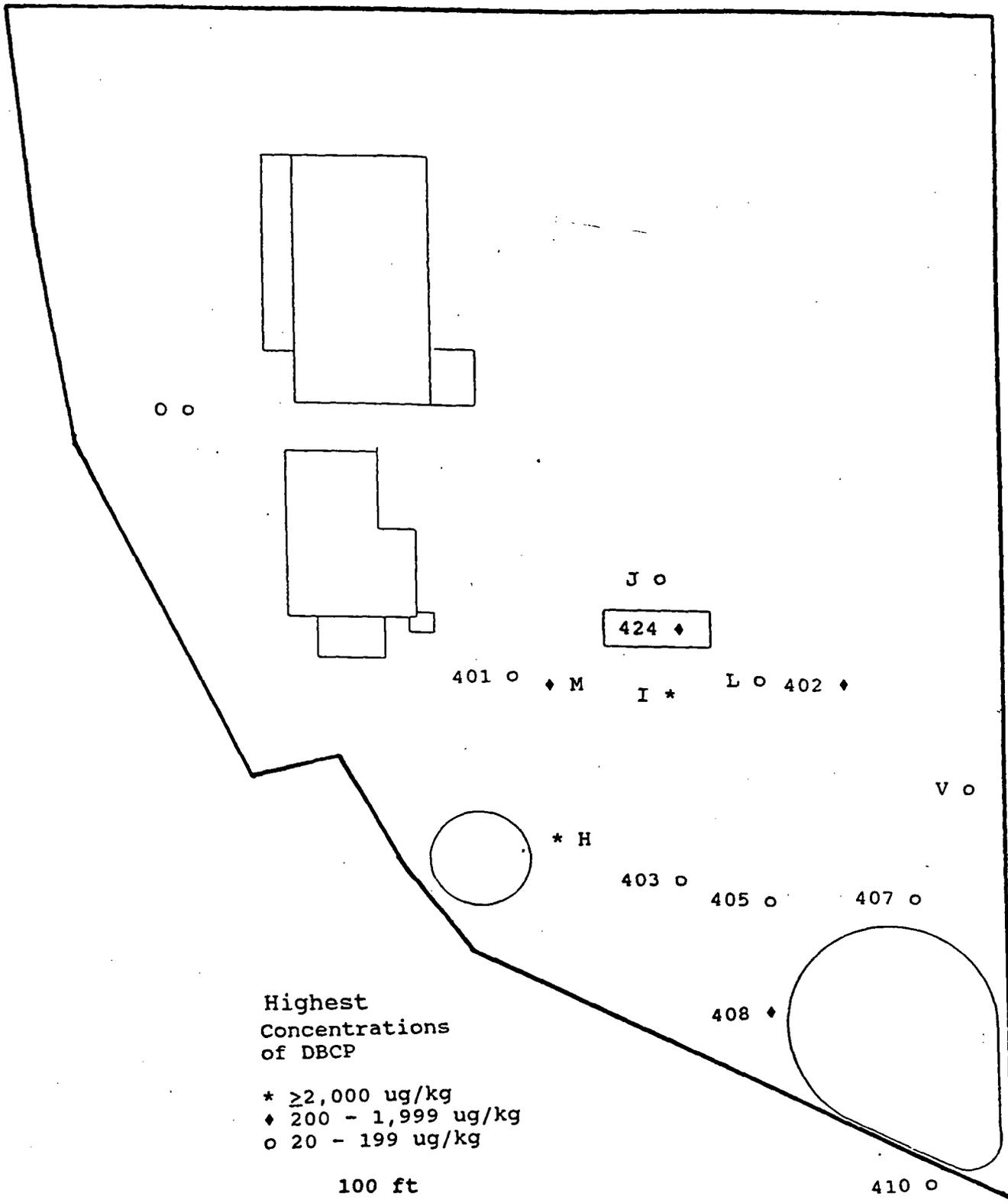
- * $\geq 2,000$ ug/kg
- ◆ 200 - 1,999 ug/kg
- 20 - 199 ug/kg

100 ft

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Figure 4.5a

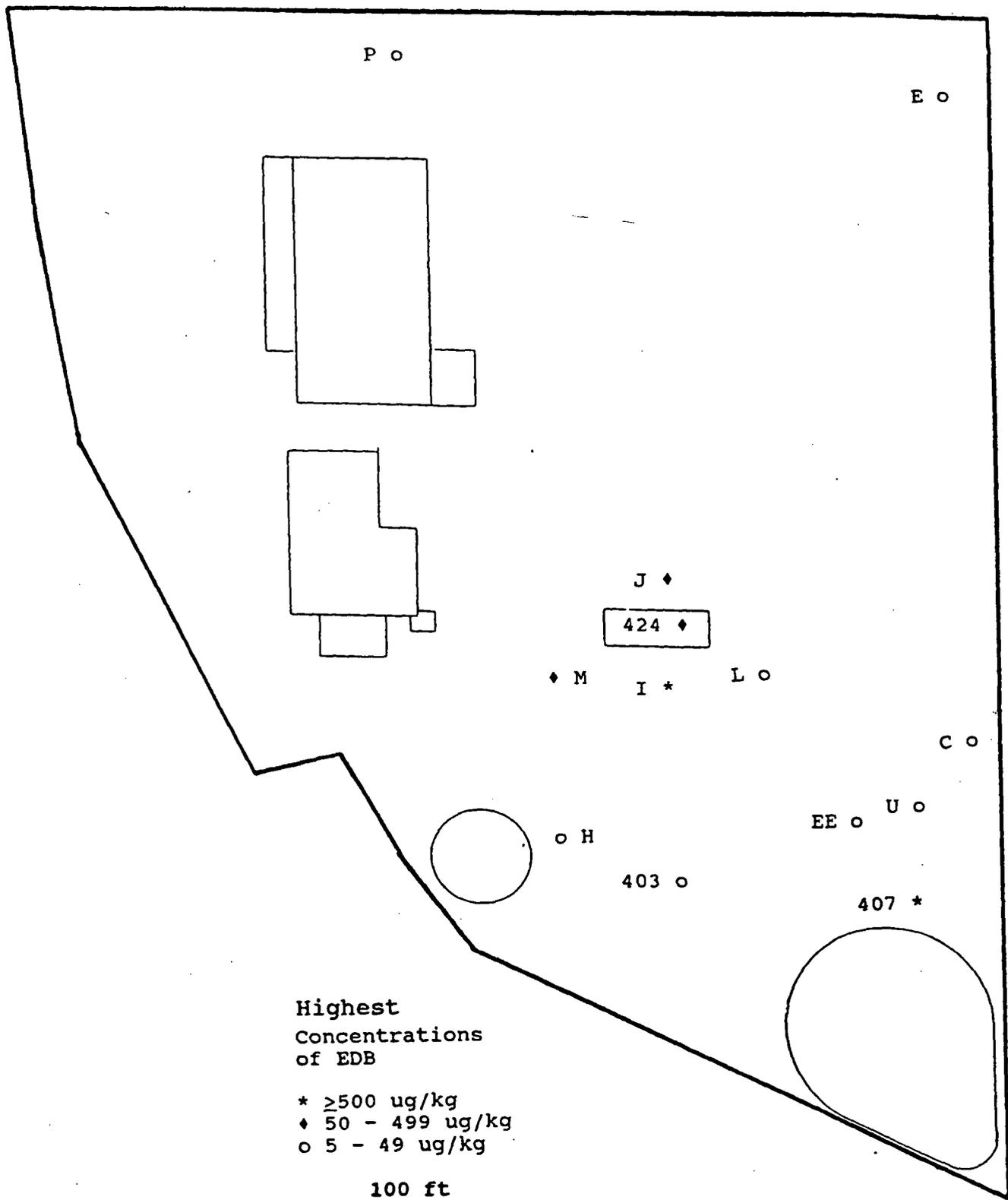
DBCP Concentrations in Top 30 feet



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Figure 4.5b

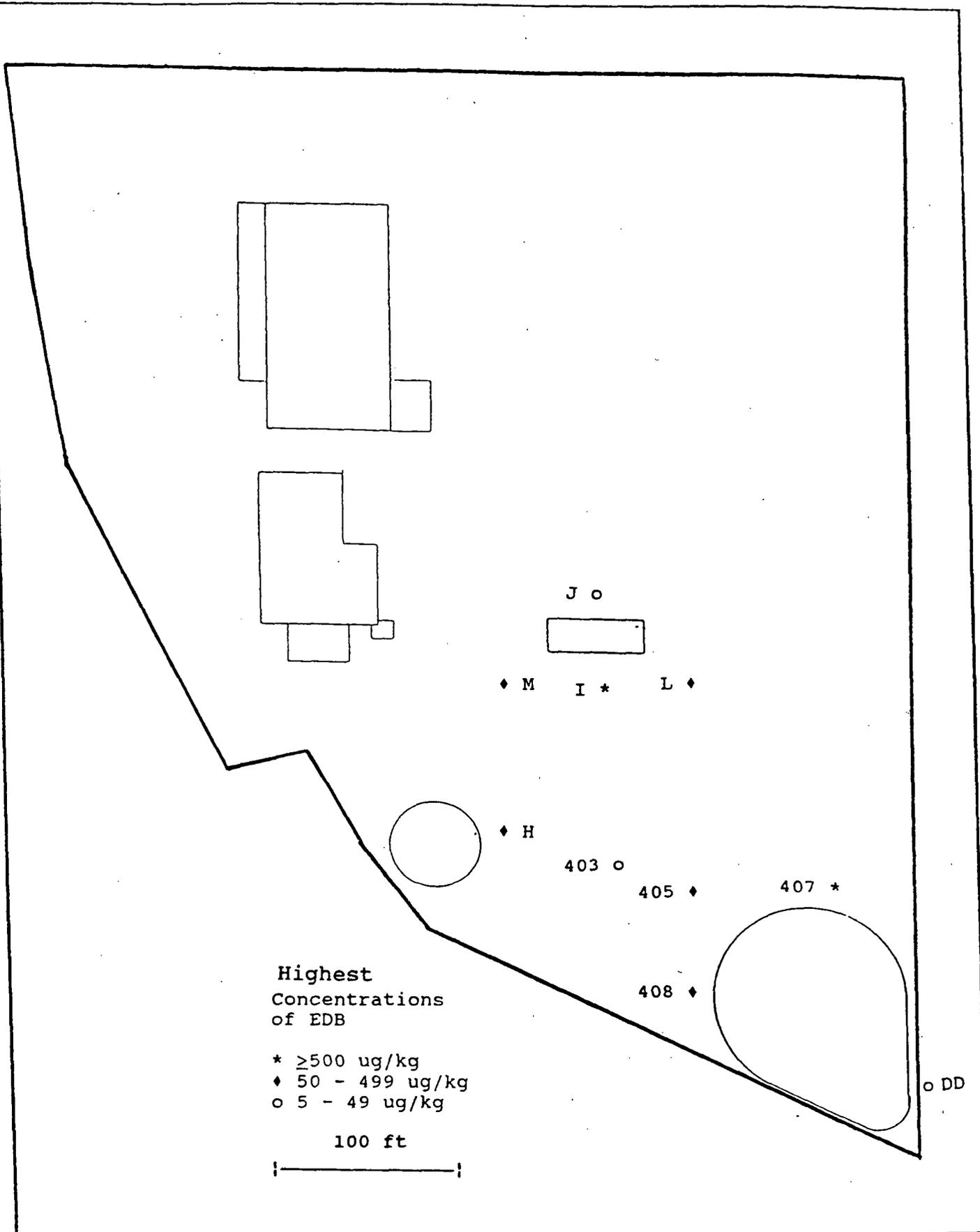
DBCP Concentrations from 30 to 65 feet



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Figure 4.6a

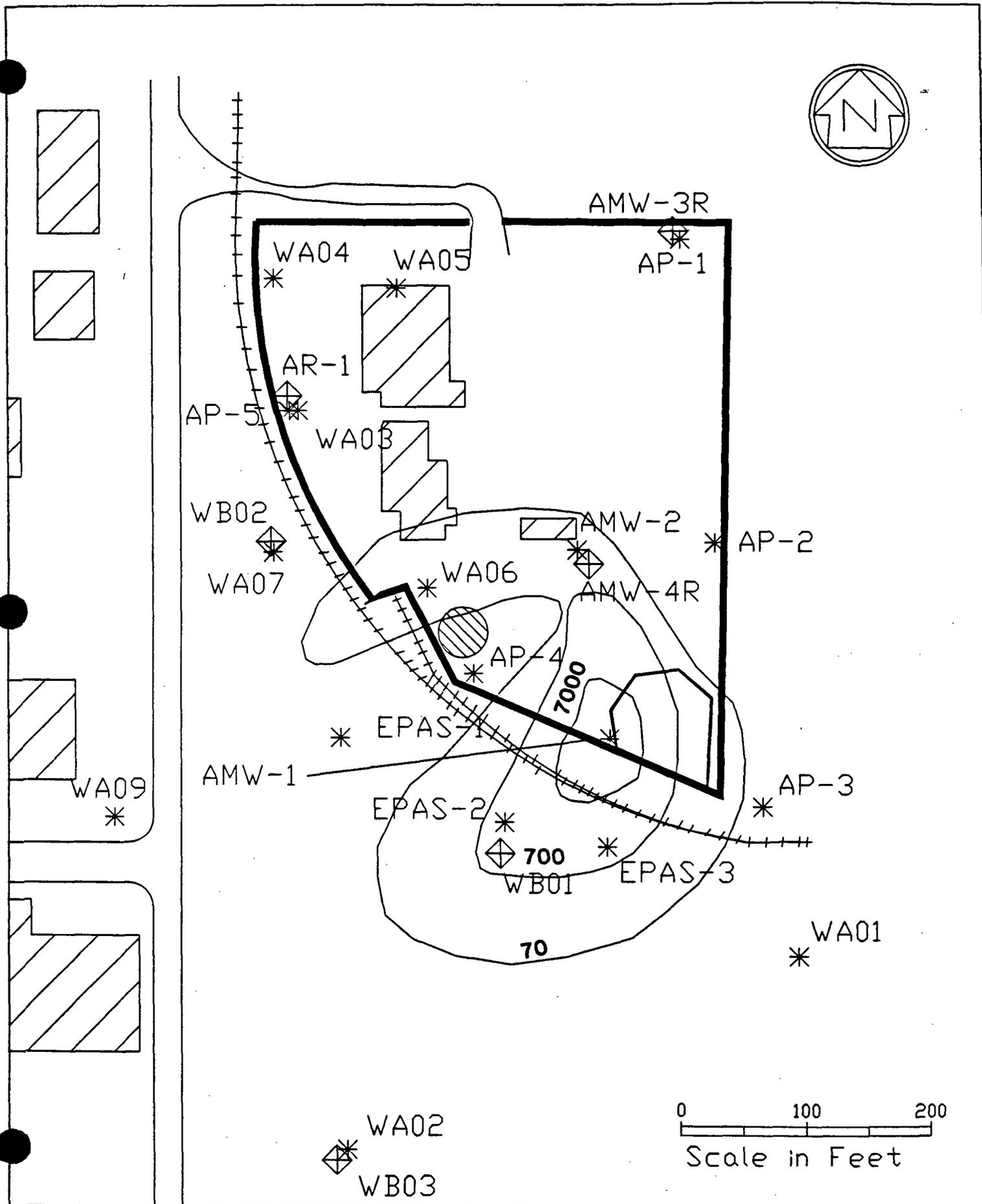
EDB Concentrations in Top 30 feet



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Figure 4.6b

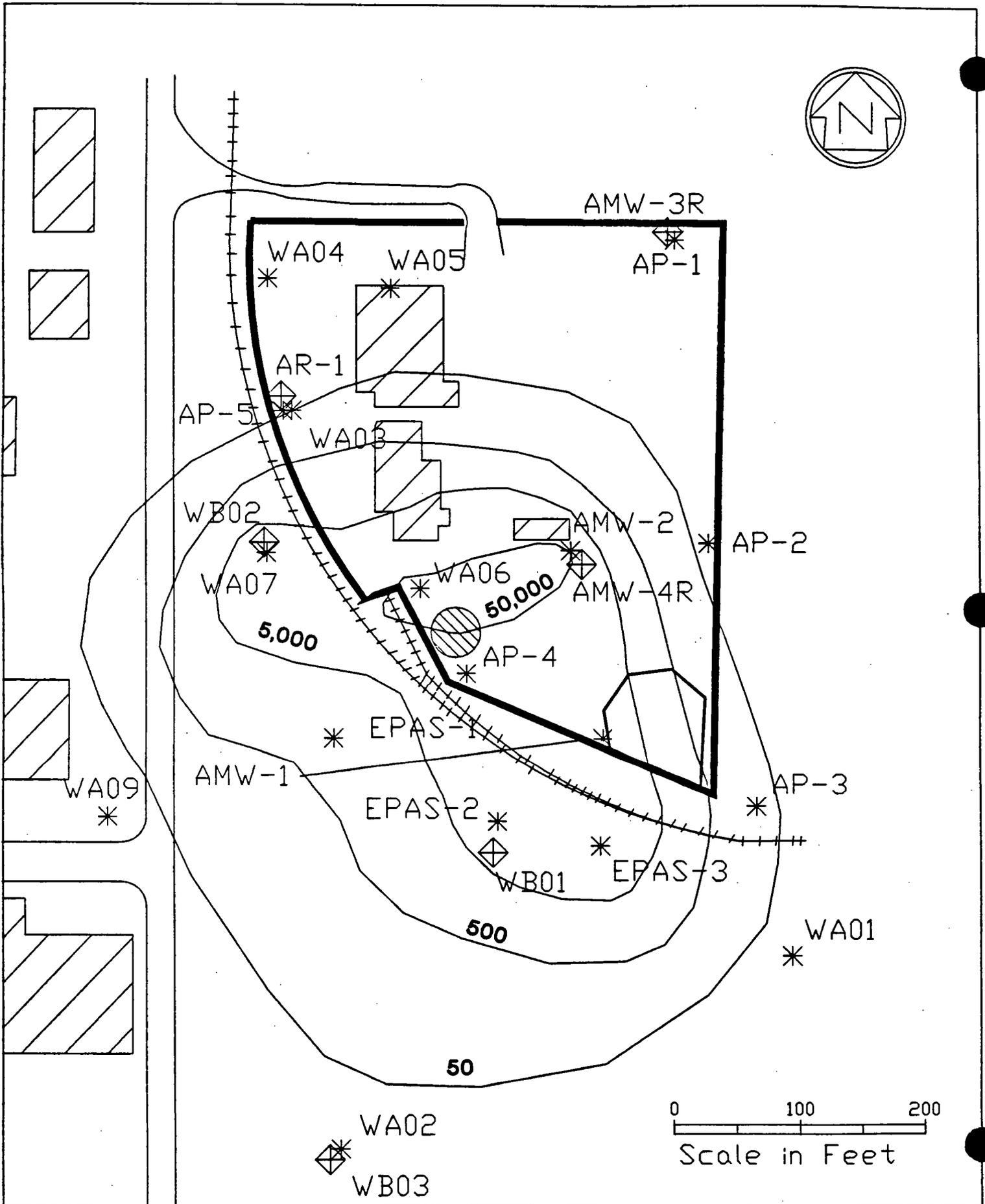
EDB Concentrations from 30 to 65 feet



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Figure 4.7

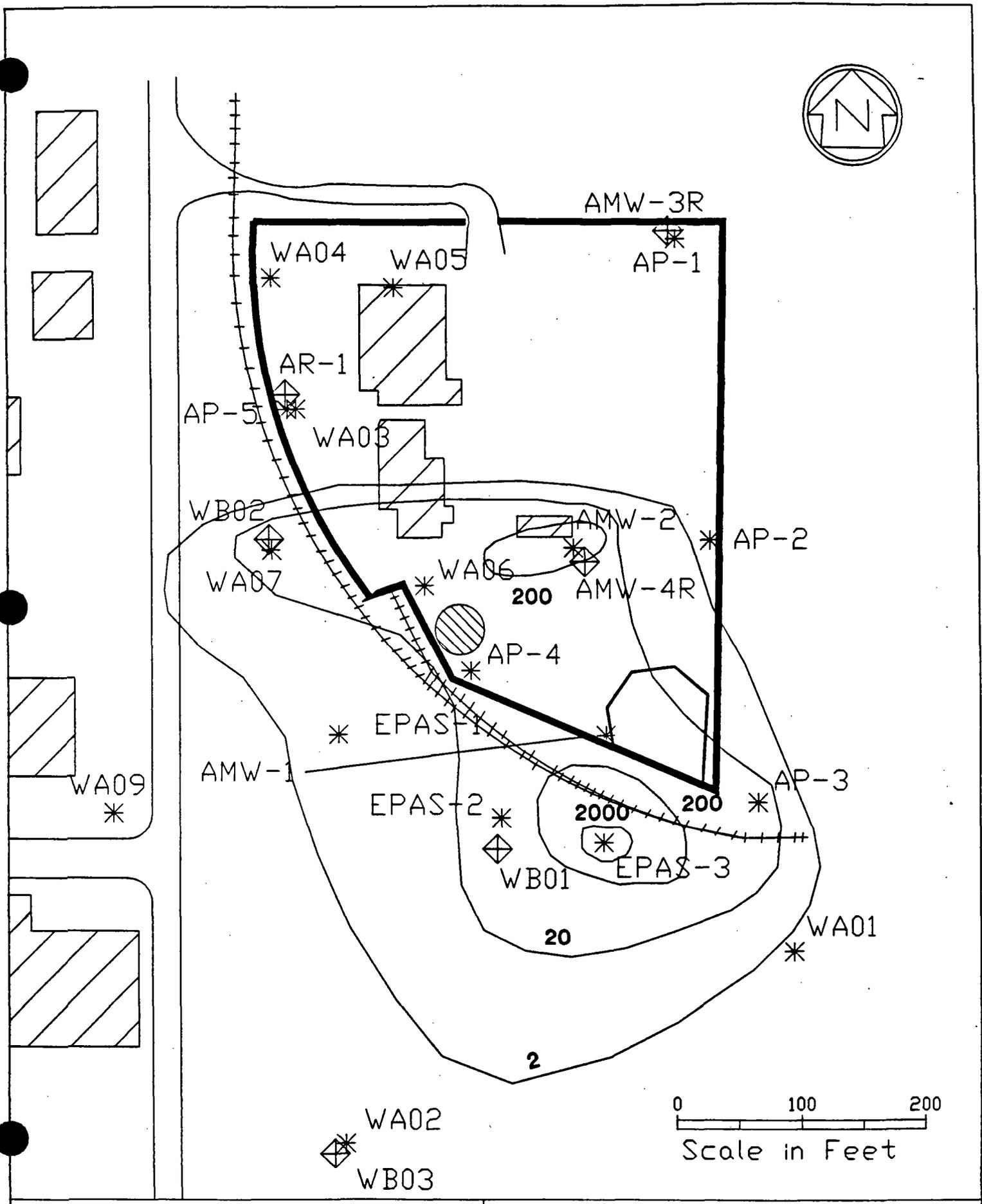
Concentrations of Dinoseb in A-Zone Groundwater, 1992 (ug/l)



Brown and Bryant Arvin, California

Figure 4.8

Concentrations of 1,2-DCP in A-Zone Groundwater, 1992 (ug/l)

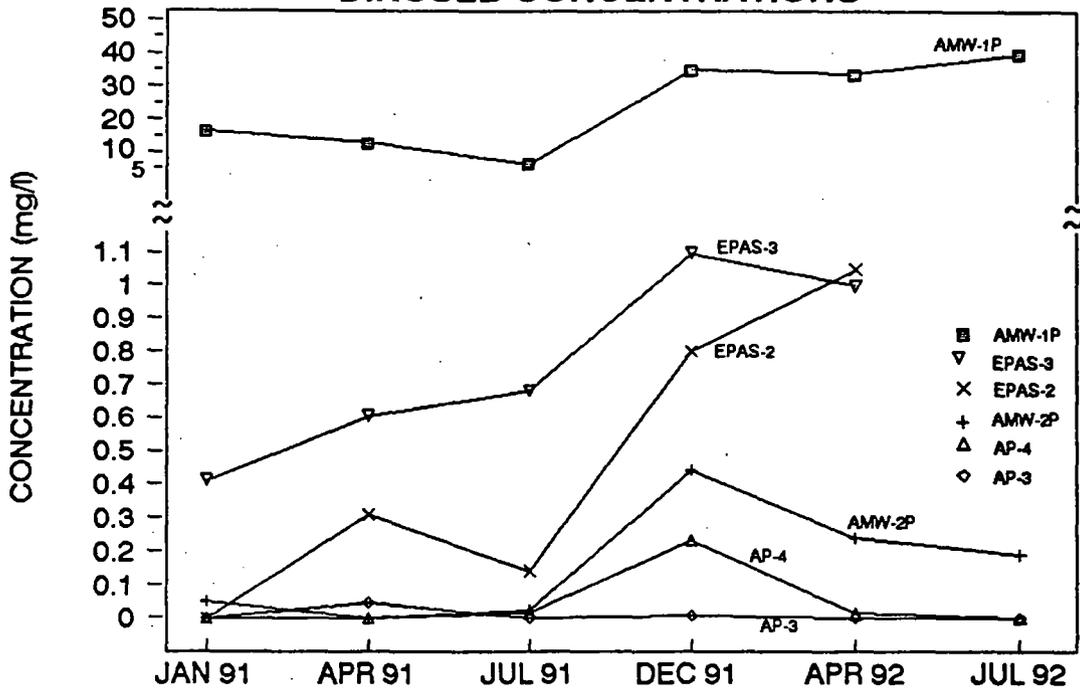


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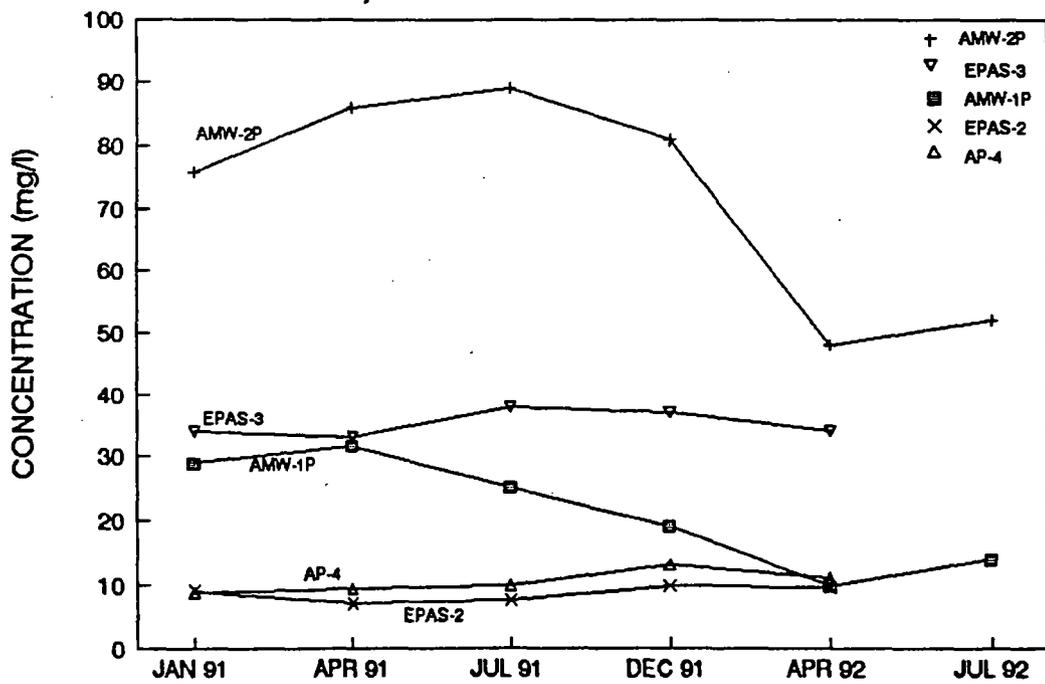
Figure 4.9

Concentrations of DBCP in A-Zone Groundwater, 1992 (ug/l)

DINOSEB CONCENTRATIONS



1,2-DICHLOROPROPANE

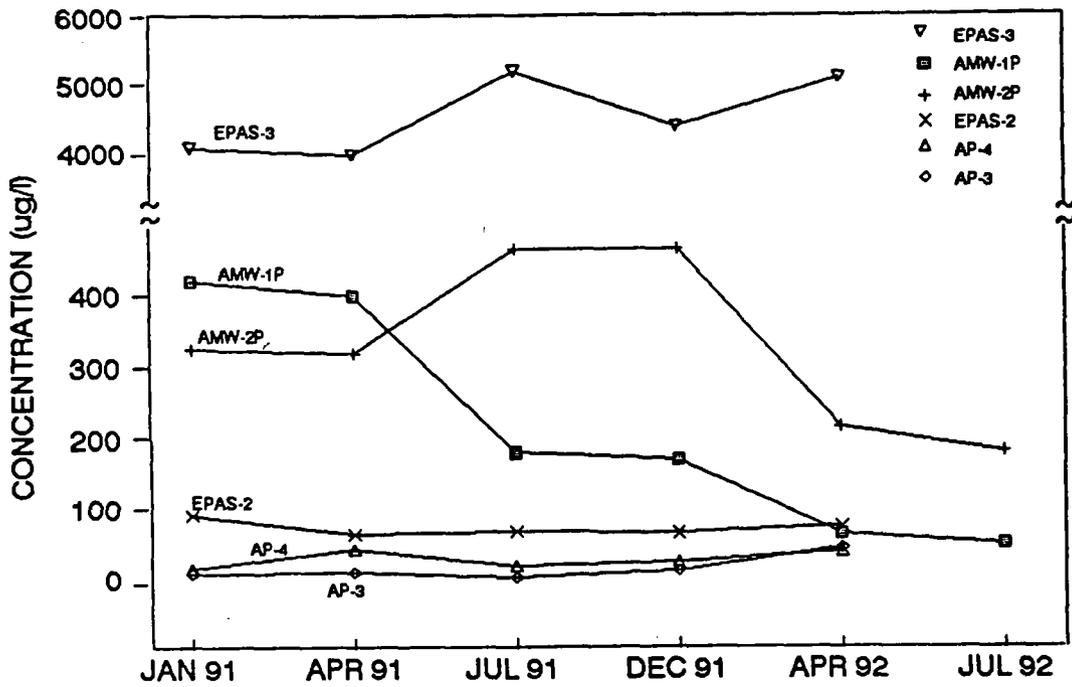


Brown & Bryant, Arvin Calif.

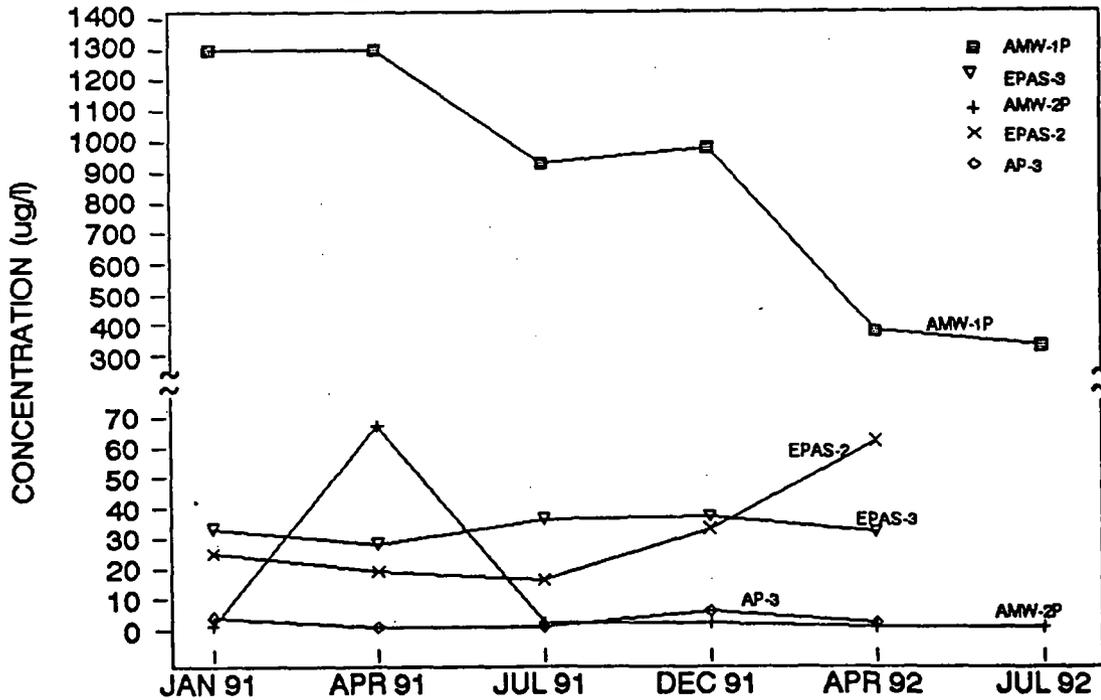
Figure 4.10a

Trends in A-Zone Groundwater Contamination for Selected Wells

DBCP CONCENTRATIONS



EDB CONCENTRATIONS

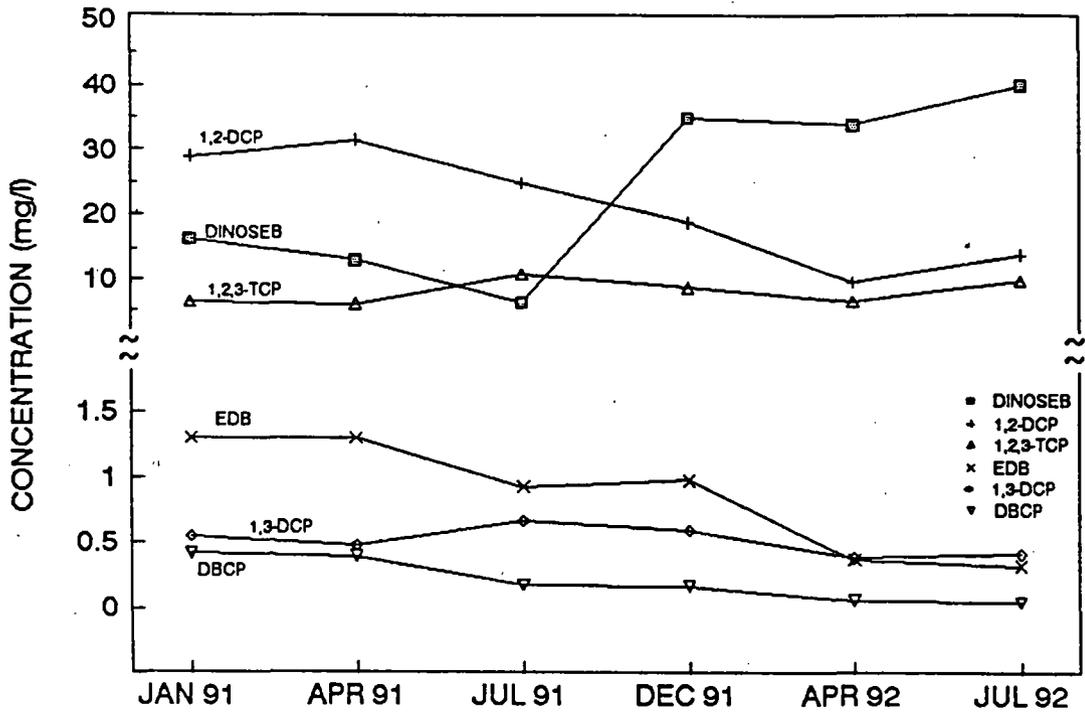


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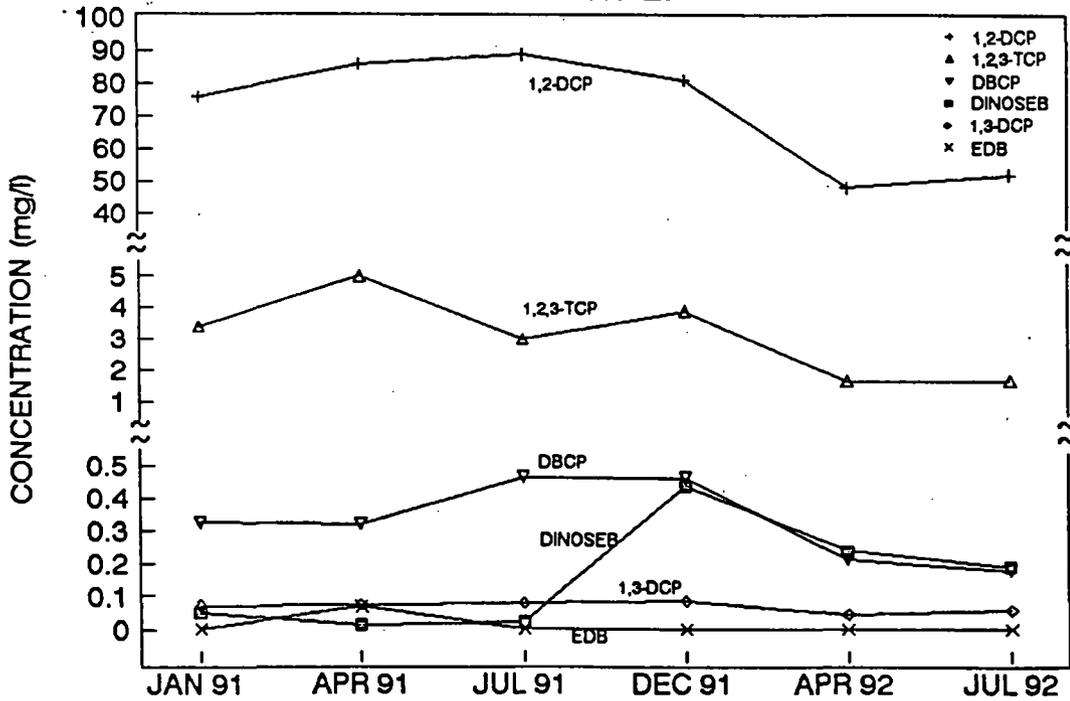
Figure 4.10b

Trends in A-Zone Groundwater Contamination for Selected Wells

WELL AMW-1P



WELL AMW-2P

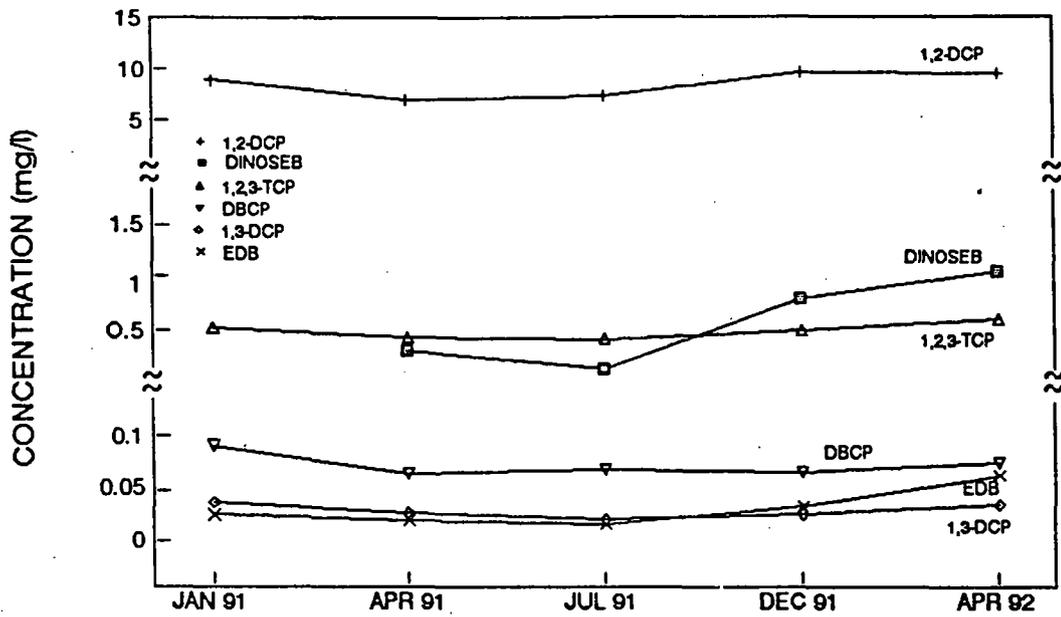


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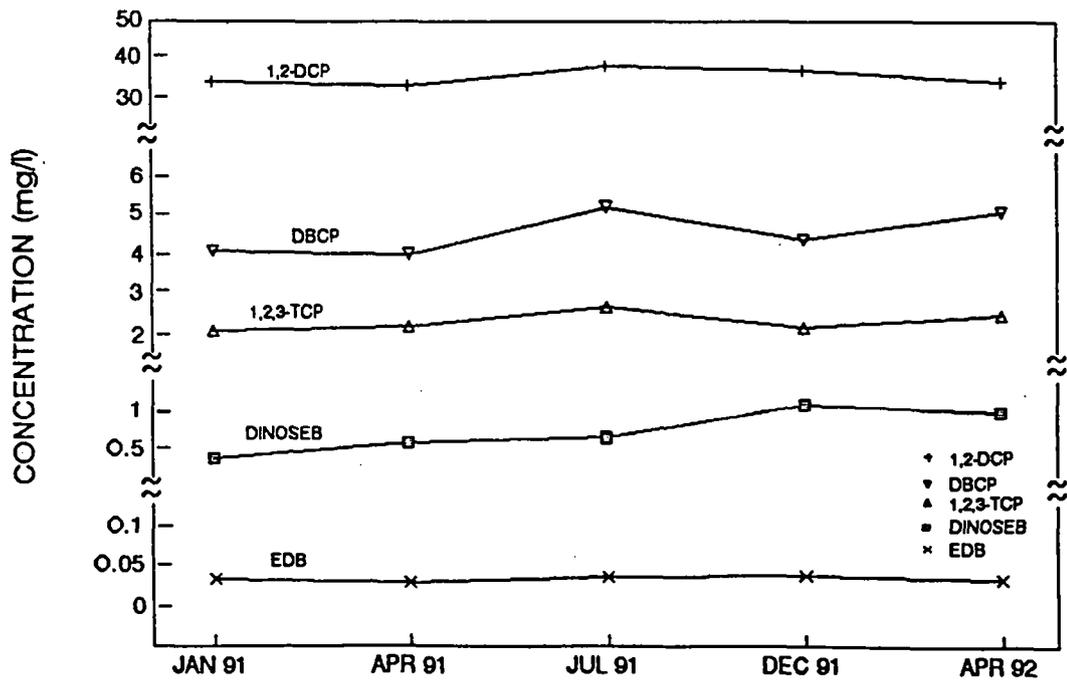
Figure 4.11a

Trends in A-Zone Groundwater Contamination by Well

WELL EPAS-2



WELL EPAS-3



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Figure 4.11b

Trends in A-Zone Groundwater Contamination by Well

SECTION 5: CHEMICAL FATE AND TRANSPORT

The purpose of this chapter is to evaluate the potential for contaminants at the site to be transported within and between environmental media, and to evaluate the potential for contaminants to be transformed within an environmental media. This information is used to predict the extent to which different environmental media may be impacted over time by site contamination, to evaluate exposure pathways for assessing the risks associated with the contamination, and to evaluate site remediation options.

5.1 General Fate and Transport Factors

The discussion in this section provides an overview of the most common factors affecting the fate and transport of contamination at a Superfund site. Table 5.1 provides a summary of key fate and transport factors. In the subsequent sections, site specific conditions are assessed to determine the critical fate and transport factors at B&B.

5.1.1 Physical Processes

Contaminants at a site will usually be in more than one phase within the media depending on site conditions. Contaminants may be in a gas phase and move through the atmosphere or through the vadose zone as a gas; it may be in a liquid phase, either as a pure product or dissolved in water, and move in surface water, the vadose zone or groundwater as a liquid; or it may be in a solid phase and move through the atmosphere as dust or over the surface by water erosion. Various physical processes affect the different phases a chemical may be found in at the site.

Volatilization of a chemical at site conditions is the primary physical process affecting contaminant movement in the gas phase. Volatilization is the process of a fluid going from a liquid phase to a gaseous phase. A measure of volatility is Henry's Law Constant (H), which is the ratio of a chemical vapor pressure to its water solubility. Henry's Law Constant provides a measure of the equilibrium of a chemical between the liquid and gas phase; thus, it indicates which phase usually is most significant for the mobility of a chemical. Chemicals with high vapor pressure and low water solubility are more volatile in aqueous systems, and, therefore, will usually be in a gas phase at greater concentrations than in a liquid phase.

Contamination in a liquid phase may be transported in the environment as free product or as a solution in water. The transport of liquids in surface flow is not discussed here because it is not a significant factor at the site. The transport of liquids through soil is governed by Darcy's Law.

Darcy's Law says that flow rate is proportional to the pressure head loss and inversely proportional to the length of the flow path. Within unsaturated soil, fluid flow is also affected by surface tension forces which retard movement and result in fluid pressures less than atmospheric pressure. When the soil is saturated, fluid pressure is greater than or equal to atmospheric pressure. Fluid flow under both saturated and unsaturated conditions is a function of the permeability of the media (although the effect is not the same for each condition). Fluid flow under unsaturated conditions is also a function of soil moisture content or the degree of saturation; flow increases with increasing moisture content because the influence of surface tension is reduced.

Advection is the transport of dissolved chemicals through the bulk movement of a fluid. Dispersion is the spreading of the fluid as it deviates from its expected path as a result of mechanical mixing and molecular diffusion. Advection and dispersion are important factors controlling the mobility of contaminants in solution in both the vadose zone and groundwater. These are also factors in the transport of contaminants in air.

Sorption is the processes by which substances in a fluid adhere to soil particles. Sorption processes include absorption, adsorption, desorption, and ion exchange. Contaminants that are sorbed onto soil are significantly less mobile within the subsurface, but may be transported as dust in the atmosphere or over the soil surface by erosion. Adsorption is the process of a liquid adhering to a soil; this is the main sorption process for organic chemicals. Adsorption of organic chemicals is especially dependent on the water solubility and organic partition coefficient of the chemical. The organic partition coefficient, which is expressed as K_{oc} , is the ratio of the concentration of a chemical sorbed by soil to the concentration in water, normalized to the fraction of organic carbon in soil. The higher the K_{oc} , and the greater the organic carbon content in soil the more the chemical is adsorbed to soil, unless the K_{oc} for the chemical is low. The octanol/water partition coefficient (K_{ow}) is also a measure of adsorption. The K_{ow} provides an indication of the extent a compound will adsorb to a soil or aquifer solid, particularly organic matter present in soil. The greater the K_{ow} value of a compound, the greater will be the tendency to be adsorbed in the subsurface; this tendency will also be directly related to the amount of organic matter present in the same way as K_{oc} is related to organic matter content.

5.1.2 Chemical Processes

The primary chemical processes that can affect the fate and transport of chemicals at a site are complexation, hydrolysis, oxidation/reduction, and photolysis.

Complexation is a chemical process where cations combine with one or more organic molecules or anions. This process can be compared to sorption as it relates to the carbon content in soil and results in an immobile form of contamination. Complexation is an important factor for the transport of metals in soil.

Hydrolysis is the chemical reaction of a compound with water molecules to form a new compound. Hydrolysis depends on whether a chemical is an acid, base or neutral, and it is influenced by the pH of the water. Basic pesticides form cations under lower pH conditions. These cations are immobilized as a result of adsorption to cation exchange sites in soil. Acid pesticides, on the other hand, are ionized at higher pH conditions to form anionic species which are more water soluble and as a result more mobile. Dinoseb is an example of an acidic pesticides. Neutral, nonpolar compounds are usually less susceptible to hydrolysis as compared to polar compounds.

Oxidation and reduction are chemical processes that result in the transfer of electrons between molecules to produce new molecular structures. The transfer of electrons can occur between dissolved, gaseous, or solid constituents. The types of reactions that occur depend on the chemical structures of the molecules involved and the amount of oxygen present.

Photolysis is the degradation of a chemical as the result of the absorption of light (solar) energy. The potential for absorption of light energy and subsequent transformation is related to chemical structure.

5.1.3 Biological Processes

The two biological processes that affect chemical fate and transport are bioconcentration and biotransformation.

Bioconcentration is the accumulation of a contaminant in an organism. Generally, bioconcentration is attributed to aquatic organisms, but it also occurs with vegetation and terrestrial organisms. The low vegetative cover at B&B would make this process insignificant at this site. Biotransformation is the alteration of a chemical compound by an organism. Biotransformation is dependent in part on the organic content in the soil; the greater the organic content in soil the more readily biotransformation can occur. The types of biotransformation also depends on whether there are aerobic or anaerobic conditions present.

5.1.4 Environmental Factors

The above processes affecting the fate and transport of contaminants will generally be controlled by site specific

environmental factors. The principal environmental factors are climatic factors and soil/geology factors.

The key climatic factors are rainfall, temperature and wind. Rainfall determines the amount of water that is available to move through soil to carry contamination by advection and dispersion through the vadose zone to groundwater. Rainfall controls the moisture content in soil which is a factor in unsaturated flow rates, oxidation/reduction reactions, and hydrolysis. The intensity and duration of rainfall events will also be a key factor in surface erosion. Temperature is primarily a factor for the volatilization of contaminants at or near the surface and in influencing the moisture content in surface soil through evaporation. The magnitude of wind speeds and direction are key factors in the dispersion of contaminated dust and volatile contaminants; it also affects chemical volatilization and water evaporation at the surface.

Key soil factors affecting fate and transport in the vadose zone are soil moisture content, soil organic carbon content, and soil type and permeability. Soil moisture content is a key factor in determining the fluid flow rates in unsaturated soil; the flow rate decreases with decreasing moisture content. The organic carbon content is a key factor in the adsorption and complexation of contamination; in general, contaminant mobility is reduced with increasing organic carbon content. The soil type will determine the permeability of the material which has a direct effect on both fluid flow and gas dispersion within the soil. The pattern of distribution of different soil types over a depth profile is defined by the site stratigraphy. A complex, heterogeneous stratigraphy such as is found at B&B, results in more complex gas and liquid flow patterns, and may result in certain preferential flow patterns or in specific zones where contaminant movement is retarded.

Site geology plays a key role in defining the fate and transport of contamination within water bearing units at the site. The key factors defined by the site geology are the thickness of saturated units, the hydraulic conductivity, and the hydraulic gradient. The latter two factors will determine the direction and flow rates of groundwater movement.

The characterization of the geology at B&B conducted during the RI allows for only general characterization of how site geology affects the transport of site contaminants. Due to the high degree of site heterogeneity, a detailed analysis of chemical transport throughout the B&B site is not possible.

5.2 Site Contaminant Fate and Transport Factors

In this section, the key fate and transport factors for the most common site contaminants are discussed. This section

focuses on the properties of the individual chemicals at the site. The following section focuses on how site specific conditions affect the fate and transport of these chemicals.

Table 5.2 includes a list of fate and transport properties for the following six common site contaminants: 1,2-dichloropropane, 1,2,3-trichloropropane, dibromochloropropane, ethylene dibromide, chloroform, and dinoseb. These values are also compared to a qualitative rating established by EPA (1990), which is also presented in the table.

All the chemicals, except for dinoseb, have relatively high vapor pressures and are considered to be volatile chemicals (the vapor pressure for DBCP, however, is somewhat low for a volatile organic chemical). These chemicals will readily vaporize into the atmosphere when occurring at the surface, and within unsaturated soils gas phase diffusion will be a significant factor in transport. The Henry's Constant for the five volatile chemicals are either high or moderate. As a result, the distribution of each chemical between gas and liquid phases will be similar and will tend towards the gas phase more than the liquid phase. The slightly lower Henry's Constant for DBCP, EDB and TCP as compared with 1,2-DCP and chloroform suggests that liquid phase transport will be relatively more important for these three chemicals. The $\log K_{oc}$ and K_{ow} values are also similar for each of these chemicals. These values are all low, indicating that adsorption will not be a significant factor in the relative mobility of these contaminants. The specific density of all six compounds is greater than 1.0, which means that the chemicals sink in water. Fate and transport characteristics similar to these chemicals are expected for most of the other site contaminants since volatile organic compounds are the most commonly detected site contamination.

Dinoseb is a nitrophenol, which is a weak acid. pK_a is a measure of an acid's dissociation in water. For dinoseb, the pK_a is 4.6, which is typical of a weak acid. At an environmental pH above the pK_a , dinoseb will occur mostly in the anionic form which will be highly soluble in water. Soil and water pH measurements at B&B have all been above 4.6. Movement of dinoseb in solution is the principal transport mechanism since the chemical is non-volatile. The K_{oc} and K_{ow} for dinoseb is low; however, adsorption of dinoseb is also effected by soil pH. Under acidic soil pH conditions, dinoseb has been shown to adsorb much more strongly to clay soils (Tomes, 1993). Soil pH measurements at B&B were all around a neutral or slightly basic pH.

The Tomes Chemical Data Base (1993) and the Handbook of Environmental Degradation Rates (HEDR, 1991) were reviewed for information on the degradation and half-life for the chemicals of interest. Both of these sources relied heavily on the Syracuse

Research Corporation's Environmental Fate Data Bases. The principal degradation factors and half-life estimates relevant to the site are summarized below for dinoseb, EDB, DBCP and 1,2-DCP. Generally, only the longer half-life numbers are listed below. Due to the low organic carbon content, low rainfall and moisture content, relatively low expected oxygen levels in the subsurface, and the toxic environment to microbes at the site, it is expected that conditions at the site generally do not favor most degradation processes. Actual chemical half-lives at B&B may vary considerably from the estimates provided below; these estimates should be used conservatively.

In surface soils, photolytic degradation is expected to be a significant fate process for dinoseb. In the subsurface, biodegradation may be the most significant fate process; however, biodegradation is expected to be slow. Hydrolysis in water has not been shown to be significant, while in soil it may be more of a factor (Tomes, 1993). Half-life estimates for dinoseb are $\frac{1}{2}$ year in soil and 1 year in groundwater (HEDR, 1991). Based on the general consistency of groundwater concentrations measured over time at site wells (see section 4), this data would suggest that these half-lives are short for site conditions.

1,2-DCP appears to be the most persistent of any of the key site chemicals. Degradation rates for 1,2-DCP have been reported as extremely slow; both biodegradation and hydrolysis have not been shown to be significant loss processes (Tomes, 1993). Half-life estimates are 3.5 years in soil and 7.1 years in groundwater; a half-life as high as 14.1 years has also been estimated for anaerobic conditions (HEDR, 1991).

The principal degradation factor affecting DBCP in the subsurface is likely to be biodegradation, though degradation rates are expected to be slow. Hydrolysis rates in groundwater have been estimated at very low rates (half-life = 141 years). Hydrolysis in acidic and neutral soils is also not expected to be significant; however, under alkaline conditions, DBCP hydrolyzes to an alcohol (Tomes, 1993). Half-life estimates are $\frac{1}{2}$ year in soil and 1 year in groundwater; a half-life of 2 years has also been estimated for anaerobic conditions (HERD).

Available information suggests that EDB may degrade slowly in soil. Degradation rates are especially dependent on the presence of oxygen. Significantly slower degradation rates have been observed under anaerobic conditions. EDB has also been shown to be very stable towards hydrolysis (half-life of 13.2 years) (Tomes, 1993). Half-life estimates of $\frac{1}{2}$ year in soil and groundwater have been estimated (HERD).

5.2.1 Site Conceptual Model

This section presents a conceptual model of the principal mechanisms for contaminant movement at B&B. Contamination at B&B is known to exist in surface soils, subsurface soils in both the A- and B-zones, and in A- and B-zone groundwater. Historically, on-site contamination resulted from a combination of spills and leaks primarily from sumps and the waste pond.

Contamination in surface soils at B&B has been subject to both wind and water erosion. The mediterranean climate of dry summer months has resulted in conditions that promote wind erosion. Annual precipitation rates are also generally low. However, rainfall events are frequently intense enough to result in on-site ponding; such events have the potential to distribute contamination at the surface as a result of water erosion. The fate of contamination in surface soils is also determined by chemical and biological processes, in particular as a result of exposure to sun light and rain. Photolytic degradation is expected to be a significant fate process for dinoseb in surface soils (Tomes, 1993).

Contamination in the A-zone soils occurs at relatively high concentrations. Moisture content in soils at B&B plays a key role in the transport of contamination by advection. In general, the dry climate does not promote rapid advection (moisture content tends to be less than 10%); however, on-site ponding has probably increased transport rates above what is normally expected for the southern portion of the site and the area east of the warehouse. The organic carbon content of soils at B&B is also low (generally less than 1%), which results in lower levels of adsorption of contamination. Much of the contamination in the A-zone soils is expected to be transported as a result of gas phase diffusion since most of the site contaminants are volatile and because of the low moisture contents (dinoseb, however, moves almost entirely by advection). Movement of both liquid and gas phase contamination in the A-zone is made more complex by the high degree of soil heterogeneity typical of the alluvial geology found at B&B. The relatively common occurrence of fine sediments in the A-zone soils results in relatively slower contaminant transport.

Contamination from A-zone soils has resulted in significant levels of contamination in the A-zone groundwater (see section 4). Contamination reaching the A-zone groundwater has migrated laterally over an area significantly larger than the area of soils contamination. This lateral movement is a function of the hydraulic conductivity and hydraulic gradient. The hydraulic conductivity is very poor in the A-zone groundwater where the water bearing unit has an abundance of fine sediments, while it is generally moderate in the B-zone groundwater where it is characteristic of a fine sand (see section 3). In contrast, the

hydraulic gradient is somewhat steep in the A-zone but is very flat in the B-zone. The quantity of groundwater in the A-zone is dependent on the amount of annual precipitation and irrigation rates on surrounding farmland. During the RI/FS a steady reduction in water level measurements in the A-zone have been observed (see section 3) due to the drought conditions and possibly a change in irrigation practices at nearby fields. The obvious result of this reduction recharge to the A-zone is a reduction in the volume of contaminated groundwater in the A-zone. In addition, the reduced hydraulic head in the A-zone would reduce the downward movement of contaminated A-zone water into the B-zone soil.

Contamination from A-zone groundwater enters the B-zone primarily as a result of advection from the A-zone water-bearing unit into the B-zone soils. The extent and rate of infiltration from the A-zone water bearing unit into the B-zone is unknown; it depends on the integrity and thickness of the clay layer which underlies the A-zone water bearing unit. Over the site the clay layer was observed to be relatively thin and very heterogeneous. It was also absent from the soil boring located furthest south of the site. Areas of preferential flow into the B-zone soils are also expected under such conditions (see section 3). Contamination entering the B-zone will be transported in the same manner as in the A-zone soils, by advection and gas phase diffusion. Organic carbon content in the B-zone is also expected to be less than in the A-zone based on the decrease in organic carbon with increasing depth observed at the site in the A-zone.

5.2.2 Vadose Zone Modeling

Modeling of vadose zone contamination was conducted in order to assess potential impacts to A- and B-zone groundwater from contamination currently present in the A-zone soils. The modeling was used to identify which chemicals in the A-zone soils may pose an unacceptable impact to groundwater, and to determine the effect of site or chemical specific variables on any potential impacts.

Two different vadose zone models were used. The MULTIMED model was employed for modeling dinoseb transport and the VLEACH model was employed for modeling the transport of volatile organic contaminants. Both models are one-dimensional models (i.e., they do not consider lateral and transverse advection and dispersion), which divide the vadose zone into individual cells to model contaminant movement through the various cells. The models are run over time intervals to show the flux of contaminants through the vadose zone. For each time step, a mass flux of contamination from the vadose zone into an aquifer is determined. This mass is then converted into a groundwater concentration by using a mixing model which assumes that the contamination is uniformly mixed within a volume of groundwater to determine a

concentration in groundwater.

Both models consider liquid advection and solid phase sorption in determining contaminant transport, while only VLEACH considers gas phase diffusion. The VLEACH model does not account for contaminant degradation while MULTIMED does. However, in this modeling exercise, degradation rates were set at zero for MULTIMED while the VLEACH results were modified using an equation for first order decay rates. MULTIMED is able to factor in the vertical variability in moisture content, percolation rate, and organic carbon fraction within the soil profile, while VLEACH treats these parameters as being uniform over the entire vadose zone. VLEACH was chosen for modeling the volatile contaminants because the other model does not take into account gas-phase diffusion, which is a major transport mode for these contaminants. MULTIMED, on the other hand, is better for non-volatile chemicals because it factors in the variability of soil properties over the profile. In both models, the initial vertical soil concentration profile for each chemical modeled is an input to the model.

5.2.2.1 VLEACH Modeling Results

The VLEACH model was run for EDB, DBCP and 1,2-DCP. Other chemicals were not modeled because they were either less common at the site or had lower risk factors. Table 5.3 includes a list of the key input variables for the modeling, and Appendix I includes a copy of input files and data outputs for the modeling runs and the calculations used to convert the model outputs to groundwater concentrations. Table 5.4 includes a summary of the modeling scenarios used for each chemical modeled, and Table 5.5 includes selected outputs for different modeling scenarios.

The modeling scenarios selected were intended to evaluate potential impacts from contamination in three source areas: the pond area, the sump area, and the A-zone groundwater. From the sump and pond source area the impact was evaluated on both the A- and B-zone groundwater. The modeling also evaluated the impact of installing a cap over the source. For impacts to the B-zone, the B-zone soil concentrations were set at either zero or MCL for a possible range of B-zone soil concentrations that may result if the A-zone groundwater is cleaned up. The impact from A-zone groundwater contamination on the B-zone groundwater was intended to look at possible B-zone impacts from cleaning up the A-zone groundwater to ten times MCL.

Modeling runs were conducted with average concentrations from the sump area and the pond area (see Table 4.9 & 4.10). To simulate a cap in the modeling, the recharge rate was reduced by an order of magnitude and volatilization to the surface was cut off.

Four additional modeling scenarios were also performed for 1,2-DCP. One scenario was identical to #6 (see Table 5.4), except that the modeling was without a cap. The three other scenarios were identical to scenarios #1, #2, and #6, except that a "low average" concentration profile for the sump was calculated that excluded the results from soil boring I in the average. Because of the exceptionally high concentrations observed in this boring as compared with other borings, the concentrations in boring I appeared to bias the overall average for the sump area. Using these two different averages in the modeling a range of possible impacts can be evaluated.

The revised averages for the sump were as follows:

Depth Interval	Average Concentration (ug/kg)
1 to 10 ft	100
11 to 20 ft	329
21 to 30 ft	3143
31 to 40 ft	4209
41 to 70 ft	1888

For each modeling scenario, the peak contamination flux to groundwater and the time of occurrence for the peak was noted. In cases where the peak occurred after 500 years, no attempt was made to determine when the peak actually occurred. By comparing between scenarios the size of the peak and the time it occurred, a relative measure of the rate and magnitude of contaminant migration can be determined.

In addition to recording the peak, the impact to the A-zone was noted for years 10, 30 and 50 for each modeling scenario. These intervals were selected in order to evaluate impacts to the A-zone groundwater that may occur during and after any A-zone groundwater remediation.

The impacts to the B-zone were noted for years 25, 50 and 100 to evaluate the possible impact to the B-zone groundwater over what might be a reasonable maximum time interval over which impacts to the B-zone may be significant.

With each of the modeling outputs the concentrations were adjusted for degradation using the half-life information discussed above. In order to calculate these adjusted concentrations an equation for first order decay rate was used. The equation is presented in Appendix I. For each chemical a range of half-lives was used to evaluate the impact at different

possible half-lives. For EDB, in addition to the half-life of 1/2 year reported in the literature, concentrations were also calculated using half-lives of 2 and 10 years for an upper range of possible half-lives under site conditions. For DBCP, a half-life of 10 years was also used in addition to the half-lives of 1 and 2 years reported in the literature. The calculation of half-life adjusted concentrations was made by assuming that the mobility of the contaminants is not changed by the degradation. While this is a conservative assumption that simplifies the half-life calculation, these adjusted concentrations are still much more realistic than the concentrations without degradation.

The results of the VLEACH modeling runs for each volatile chemical modeled are summarized below.

To check the accuracy of the modeling results, a comparison was made between current groundwater concentrations near the pond to concentrations for 1,2-DCP and EDB at time one year for impacts from the pond, without a cap (see Table 5.5). These results were selected because the soil data shows that the slug of soil contamination is currently at the groundwater for these chemicals below the pond, where as at the sump the soil data indicates that the contamination has largely entered the groundwater and that the bulk of contamination currently in the soil is still well above the groundwater. The model predicted a concentration for 1,2-DCP of 37,932 ug/l and for EDB of 1,392 ug/l. Actual concentrations for the last sampling round for wells in the pond area are between 9,600 - 34,000 ug/l for 1,2-DCP and between 78 - 5,100 ug/l for EDB. The observed results are consistent with the concentrations predicted by the model. Groundwater data from the A- and B-zones are support the model prediction that 1,2-DCP is the most mobile volatile contaminant at the site.

The results for DBCP show that reducing the water recharge with a cap, which reduces the liquid advection, result in significant retardation of contamination. In the pond area, there was no impact from soil contamination for any scenario that involved a cap. In the sump area, the peak concentration without a cap was at 180 year, where as with a cap the peak was >500 years. The impact from the sump to the A-zone groundwater, using the literature reported half-lives of 1 and 2 years, was in the low ppb range after ten years and then decreases to no impact. Impacts to the B-zone groundwater with only a cap for controls are predicted to be acceptable when compared to the MCL. The modeling results between the A- and B-zone groundwater show no impact to the B-zone from A-zone concentrations at 10 times MCL.

A similar pattern of modeling results for EDB was also found. The addition of a cap to the modeling scenario resulted in a 50% reduction in the contaminant output to the A-zone groundwater. Impacts to the B-zone with only a cap for controls

are predicted at significantly below MCL (<0.05ug/l). The modeling results between the A- and B-zone groundwater also show no impact to the B-zone from A-zone concentrations at 10 times MCL. EDB has the smallest half-life of any of the three volatiles ($\frac{1}{2}$ year); however, even using much higher half-lives, the impact is not significant.

Modeling results for 1,2-DCP show that this chemical is the most mobile and persistent of the contaminants modeled, and that the addition of a cap in the modeling scenarios did not significantly modify the model outputs. The predicted impacts to the A-zone groundwater from the pond were between 1 and 10 mg/l for year 10 and dropped to generally less than 1 mg/l after year 10. The predicted impacts to the A-zone groundwater for the sump were between 1 and 20 mg/l for all scenarios, including the "low sump" scenario for year 10. By year 30 the predicted impacts were between 0.03 and 2 mg/l for the "low sump" scenario and between 0.1 and 10 mg/l for other sump scenarios. Impacts to the B-zone groundwater from A-zone soil contamination from both the pond and sump areas were generally between 0.1 and 0.001 mg/l for year 25 and continued to decline thereafter. These higher impacts as compared to EDB and DBCP are probably due to the higher vapor pressure and Henry's constant and the longer expected half-life for 1,2-DCP as compared to EDB and DBCP. The concentrations of 1,2-DCP are also generally higher throughout the A-zone, but do not appear to be significantly different when compared to DBCP concentrations, especially considering that DBCP has an MCL more than 10 times below the MCL for 1,2-DCP. Sample results for the B-zone groundwater also confirm that 1,2-DCP has migrated to the greatest extent of any of the site contaminants (see section 4).

The addition of a cap to the modeling scenarios for 1,2-DCP did not make a significant difference in the model outputs. In almost every scenario the peak flux of contamination occurs in the same year for the scenario with a cap as compared to without a cap.

The modeling results between the A- and B-zone groundwater with initial A-zone groundwater concentrations set at 10 times MCL show an impact to the B-zone that is near the MCL of 5 ug/l.

5.2.2.2 MULTIMED Modeling Results

To model dinoseb transport in the vadose zone the MULTIMED model was used, and the modeling was conducted under contract with ASci Corporation. The results, input variables and modeling assumptions of the MULTIMED modeling are discussed in the report, Preliminary Screening Level Modeling to Establish Soil Cleanup Levels at Brown & Bryant Site, Region IX, prepared for EPA by ASci Corp., July 20, 1992. The results are summarized below.

The MULTIMED modeling included two modeling scenarios. In the first scenario, dinoseb concentrations in A-zone soils were modeled to predict the impact to the A-zone groundwater, and in the second scenario the impact to the B-zone groundwater was modeled. The second scenario assumed that contamination passed through the A-zone groundwater as though this layer was another unsaturated zone.

The inputs to the model included a profile of site physical properties derived from the various soil borings conducted at the site. The modeling results were then biased high by using an inflated average concentration for dinoseb through the soil profile. The average was arrived at by averaging only the highest detected results from the site.

In both modeling scenarios the transport rates for dinoseb were found to be very slow. Impacts to the A-zone groundwater from current soil contamination were predicted only after over 400 years and impacts to the B-zone groundwater were predicted after 500 years. Given the length of time predicted by the model for dinoseb to impact the B-zone groundwater and the effects degradation would have over this period, dinoseb concentrations in the vadose zone are not considered a significant continuing threat.

The two most likely factors leading to these modeling results are the low soil moisture content and the low volatility of dinoseb. As discussed above, since dinoseb is essentially non-volatile, liquid advection is the primary transport mechanism for dinoseb. Soil moisture content values determined from field samples and used in the modeling were consistently low. For this reason the relative transport rates for dinoseb are expected to be significantly lower than for the other chemicals which are also transported in the vadose zone as gases. Transport of dinoseb is expected to be strongly influenced by changes in soil moisture content as a result of on-site rain water ponding or preferential flow paths between the A-and B-zone groundwater as a result of the heterogenous geology or buried stream channels which may occur in the alluvial geology at B&B.

5.2.2.3 Modeling Conclusions

The following general conclusions can be draw from the VLEACH and MULTIMED modeling results: (1) the addition of a cap to the site should significantly retard the migration of dinoseb, EDB and DBCP in the A-zone soils but may not significantly impact the migration of 1,2-DCP; (2) the only potential significant impacts from A-zone soil contamination may be from 1,2-DCP if a cap is installed at the site; (3) contamination impacts from the sump area are generally expected to be greater than from the pond area; (4) A-zone groundwater concentrations for EDB, DBCP and 1,2-DCP at least 10 times MCL were predicted to not significantly

impact the B-zone groundwater; and (5) the most significant variable in assessing the potential impact from contamination in the vadose zone is the half-life of the contaminant.

The modeling results presented here are only some of the factors that will be considered in determining whether soil contamination in a given portion of the site requires remediation. The relative size of these potential impacts and the costs of treating the contamination in soil versus treating it when it reaches either the A- or B-zone groundwater are also important factors that will be considered. The actual transport of contamination may also vary significantly from what is predicted by the modeling. Local variations in geology, primarily as a result of the distribution of soil types of different permeabilities, and variation in soil moisture content as a result of ponding of rain water or preferential flow patterns between the A-and B-zone groundwater may significantly the transport of contamination within the vadose zone.

5.3 Tables and Figures

- Table 5.1: Key Fate and Transport Factors
- Table 5.2: Chemical Specific Fate and Transport Factors
- Table 5.3: Key VLEACH Modeling Variables
- Table 5.4: VLEACH Modeling Scenarios
- Table 5.5: VLEACH Modeling Results

Table 5.1
Key Fate and Transport Factors

Absorption	The penetration of one substance into another.
Adsorption	Liquid adhesion to the surface of a solid substance.
Advection	The transport of dissolved chemicals by the bulk motion of a fluid such as groundwater.
Bioconcentration	Accumulation of a contaminant in an organism.
Biotransformation	Partial alteration of a parent compound into intermediate products by microorganisms.
Complexation	Cations combining with one or more organic molecules or anions.
Desorption	Reversal of the adsorption process where the adsorbed material moves into the liquid phase from the solid phase.
Diffusion	Ionic or molecular constituent movement under the influence of kinetic activity in the direction of a concentration gradient.
Dispersion	Tendency for a dissolved chemical to spread out from its expected flow path due to spatial variations in permeability, fluid mixing, and molecular diffusion. This process causes dilution of the the chemical in solution.
Hydrolysis	Chemical reaction of a compound with water or an aqueous solution to form a new compound containing a carbon-oxygen compound.
Oxidation/Reduction	Transfer of electrons between dissolved, gaseous, or solid constituents which results in a change in the oxidation states of the reactants and the products.
Photolysis	Degradation of a chemical caused by direct absorption of solar energy or by transfer of energy from other substances that absorb solar energy.
Sorption	A term that encompasses the processes of absorption, adsorption, desorption, and ion exchange.
Volatization	A contaminant vaporizing from a liquid phase to a gas phase. The volatility of a chemical is a function of its vapor pressure.

TABLE 5.2: Chemical Specific Fate and Transport Factors

	MOLE WT	BOIL PT (°C)	MELT PT (°C)	VAPOR PRESSURE	SPECIFIC DENSITY	WATER SOLU (mg/l)	HENRY'S CONSTANT	LOG K _{OW}	LOG K _{OC}
1,2 DCP	112.99	96.8°C	-100°C LOW	39.5 HIGH	1.560 at 20/4°C	2700 MOD	3.6 E-03 HIGH	2.02 LOW	1.71 LOW
DBCP	236.36	196°C	5°C LOW	0.8 @21°C MOD	2.08 at 20/20°C	1230 MOD	1.47 E-04 MOD	2.28 LOW	2.11 LOW
CHLOROFORM	119.38	61.7°C	-63.5°C LOW	160 HIGH	1.4832 (20/4°C)	8200 MOD	3.75 E-03 HIGH	1.97 LOW	1.64 LOW
1,3-DCP	113.0	120.4°C	-100°C LOW	18.2 HIGH	1.1876 (20/4°C)	2800 MOD	4.07 E-02 HIGH	2.00 LOW	1.83 LOW
TCP	147.4	156.8°C	-14.7°C LOW	3.1 @25°C HIGH	1.3889 (20/4°C)	1750 MOD	3.44 E-04 MOD	N/A	1.85 LOW
EDB	187.88	131°C	9.8°C LOW	11 HIGH	2.19 (20/4°C)	3400 MOD	3.18 E-04 MOD	2.13 LOW	1.64 LOW
DINOSEB	240	131.4°C	40°C MOD	6.35 E-08 LOW	1.2647 (45/4°C)	Highly solu at pH >5*	1.06 E-09 LOW	2.27 LOW	2.09* LOW
LOW	-	-	≤13	≤0.001	-	≤1000	<1.00 E-05	<2.5	≤2.2
MODERATE	-	-	>13 ≤100	>0.001 ≤1.00	-	>1000 ≤1,000,000	>1.00 E-05 ≤1.00 E-03	≥2.5 <3.5	>2.2 ≤3.2
HIGH	-	-	>100	>1.00	-	>1,000,000	>1.00 E-03	≥3.5	>3.2

molecular weight = g/mole
vapor pressure = mmHg (20°C)
Specific Density = g/cc
Henry's Constant = atm-m³/mol

*Dinoseb is a weak acid with a pKa of 4.62; at pH >5 dinoseb will ionize to be very soluble in water. The Log Koc is also pH dependent. Under conditions of a buffered pH of 3, a Log Koc value of 3.82 has been measured; therefore, at lower pH dinoseb is sorbed more strongly to soil.

Source: "Subsurface Remediation Guide" (EPA/540/2-90/011b)

"Micromedix TOMES (Toxicology, Occupational Medicine and Environmental Series) (R) Data Base System," vol 15, 1993.

Table 5.3: Key VLEACH Modeling Variables

Modeling Variable	1,2-DCP	EDB	DBCP
Organic Carbon Distr. Coeff. (ml/g)	129	44	51
Henry's Constant (dimensionless (DL))	0.150	0.013	0.006
Water Solubility (mg/l)	2700	3400	1230
Free Air Diff. Coeff. (m ² /day)	0.7172	0.7172	0.7172
A-Zone Groundwater Conc. (mg/l)	0.05	0.0005	0.002
B-Zone Groundwater Conc. (mg/l)	0.0	0.0	0.0
	Modeling to A-Zone Grdwtr	Modeling to B-Zone Grdwtr	
Porosity (DL)	0.422	0.383	
Water Content (DL)	0.095	0.133	
Organic Carbon (DL)	0.00822	0.00392	
Bulk Density (g/cc)	1.86	1.86	
Recharge Rate (ft/yr) (No Cap)	0.33	0.33	
Recharge Rate (ft/yr) (With Cap)	0.033	0.033	

Table 5.4: VLEACH Modeling Scenarios

	Source Area	Modifiers	Impacted Area
1	Sump Area	With a Cap	A-Zone Groundwater
2	Sump Area	Without a Cap	A-Zone Groundwater
3	Pond Area	Without a Cap	A-Zone Groundwater
4	Pond Area	With a Cap	A-Zone Groundwater
5	Sump Area	With a Cap, B-Zone Soil Conc. set at MCL	B-Zone Groundwater
6	Sump Area	With a Cap, B-Zone Soil Conc. set at 0	B-Zone Groundwater
7	Pond Area	With a Cap, B-Zone Soil Conc. set at MCL	B-Zone Groundwater
8	Pond Area	With a Cap, B-Zone Soil Conc. set at 0	B-Zone Groundwater
9	A-Zone Groundwater	A-Zone Source Set at 10x MCL, B-Zone Soil Conc. set at 0	B-Zone Groundwater

TABLE 5.5a
VLEACH MODELING RESULTS FOR 1,2-DCP

SUMP w/ CAP, A-ZONE IMPACT GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	3974	2	49	40551	5487	15044	24724
30	4224	2	49	43102	112	2207	9750
50	3493	2	49	35643	1.75	250	2994
MAX t=20	4583	2	49	46765			

SUMP w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	5052	2	49	51551	6975	19125	31431
30	4810	2	49	49082	128	2513	11102
50	2364	2	49	24122	1.18	189	2026
MAX t=20	5994	2	49	61163			

POND w/ CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	661	1	74	8932	1209	3314	5446
30	3447	10	74	4658	12	238	1054
50	1838	10	74	2484	0.12	17	209
100	815	10	74	1101	<0.01	<0.01	<0.01
MAX t=1	2498	1	74	33757			

POND w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	818	1	74	11054	1496	4101	6740
30	3970	10	74	5365	14	275	1214
50	1572	10	74	2124	0.10	15	178
100	0	10	74	0	<0.01	<0.01	<0.01
MAX t=1	2807	1	74	37932			

LOW SUMP w/ CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	1942	2	49	19816	2681	7352	12082
30	1067	2	49	10888	28	557	2463
50	718	2	49	7327	0.36	51	615
MAX t=1		2	49	0			

TABLE 5.5a(cont'd)
VLEACH MODELING RESULTS FOR 1,2-DCP

LOW SUMP w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
10	2320	2	49	23673	3203	8783	14434
30	1233	2	49	12582	33	644	2846
50	651	2	49	6643	0.33	47	558
MAX t=1		2	49	0			

SUMP w/ CAP, B-ZONE SOIL = 50, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	888	25	35	1015	7	85	294
50	1765	25	35	2017	0.10	14	169
100	4504	25	35	5147	<0.001	0.25	36
MAX t=275	8641	25	35	9875			

SUMP w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	437	25	35	499	3	42	145
50	1512	25	35	1728	0.08	12	145
100	4373	25	35	4998	<0.001	0.24	35
MAX t=275	8661	25	35	9898			

SUMP w/o CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	764	25	35	873	6	73	253
50	4631	25	35	5293	0.26	37	445
100	21579	25	35	24662	<0.001	1.21	173
MAX t=150	27391	25	35	31304			

POND w/ CAP, B-ZONE SOIL = 50, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	1253	25	53	946	7	79	274
50	1209	25	53	912	0.04	6	77
100	1599	25	53	1207	<0.001	0.06	8
MAX t=275	1799	25	53	1358			

TABLE 5.5a(cont'd)
VLEACH MODELING RESULTS FOR 1,2-DCP

POND w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	238	25	53	180	1	15	52
50	639	25	53	482	0.02	3	41
100	1303	25	53	983	<0.001	0.05	7
MAX t=275	1648	25	53	1244			

LOW SUMP w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	261	25	35	298	2	25	86
50	745	25	35	851	0.04	6	72
100	1660	25	35	1897	<0.001	0.09	13
MAX t=225	2336	25	35	2670			

IMPACT FROM A TO B-ZONE GROUNDWATER,
TOP 20 ft OF SOIL SET AT 10x MCL, REST OF SOIL = 0

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=3.5	HL=7	HL=14
25	50	25	35	57	0.40	5	17
50	70	25	35	80	<0.001	0.56	7
100	63	25	35	72	<0.001	<0.001	0.50
MAX t=75	71	25	35	81			

TABLE 5.5b
VLEACH MODELING RESULTS FOR EDB

SUMP w/ CAP, A-ZONE IMPACT GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
10	168	10	49	343	<0.001	11	171
30	180	10	49	367	<0.001	0.011	46
50	192	10	49	392	<0.001	<0.001	12
100	441	20	49	450	<0.001	<0.001	0.44
MAX t=300	552	20	49	563			

SUMP w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
10	340	10	49	694	0.001	22	347
30	483	10	49	986	<0.001	0.030	123
50	856	10	49	1747	<0.001	<0.001	55
100	2475	10	49	5051	<0.001	<0.001	4.90
MAX t=20	2475	10	49	5051			

POND w/ CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
10	243	10	74	328	<0.001	10	164
30	214	10	74	289	<0.001	0.009	36
50	191	10	74	258	<0.001	<0.001	8
100	148	10	74	200	<0.001	<0.001	0.19
MAX t=1	47	1	74	635			

POND w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
10	796	10	74	1076	0.001	34	538
30	708	10	74	957	<0.001	0.029	120
50	652	10	74	881	<0.001	<0.001	28
100	358	10	74	484	<0.001	<0.001	0.47
MAX t=1	103	1	74	1392			

SUMP w/ CAP, B-ZONE SOIL = 0.5, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
30	0.525	10	35	1.5	<0.001	<0.001	0.188
50	4.78	50	35	2.7	<0.001	<0.001	0.085
100	8.4	50	35	4.8	<0.001	<0.001	0.005
MAX t=500	181	50	35	103.4			

**TABLE 5.5b(cont'd)
VLEACH MODELING RESULTS FOR EDB**

SUMP w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
30	0	10	35	0.0	0.0	0.0	0.0
50	2.8	50	35	1.6	<0.001	<0.001	0.050
100	6.75	50	35	3.9	<0.001	<0.001	0.004
MAX t=500	170	50	35	97.1			

POND w/ CAP, B-ZONE SOIL = 0.5, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
30	1.15	10	53	2.2	<0.001	<0.001	0.271
50	7.87	50	53	3.0	<0.001	<0.001	0.093
100	11	50	53	4.2	<0.001	<0.001	0.004
MAX t=500	116	50	53	43.8			

POND w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
30	0.16	10	53	0.3	<0.001	<0.001	0.038
50	3.44	50	53	1.3	<0.001	<0.001	0.041
100	7.35	50	53	2.8	<0.001	<0.001	0.003
MAX t=500	113	50	53	42.6			

**IMPACT FROM A TO B-ZONE GROUNDWATER,
TOP 20 ft OF SOIL SET AT 10x MCL, REST OF SOIL = 0**

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=0.5	HL=2	HL=10
30	0.01	10	35	0.03	<0.001	<0.001	0.004
50	0.108	50	35	0.06	<0.001	<0.001	0.002
100	0.13	50	35	0.07	<0.001	<0.001	<0.001
MAX t=550	0.39	50	35	0.22			

TABLE 5.5c(cont'd)
VLEACH MODELING RESULTS FOR DBCP

SUMP w/ CAP, A-ZONE IMPACT GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
10	296	10	49	604	0.586	19	302
30	315	10	49	643	<0.001	0.019	80
50	333	10	49	680	<0.001	<0.001	21
100	381	10	49	778	<0.001	<0.001	0.75
MAX t=500	1955	25	49	1596			

SUMP w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
10	355	10	49	724	0.703	23	362
30	494	10	49	1008	<0.001	0.030	126
50	688	10	49	1404	<0.001	<0.001	44
100	1630	10	49	3327	<0.001	<0.001	3.23
MAX t=180	8819	10	49	17998			

POND w/ CAP, IMPACT TO A-ZONE GROUNDWATER

NO IMPACT

POND w/o CAP, IMPACT TO A-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
10	168	10	74	227	0.220	7	114
30	182	10	74	246	<0.001	0.007	31
50	192	10	74	259	<0.001	<0.001	8
100	210	10	74	284	<0.001	<0.001	0.28
MAX t=150	224	10	74	303			

SUMP w/ CAP, B-ZONE SOIL = 2, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
25	1.56	25	35	1.8	<0.001	<0.001	0.315
50	1.55	25	35	1.8	<0.001	<0.001	0.055
100	1.58	25	35	1.8	<0.001	<0.001	0.002
MAX t=500	8.11	25	35	9.3			

TABLE 5.5c(cont'd)
VLEACH MODELING RESULTS FOR DBCP

SUMP w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
25	0.11	25	35	0.1	<0.001	<0.001	0.022
50	0.16	25	35	0.2	<0.001	<0.001	0.006
100	0.3	25	35	0.3	<0.001	<0.001	0.000
MAX t=500	7.2	25	35	8.2			

POND w/ CAP, B-ZONE SOIL = 2, IMPACT TO B-ZONE GROUNDWATER

NO IMPACT

POND w/ CAP, B-ZONE SOIL = 0, IMPACT TO B-ZONE GROUNDWATER

NO IMPACT

IMPACT FROM A TO B-ZONE GROUNDWATER,
TOP 20 ft OF SOIL SET AT 10x MCL, REST OF SOIL = 0

YEAR	MASS	TIME STEP	Q	CONC (ug/l)	CONC. ADJUSTED FOR HALF-LIFE		
					HL=1	HL=2	HL=10
25	0.012	25	35	0.01	<0.001	<0.001	0.002
50	0.014	25	35	0.02	<0.001	<0.001	0.001
100	0.02	25	35	0.02	<0.001	<0.001	<0.001
MAX t=500	0.11	25	35	0.13			

SECTION 6: RISK ASSESSMENT

An integral facet of the RI process is the performance of the human health risk assessment (RA) (see definitions in section 6.8). The RA defines the site's potential risk to human health and provides guidance for future potential remedial activities that may be required to protect the environment.

A human health baseline risk assessment evaluates and characterizes all potential pathways of exposure and site surveyed contaminants that may contribute to site risk. This method is necessary when a multi-media characterization assessment is being conducted.

A screening risk assessment analyzes only those dominant pathways and contaminants that may significantly contribute to the site risk. The screening assessment method was chosen for this site as an appropriate method to assess the site's dominant risk. This method is appropriate for sites that have been divided into operable units by single medium, such as a soils operable unit with an inactive sole source contamination. The B&B RA assesses only surface soil risk including soil within the construction zone (to 7 feet bgs). The risks associated with the top one foot of soil were assessed separately from the risks associated with soil in the construction zone. Subsurface soil and ground water contamination may be assessed in future risk assessment documents as needed. For this operable unit RI/FS, the health based drinking water MCLs are being used for assessing and evaluating contamination in groundwater and contamination in soils that threaten groundwater.

A separate assessment of ecological risks was completed during the RI. The report concluded that there were no significant ecological risks associated with the site (see Appendix E).

The key elements used to perform a screening risk assessment include:

- Selection of Contaminants of Concern (COCs)
- Assessment of Exposure
- Pathway Analysis
- Toxicity Assessment
- Risk characterization

6.1 Contaminants of Concern (COCs)

The objective of the COC selection procedure is to identify chemicals that are most likely to contribute significantly to the potential site risk. The assessment focuses only on those chemicals which are potentially toxic chemicals and which were reported in the survey media as occurring at frequencies greater than 5%. (Table 2.3 summaries all the analyses of surface soils

which were performed, and Tables 4.1 and 4.2 list all the chemicals that were detected in surface soil samples; Figure 2.5 locates all the surface soil samples taken.) Metals, though found at frequencies greater than 5%, were excluded from the assessment procedure as the absorbance values are low, and the identified contaminants were below California State Clean Up Levels. Their inclusion would not significantly contribute to site risk and/or provide guidance for site remediation.

Contaminants which were surveyed at frequencies greater than 5% were further screened to determine if the surveyed concentrations would contribute significantly to the site's risk. Significance is defined as those contaminants having a risk range of >0.1 hazard quotient value and/or a cancer screen risk of $>10^{-7}$.

In the top one foot of soil, the substances eliminated using this criteria included 1,2-dichloropropane (maximum detected concentration 1 LJ mg/kg) with an estimated risk based concentration of 900 mg/kg which is equivalent to a cancer risk of 10^{-4} , toluene (maximum detected concentration 0.016 LJ mg/kg) which was surveyed at more than 40 times below the no observed effect level (NOEL), and hexachlorobenzene (maximum detected concentration 2 mg/kg) which exceeded the NOEL by 0.4 ppm but was only detected in 2 out of 32 samples (6% frequency). The probability of repeated or prolonged exposure to hexachlorobenzene is unlikely and does not contribute significantly to the overall risk.

In the construction zone, the substances eliminated using the 5% criteria included 1,2-dichloropropane, 1,2,3-trichloropropane and dibromochloropropane. The highest concentration surveyed for 1,2-DCP in this zone was 1.1 mg/kg and the average concentration surveyed was 0.1 mg/kg. The highest concentration surveyed for DBCP was 0.9 mg/kg and the average was 0.03 mg/kg. The highest concentration surveyed for TCP was 0.4 mg/kg and the average was 0.03 mg/kg. All of these concentrations are well below EPA Region 9 Preliminary Remediation Goals for residential soil which are 1.6 mg/kg for 1,2-DCP, 20 mg/kg for DBCP, and 310 mg/kg for TCP (draft, 1/30/93).

The only COC selected for the surface soil (including the construction zone is dinoseb because of the contaminant's persistence and potential toxicity, surveyed concentration, and frequency of occurrence. Table 6.1 lists the results for all dinoseb analyses performed on surface soils in the top one foot; this data includes only those samples that were collected with a hand trowel from the top 6 to 12 inches. Table 6.2 lists the results for the construction zone; this data includes only soil boring samples from 0 to 7 feet deep. These data include results for areas that were subsequently cleaned-up as part of an interim

removal action conducted by EPA's Emergency Response Section; the removal action, however, did not eliminate all the potential risk at the site.

6.2 Assessment of Exposure

Assessment of exposure is the next step in the site risk assessment process. Three steps are taken to complete this phase of the risk assessment protocol.

- 6.2.1 Pathway Analysis
- 6.2.2 COC Toxicity Assessment (Carcinogen and Noncarcinogen)
- 6.2.3 Chronic Daily Intake Assessment

6.2.1 Pathway Analysis

An exposure pathway consists of four elements: (1) a source and mechanism of chemical release, (2) retention medium, (3) a point of potential human contact with the contaminated medium (referred to as the exposure point), and (4) an exposure route (e.g., ingestion) at the contact point.

The pathway analysis performed on the B & B site identified three dominant surface soil pathways. These included dermal absorption of soil, incidental ingestion of soil, and inhalation of soil particulates. The dominant route of exposure selected for this screening assessment was incidental ingestion. This pathway was selected for the frequency of occurrence and the receptors' sensitivity. Dermal absorbance of dinoseb was not chosen as the absorbance data was insufficient to quantitatively assess dosage. The deletion of other pathways may serve to minimally underestimate site risk. Table 6.3 illustrates the potential pathways.

6.2.2 COC Toxicity Assessment

Dinoseb (C.A.S.:88-85-7) is a general purpose herbicide that was formerly used on soybeans, peanuts, and vegetable crops.

To assess the potential toxicity of dinoseb, the IRIS¹ data bases was searched. As a result of that search, the compound was identified as a potential reproductive and developmental toxicant. Dinoseb is found to be readily absorbed by the skin and the gastrointestinal tract. The compound is moderately toxic. The oral LD50 ranges from 58 mg/kg in rats to 200 mg/kg in guinea pigs. The substance was found to affect liver and kidney functions. The compound does not appear to have potential carcinogenic properties (IRIS, 1992).

¹ IRIS: Integrated Risk Information System (July 1992)

6.2.2.1 Noncarcinogen Assessment (Chronic Reference Dose)

In an effort to quantify the potential noncarcinogen risks associated with dinoseb the USEPA reference dose value (RFD) is used to assess the non-carcinogenic potential of dinoseb. This value represents a dose that is not likely to be associated with any risks of deleterious effects to human health during a lifetime. The dinoseb RFD value was developed using the results of toxicity studies performed on animal subjects. The value represents the dose that provoked decreased fetal weight in a multi-generational animal study. The RFD was developed from the no observable effect exposure dose levels (NOEL) and no observable adverse effect exposure dose levels (NOEAL) that were observed within animal experimentation studies. These values are then extrapolated to the human experience, by allowing for the uncertainty that the animal response is not similar to the human response, e.g., different metabolic pathways or levels of sensitivity between animal subject and the human experience. The NOEL and/or NOEAL doses are subsequently divided by a factor of 10 to 1000 to account for that uncertainty of species to species variability of response.

The dinoseb RFD is an integral part of the risk assessment processes that have been used in the B&B risk assessment to determine the potential B&B site risk to potential site receptors (EPA, 1989a). The RFD value is subsequently compared to the modeled chronic daily intake dose to characterize the site risk.

6.2.3 Chronic Daily Intake (CDI) Assessment

Intake assessments are developed from remedial investigation site surveys of the B&B soil medium. As this is a screening risk assessment, it was decided that only the maximum and average surveyed concentrations of dinoseb would be used for the CDI model. The site surveyed concentrations appear in Table 6.1 and 6.2. These surveyed dinoseb concentrations are used to represent reasonable potential exposure concentrations for intake modeling. The model selected to assess the potential risk due to soil ingestion was the USEPA ingestion protocol (EPA, 1989a). Table 6.4 describes the ingestion modeling mechanism.

The modeling parameters selected to assess the site risk as the result of incidental soil ingestion are as follows:

For the top one foot of soil, the child was selected as the most likely receptor to be exposed to contaminated surface soil.² The child will likely come into contact with soil as a

² "Age of concern for soil ingestion. Based on observational data, children are most likely to ingest soil from ages 1 to 6 (Walter et al. 1980, Cooper 1957, Charney et al. 1980, Sayre et al.

result of playing within the nearby yards and trespassing on site. Young adults may also be exposed as a result of trespassing. The length of exposure for a child would be 6 years. The length of exposure for a young adult would be 9 years. These subjects would have the highest potential for exposure both for frequency and duration of exposure. Both subjects are assumed to come in contact with the soil on a daily basis, or 350 days a year. Adults were not selected for this part of the assessment as their exposure would not be significant. Adults activities include work away from the home and the site, thereby minimizing exposure to soil, either through recreational activities or incidental intrusion.

For soil in the construction zone, the adult (a construction worker) was selected as the most likely receptor to be exposed to contaminated soil during a construction event. For this exposure, the adult construction worker is assumed to come in contact with the soil for five days a week over three months, or 65 days of exposure.

6.3 Risk Characterization

Dinoseb contamination is widespread throughout the B&B site. The dominant concentrations, however, were found in the south central portion of the site near the location of a former spill. Contact with the soil could occur through dermal exposure, inhalation, or incidental ingestion of the soil by site visitors, workers, children, or adult trespassers who may enter the site. Contact could occur also as the result of site erosion and/or wind which might deposit the soil in nearby resident yards or adjacent light industrial areas. The dominant exposure pathway selected for the screening assessment, however, was the incidental ingestion scenario. The exclusion of the other pathways, though not dominant, could serve to underestimate the site risk.

In an effort to quantify the potential noncarcinogenic hazards associated with exposure to the site's surface soil contaminants, a hazard index was developed. The hazard index was developed by dividing the chronic daily intake into the reference

1974). Several researchers have investigated the age of occurrence of soil ingestion and the duration of the behavior. Soil ingestion is usually established by the 18th month and abnormal behavior may persist until age 6 or 7 (Walter et al. 1980, Cooper 1957, Charney et al. 1980, Sayre et al. 1974). Ingestion of non-food substances beyond age 6 or 7 is usually the result of inadvertent ingestion (e.g., from soil or dust present)" (USEPA 1989b).

dose (RFD)³, The chronic daily intake was calculated using the maximum and average site surveyed concentration as the site characterization treatment is on-going. A resultant hazard quotient of less than 1.00 using this methodology indicates that the exposure does not present appreciable risk of deleterious effects to human receptors (USEPA, 1989a). The results of these characterizations appear in Table 6.5.

6.4 Results

The incidental surface soil ingestion scenario for children and young adults exceeded the threshold for deleterious effects to human health for maximum surveyed concentrations of contaminated soil. The hazard quotient was 67.0 for children and 10.0 for young adults. The average surveyed concentration modeled for children exceeded the threshold for deleterious effects. The average surveyed contamination for children was 2.0 (Table 6.5). The average surveyed concentrations modeled for young adults did not exceed the threshold for deleterious effects.

For the construction worker scenario, the threshold for deleterious effects to human health was exceeded for the maximum surveyed concentration (HQ = 5), but was not exceeded for the average surveyed concentration (HQ = 0.1).

6.5 Conclusions

The screening risk assessment identified a potential human health hazard to the surrounding residents of the B&B site from exposure to the top one foot of soil. The potential hazard could occur as the result of children and young adults at play adjacent to the site and/or trespassing on site. The most significant risk appears to be related to the surface soil contamination within the south central area of the site.

The screening risk assessment also identified a potential human health hazard to adult workers at the site who may be exposed to contaminated soil down to 7 feet during on-site construction. The most significant risks appear to be associated

³ USEPA Definition Chronic Reference Doses (RFD) - An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that it is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RFDs are specifically designed to be protective for long term exposure to a compound.

Chronic Noncancer Hazard Index

CDLi = chronic daily intake for the ith toxicant in mg/kg-day; and

RFDi = chronic reference dose for the ith toxicant in mg/kg-day.

with contamination in the dinoseb spill area. This area has already been partially remediated during an EPA removal action.

6.6 Uncertainties

The performance of the risk assessment is based on numerous assumptions including level of exposure, frequency of exposure, and sampling methodology used to access both the level and the extent of site contamination. As a result, the assessment of site risk may be over and/or underestimated based on the methods used to perform the risk assessment. The uncertainties of this assessment are discussed in Table 6.6.

6.7 Tables and Figures

Table 6.1:	Dinoseb Results for Surface Soil Samples
Table 6.2:	Dinoseb Results for Samples from 1 to 7 feet
Table 6.3:	Soil Pathway Analysis
Table 6.4:	Ingestion of Chemicals in Soil
Table 6.5:	Risk Characterization
Table 6.6:	Uncertainty Analysis for Brown & Bryant Interim Risk Assessment

6.8 Definition of Terms

1. Chronic Reference Dose (RfD). An estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chronic RfDs are specifically developed to be protective for long-term exposure to a compound (as a Superfund program guideline, seven years to lifetime).

2. Dose-response Evaluation. The process of quantitatively evaluating toxicity information and characterizing the relationship between a dose of a contaminant administered or received and the incidence of adverse health effects in the exposed population. From the quantitative dose-response relationship, toxicity values are derived that are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at different exposure levels.

3. Hazard Identification. The process of determining whether exposure to an agent can cause an increase in the incidence of a particular adverse health effect (e.g., cancer, birth defect) and whether the adverse health effect is likely to occur in humans.

4. Integrated Risk Information System (IRIS). An EPA data base containing verified RfDs and slope factors and up-to-date health risk and EPA regulatory information for numerous chemicals. IRIS is EPA's preferred source for toxicity information for Superfund.

5. Lowest-Observed-Adverse-Effect-Level (LOAEL). In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effect between the exposed population and its appropriate control group.

6. No-Observed-Adverse-Effect-Level (NOAEL). In dose-response experiments, an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered to be adverse, nor precursors to specific adverse effects. In an experiment with more than one NOAEL, the regulatory focus is primarily on the highest one, leading to the common usage of the term NOAEL to mean the highest exposure level without adverse effect.

7. No-Observed-Effect-Level (NOEL). In dose-response experiments, an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of any effect between the exposed population and its appropriate control.

8. Reference Dose (RfD). The Agency's preferred toxicity value for evaluating non-carcinogenic effects resulting from exposures at Superfund sites. See specific entries for chronic RfD, subchronic RfD, and developmental RfD. The acronym RfD, when used without other modifiers, either refers generically to all types of RfDs or specifically to chronic RfDs; it never refers specifically to subchronic or developmental RfDs.

9. Slope Factor. A plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

10. Toxicity Value. A numerical expression of a substance's dose-response relationship that is used in risk assessments. The most common toxicity values used in Superfund program risk assessments are reference doses (for non-carcinogenic effects) and slope factors (for carcinogenic effects).

11. Weight-of-Evidence Classification. An EPA classification system for characterizing the extent to which the available data indicate that an agent is a human carcinogen. Recently EPA has developed weight-of-evidence classification systems for some other kind of toxic effects, such as developmental effects.

12. Exposure. Contact of an organism with a chemical or physical

agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g., skin, lungs, gut) and available for absorption.

13. Exposure Assessment. The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of exposure.

14. Exposure Pathway. The course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or origination from a site.

15. Exposure Route. The way a chemical or physical agent comes in contact with an organism (e.g., by ingestion, inhalation, dermal contact).

16. Hazard Index (HI). The sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures.

17. Hazard Quotient. The ratio of a single substance exposure level over a specified time period (e.g., subchronic) to a reference dose for that substance derived from a similar exposure period.

18. Intake. A measure of exposure expressed as the mass of a substance in contact with the exchange boundary per unit body weight per unit time (e.g., mg chemical/kg body weight-day). Also termed the normalized exposure rate; equivalent to administered dose.

19. Reference Dose (RfD). The Agency's preferred toxicity value for evaluating noncarcinogenic effects result from exposures at Superfund sites. See specific entries for chronic RfD, subchronic RfD, and developmental RfD. The acronym RfD, when used without other modifiers, either refers generically to all types of RfDs or specifically to chronic RfDs; it never refers specifically to subchronic or developmental RfDs. An integral facet of the RI process is the performance of the human health risk assessment (RA) (See attached definitions). The RA serves to define the site's potential risk to human health and to provide guidance for future potential remedial activities that may be required to protect the environment.

Table 6.1
 DINOSEB RESULTS FOR SURFACE SOIL SAMPLES
 (concentrations in ug/kg)

Surface Soil Data
 Collected by EPA (1/91)

Surface Soil Data Collected by
 Ecology & Environment (10/91)

Surface Soil Data
 Collected by EPA (12/91)

SAS NO.	LOCATION NO.	RESULT	SAS NO.	BORE HOLE NO.	RESULT	SAS NO.	LOCATION NO.	RESULT
8	SS-11 DUP	34000	1	SB-401	2800	101	1	110 U
7	SS-11 DUP	35000	2	SB-403	41000	102	2	120 U
3	SS-12	240 J	3	SB-405	14000	103	3	680
5	SS-13	620 J	4	SB-407	19000	104	4	110 U
10	SS-21	5800	5	SB-408	1000 U	105	5	560000 J
12	SS-22	6200	6	SB-410	200 U	106	6 DUP	130000 J
14	SS-23	88000	7	SB-411 DUP	510000	121	6 DUP	300000 J
			8	SB-411 DUP	450000	107	7	1000 J
			9	SB-413	5000 U	108	8	260
			10	SB-414	2500 U	109	9	140
			11	SB-415	1000 U	110	10 DUP	520000 J
			12	SB-416	200 U	122	10 DUP	350000 J
			13	SB-417	200 U	111	11	180
			55	SB-406	200 U Background	112	12	400
			57	SB-424 DUP	200 U	113	13	980 J
			58	SB-424 DUP	200 U	114	14	110 U
			87	SB-418	110 U	115	15	1200 J
			104	SB-423	220	116	16	450
			121	SB-402	5300	117	17	110 U

All surface soil samples were collected from 0 to six inches below ground surface.

The calculations provided below are based on the above data, excluding the single background data point. For duplicate sample results, the duplicates were averaged and included as a single result in the calculations. For nondetected results, the detection limits were used in the calculations.

***See next page for calculations based on the above data.

Table 6.1 (continuation)
SOIL SAMPLE CALCULATIONS

Total Data Points: 39

1. Frequency of detected concentrations: 26 of 39 (74%)
2. Range of concentrations: Nondetect (110U to 5,200,000 ug/kg (J)
3. Highest concentration: 5,200,000 ug/kg (J)
4. Mean concentration: 149,716 ug/kg (including highest result)
5. Standard deviation: 691,521 (including highest result)
6. Mean concentration: 39183 ug/kg (excluding highest result)
7. Standard deviation: 119,561 (excluding highest result)

Table 6.2
DINOSEB IN TOP 7 FEET OF SOIL (ug/kg)

LOC.	DEPTH	CONC.		LOC.	DEPTH	CONC.	
SB 4 01	D000	2800.00		SB NN	D000	11.00	UJ
SB 4 01	D005	5.00	UR	SB NN	D002	11.00	UJ
SB 4 01	D005	5.00	UR	SB NN	D005	11.00	UJ
SB 4 02	D000	5300.00		SB OO	D000	10.00	UJ
SB 4 02	D005	5.00	UR	SB OO	D002	10.00	UJ
SB 4 03	D000	41000.00		SB OO	D005	10.00	UJ
SB 4 05	D000	14000.00		SB _A	D002	4100.00	
SB 4 06	D000	200.00	U	SB _B	D000	17000.00	
SB 4 06	D005	5.00	UR	SB _C	D000	7400000.00	
SB 4 07	D000	19000.00		SB _C	D002	4300000.00	
SB 4 08	D000	1000.00	U	SB _C	D005	580000.00	
SB 4 10	D000	200.00	U	SB _D	D000	4100.00	
SB 4 11	D000	510000.00		SB _D	D004	5700.00	
SB 4 11	D000	450000.00		SB _G	D000	10.00	U
SB 4 13	D000	5000.00	U	SB _G	D002	59.00	
SB 4 13	D003	26.00	J	SB _G	D005	25.00	
SB 4 14	D000	2500.00	U	SB _H	D002	10.00	U
SB 4 14	D003	5.00	UR	SB _I	D005	10.00	U
SB 4 15	D000	1000.00		SB _N	D000	360.00	
SB 4 15	D003	5.00	UR	SB _N	D000	270.00	
SB 4 15	D003	5.00	UR	SB _O	D000	10.00	U
SB 4 16	D000	200.00	U	SB _O	D002	10.00	U
SB 4 16	D003	5.00	UR	SB _O	D005	10.00	U
SB 4 16	D003	5.00	UR	SB _P	D001	10.00	U
SB 4 17	D000	200.00	U	SB _P	D003	10.00	U
SB 4 17	D002	10.00	UR	SB _P	D005	10.00	U
SB 4 18	D000	110.00	U	SB _Q	D000	10.00	U
SB 4 18	D001	10.00	UR	SB _R	D000	360.00	
SB 4 23	D000	220.00		SB _R	D002	10.00	UJ
SB 4 23	D003	5.00	UR	SB _R	D005	10.00	U
SB 4 24	D000	200.00	U	SB _S	D000	7000.00	
SB 4 24	D000	200.00	U	SB _T	D000	650.00	
SB 4 24	D005	5.00	UR	SB _T	D002	170.00	
SB AA	D000	54.80		SB _T	D005	2300.00	
SB AA	D002	10.00	UR	SB _U	D000	89000.00	
SB AA	D005	10.00	U	SB _U	D002	14200.00	
SB BB	D000	10.80	UJ	SB _U	D005	21500.00	
SB BB	D002	23.10	J	SB _V	D000	2310.00	
SB BB	D005	16600.00		SB _V	D002	2870.00	
SB CC	D000	25.20	J	SB _V	D005	30800.00	
SB CC	D002	6.20	J	SB _W	D000	12000.00	
SB CC	D005	41.80		SB _W	D002	5260.00	
SB EE	D000	470.00	J	SB _W	D005	1880.00	
SB EE	D002	5.50	J	SB _X	D000	110000.00	
SB EE	D005	36.00	J	SB _X	D002	9960.00	
SB FF	D000	42.60		SB _X	D005	11300.00	J
SB FF	D002	6.80	J	SB _Y	D000	23.80	
SB FF	D005	15.40	J	SB _Y	D002	76.60	J
SB MM	D000	10.00	UJ	SB _Y	D005	100.00	
SB MM	D002	11.00	UJ	SB _Z	D000	3.00	J
SB MM	D005	10.00	UJ	SB _Z	D002	10.00	U
				SB _Z	D005	1.60	J

Table 6.2 (cont'd)
SOIL SAMPLE CALCULATIONS

Total Data Points: 106

1. Frequency of detected concentrations: 55 out of 103 (53%)
2. Range of concentrations: Nondetect to 7,400,000 ug/kg
3. Highest concentration: 7,400,000 ug/kg
4. Mean concentration: 133,050 ug/kg
5. Standard deviation: 837,534

*Soil boring data from 0 to 7 feet was used for characterizing worker exposure.
Surface soil data from Table 6.1 was not used.

TABLE 6.3 SOIL PATHWAY ANALYSIS

Release Mechanism	Exposure	Receptors	Probability
Erosion	Ingestion/ absorbance	Residents/ workers/vistors	Low probability. Site is bermed. Topography flat
Wind	Ingestion/inhalation Absorbance	Residents/workers/ vistors	Low probability. Site is covered with asphalt, building and gravel. Site dust generation would be infrequent and for the most part minimal.
Site work/Trespassers at play	DOMINANT INCIDENTAL INGESTION(1) Secondary inhalation and dermal absorbance	Remediation workers/ Children and young adults trespasseers	Site workers would be exposed for a short period of time during remediation activities. Trespassers could be exposed frequently and for prolonged periods

(1) Incidental ingestion was selected as the dominant pathway. This pathway was selected for the screening risk assessment as the dominant pathway both for extent and frequency of exposure.

Table 6.4
INGESTION OF CHEMICALS IN SOIL

Equation:
$$\text{Intake (mg/kg-day)} = \frac{\text{CS} \times \text{IR} \times \text{CF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

- CS = Chemical Concentration in Soil (mg/kg)
- IR = Ingestion Rate (mg soil/day)
- CF = Conversion Factor (10^{-6} kg/mg)
- EF = Exposure Frequency (days/year)
- ED = Exposure Duration (years)
- BW = Body Weight (kg)
- AT = Averaging Time (period over which exposure is averaged - days)

Variable Values (Surface Soil Exposure):

- CS: Site-specific measured concentration
- IR: 200 mg/day (children 1 through 6 years old; EPA 1989g)
100 mg/day (age groups greater than 6 years old; EPA 1989g)
NOTE: IR values are default values and could change based on site-specific or other information. IR values do not apply to individuals with abnormally high soil ingestion rates (i.e., pica).
- CF: 10^{-6} kg/mg
- EF: 350 days/year
- ED: 6 and 9 years
- BW: 15 kg (children 1 through 6 years old, average; EPA 1989b)
50 kg (young adult, 12 to 18 years old, average; EPA 1989b)
- AT: Pathway specific period - ED x 365 days/year (non-carcinogen)

Variable Values (Worker Exposure during Construction):

- CS: Site-specific measured concentration
- IR: 100 mg/day (age groups greater than 6 years old; EPA 1989g)
NOTE: IR values are default values and could change based on site-specific or other information. IR values do not apply to individuals with abnormally high soil ingestion rates (i.e., pica).
- CF: 10^{-6} kg/mg
- EF: 260 days/year (5 days/week)
- ED: 0.25 years
- BW: 70 kg (adult, average; EPA 1989b)
- AT: Pathway specific period - ED x 365 days/year (non-carcinogen)

Table 6.5

Risk Characterization DINOSEB (RFD: 1E-3)					
Receptor(1)	Range*	Frequency of Occurrence	Ave*	CDI(AVE)	CDI(MAX)
Child (0-6 Years) Body Weight 15 kg	0.1 to 5,200	26/39	150	0.002	0.067
				HQ: 2	HQ: 67
Young Adult (12 to 18 yrs) Body Weight 50 kg	0.1 to 5,200	26/39	150	0.00029	0.01
				HQ: 0.3	HQ: 10
Adult Worker Body Weight 70 kg	0.01 to 7,400	55/103	133	0.00014	0.005
				HQ: 0.1	HQ: 5

(1) USEPA Exposure Factors Handbook EPA/600/8-89/043(1989)

* Surveyed Concentrations (mg/kg) -- prior to removal

HQ: Hazard Quotient

CDI: Chronic Daily Intake

TABLE 6.6

**UNCERTAINTY ANALYSIS FOR BROWN AND BRYANT INTERIM RISK
ASSESSMENT
EFFECT ON EXPOSURE^a**

ASSUMPTION	Potential Magnitude for Over- Estimation of Exposure	Potential Magnitude for Under- Estimation of Exposure	Potential Magnitude for Over- or Under Estimation of Exposure
ENVIRONMENTAL SAMPLING AND ANALYSIS			
Sufficient Samples may have not been taken to characterize the soil medium either extent or level.			*Moderate
Air and food chain samples were not taken during the screening assessment. The deletion of these pathways may serve to underestimate the site risk.		Moderate	
Sampling was not performed in a random manner, therefore the results and characterization may bias the exposure intake analyses.			Low
Only one medium was selected for this assessment. The deletion of groundwater medium from this assessment may serve to underestimate the site risk.		Moderate	
EXPOSURE PARAMETER ESTIMATION			
The standard assumptions regarding body weight, period exposed, life expectancy, population characteristics, and lifestyle may not be representative of the sites actual exposure situation.			Moderate
The amount of media intake is assumed to be constant representative of the exposed population. The hot spot characterization method used to determine the level and extent of the contamination may serve to over and/or underestimate the receptors exposure.			Moderate

^a As a general guideline, assumptions marked as "low", may affect estimates of exposure by less than one order of magnitude; assumptions marked "moderate" may affect estimates of exposure between one and two orders of magnitude; and assumptions marked "high" may affect estimates of exposure by more than two orders of magnitude.

SECTION 7: SUMMARY AND CONCLUSIONS

7.1 Summary of Nature and Extent of Contamination

This RI Report focuses on three media of concern: surface soils, the A-zone soils, and the A-zone groundwater. Although B-zone soils and groundwater were also discussed, they are not the focus of this investigation.

In surface soils, dinoseb was the only contaminant identified as posing a significant contamination threat and as occurring both widely over the site and in high concentrations. Dinoseb was detected at over 7,000,000 ug/kg. The principal hot spot of dinoseb contamination occurs where a significant spill of dinoseb was recorded along the east fence-line (see Figure 4.2). High concentrations of dinoseb were also found scattered in three other locations on-site and low concentrations were found over much of the site. Within the potential construction zone for the site, which has been identified as down to 7 ft bgs, dinoseb was also the only contaminant present at significant concentrations. Concentrations in both the surface soil and construction zone were found to pose a potential human health risk (see section 6). The spill area, however, is the only part of the site where high concentrations of dinoseb were found in the construction zone, and this location was also partially remediated by EPA's Emergency Response Section during the RI.

Soil contamination down to the A-zone groundwater was found over much of the site, but was primarily concentrated in three areas: the sump and wash pad area, the dinoseb spill area, and the pond and area between the pond and the large storage tank in the southwest corner of the site (see Figure 4.2). Within these three areas and over the entire site, six chemicals were identified as occurring at highest concentrations and to the greatest extent within the A-zone soils. These chemicals are 1,2-dichloropropane, 1,3-dichloropropane, dibromochloropropane, 1,2,3-trichloropropane, ethylene dibromide, and dinoseb. All of these chemicals except for dinoseb are volatile organic chemicals.

Dinoseb was found concentrated in the top 30 feet of the spill area and then declined significantly in concentration down to the A-zone groundwater. In the pond and sump areas, the concentrations were significantly less than in the spill area.

Volatile organic contaminants were found in highest concentrations in the sump and wash pad area. One boring in particular, boring I (located in the center of the sump), stands out for its exceptionally high concentrations. These contaminants were also found at significant levels in the area of the pond, and then were found in only relatively small concentrations elsewhere at the site. In the sump and wash pad

area, concentrations were highest from 20 and 30 ft bgs, but were also found at concentrations greater than 1,000 ug/kg over most of the A-zone within this area, with the exception of the top ten feet. 1,2-DCP was the volatile contaminant found at highest concentrations, followed by DBCP, TCP, EDB, and 1,3-DCP. In the area of the pond, concentrations were highest from 30 to 40 ft bgs, but in general were found fairly evenly distributed over the A-zone. From highest to lowest, the contaminants in the pond area were the same as in the sump and wash pad area.

Within the A-zone groundwater the same six chemicals plus chloroform were found in highest concentrations and were most widely distributed. The reservoir of contamination in the A-zone groundwater appears to be significantly larger than any other contaminated media at the site. Concentrations for each of the seven contaminants, except for 1,3-DCP, were found at levels as high as 1,000 to 100,000 ug/l. The highest concentrations were consistently observed in well AMW-2P, located near the sump, and at well WA-6, which is directly west of the sump, and at wells AMW-1P, EPAS-2 and EPAS-3, which are all located near the pond. The distribution of contaminants was consistent with the locations of the major sources areas and follow a pattern consistent with the groundwater flow in the A-zone (see Sections 3 & 4). In general, contamination was observed at slightly higher levels at wells near the pond when compared with the wells near the sump; 1,2-DCP was a notable exception.

1,2-DCP was found to be the most wide ranging contaminant in the A-zone groundwater and was found at higher concentrations than any other contaminant. It was found over an area of approximately 5 ½ acres at concentrations greater than or equal to 50 ug/l, or ten times the MCL, and was detected at concentrations as high as 100,000 ug/l in well WA-6. The other six contaminants were also found over large portions of the A-zone groundwater unit, though to lesser extents than 1,2-DCP. Figures of contaminant distribution are included in section 4.

In the B-zone, 1,2-DCP was also observed at levels significantly higher than any other contaminant and was observed at least once in every well. The highest observed concentration of 1,2-DCP in the B-zone was 1,700 ug/l in well WB2-1 (the MCL is 5 ug/l). Except for chloroform, the other principal contaminants from the A-zone groundwater were also observed in the B-zone, though all at concentrations below 100 ug/l.

7.2 Summary of Contaminant Fate and Transport

The fate and transport of contaminants at the site are controlled by chemical specific properties and environmental characteristics and the interaction of these factors. Except for dinoseb which is non-volatile, the key site contaminants are all volatile organic chemicals. All of the

contaminants are relatively mobile in the environment. The volatile contaminants are transported in the environment as gases or in solution, whereas dinoseb is transported primarily in solution in the subsurface and in either solution or adsorbed to soil at the surface. All of the chemicals are weakly absorbed in soil, although the adsorption of dinoseb is pH dependent.

Vadose zone modeling was conducted to characterize the transport of key site chemicals in subsurface soil under site conditions. The modeling results predict that 1,2-DCP is the most mobile of the key site contaminants. This appears to be related to its greater mobility as a gas when compared with the other site contaminants. The mobility of dinoseb on the other hand is highly dependent on the amount of water infiltration. In the absence of any water infiltrating into the subsurface, as would occur with a cap, dinoseb migration would be significantly retarded. The solubility of dinoseb is also highly pH dependent. Under neutral or basic pH conditions, dinoseb is highly soluble.

Also crucial to the fate of site contaminants are their degradation rates. The modeling looked at a range of possible degradation rates based on literature values for key site volatile contaminants. The results of this modeling showed that the degradation rate was generally the most significant variable affecting the long term impact from site contamination.

Probably the most important environmental factors influencing the fate and transport of contaminants at the site are the geology and the amount of water infiltrating into the A-zone. As presented in section 3, the site geology is a heterogeneous mixture of different soil types characteristic of an alluvial geology typical of that region. This type of geology results in a high degree of variability both vertically and laterally in the permeability of the soil material, which in turn results in spacial variability in the rate of contaminant transport at the site. Where possible regional features have been identified and some generalizations have been made with regard to the site geology (see section 3). Within the A-zone it was generally observed that finer grained sediments are more common below 30 feet until the A-zone water bearing unit is encountered. The base of the A-zone is a thin, mostly sandy clay unit that retards downward water movement.

Groundwater flow within the A-zone water bearing unit is very slow as a result of a low hydraulic conductivity. However, local variations in flow are expected due to difference in the lithology of this water bearing unit over the site; higher hydraulic conductivities are expected at the south-east side of the site where more sand was observed within this unit (see Figure 3.5). Patterns of contaminant distribution in the A-zone groundwater are generally consistent with the direction of groundwater flow. The exact nature of water movement between the

A-and B-zone is not known. The A-zone is expected to be leaky and it may be that there are preferential downward flow paths were the clay layer at the base of the A-zone thins out. At a soil boring located 900 ft south of the site this clay layer and the A-zone groundwater were not observed.

The infiltration of water into the A-zone is important because of its impact on contaminant movement in the vadose zone and as a source for the groundwater in the A-zone. The transport of dinoseb in particular is directly related to the amount of water infiltration because of its high solubility and low volatility.

7.3 Data Gaps

For the purposes of conducting a Remedial Investigation, i.e., to collect data necessary to adequately characterize the site for the purpose of developing remedial alternatives, the characterization conducted to date has been adequate so that remedial alternatives could be developed in the Feasibility Study. This characterization, however, will probably need to be supplemented for the design and implementation of the remedial alternative selected. Depending on the alternative selected for the site, additional data may need to be collected regarding the extent of contamination for any of the media investigated during this RI/FS. Likewise, additional characterization of the geology and hydrogeology may also be necessary to adequately design the remedial alternative selected.

Perhaps one of the most significant variables not well characterized for the site is the half-life of the various site contaminants under site conditions. The degradation rates of site contaminants may play a significant role in determining the amount of time that is required to remediate the site. The degree of attenuation of contaminants in the site media is also not well known, especially because of the complex site geology.

7.4 Conclusions

Contamination at Brown & Bryant consists primarily of a small number of volatile pesticides (principally 1,2-DCP, EDB, DBCP and TCP) and dinoseb.

At the surface and in the construction zone (to 7 ft. bgs), dinoseb is the contaminant of concern. Though found widely over the site at varying concentrations, hot spots of dinoseb were found at four locations, the largest being the dinoseb spill area along the east fence-line. This spill area was also the only portion of the site with significant concentrations of dinoseb in the construction zone.

Contamination in the vadose zone was investigated to determine how this contamination may continue to impact groundwater zones below the site. Three principal source areas were identified: the sump and wash pad area, the pond and area adjacent to the pond, and the dinoseb spill area. Extensive soil sampling within these areas found that the volatile pesticides were primarily concentrated in the pond and sump areas and that dinoseb was primarily concentrated in the spill area. Vadose zone modeling was conducted to predict the potential impacts from this contamination. The modeling predicted that a cap over the source areas would significantly retard all of the primary contaminants as a result of a reduction in water infiltration, except for 1,2-DCP. 1,2-DCP was predicted by the model to be the most wide spread contaminant and data from groundwater sampling found this to be true.

The contamination in the A-zone groundwater was identified as the most significant current source of subsurface contamination. This groundwater zone, however, is not a potential drinking water source because of its low water production capacity. Therefore, the investigation of A-zone groundwater contamination focused primarily on characterizing this contamination as a source potentially impacting deeper groundwater, primarily the B-zone groundwater. 1,2-DCP is the most wide spread contaminant in the A-zone groundwater, occurring over a 5½ acre area at 10 times MCL. It also occurs at concentrations higher than any other contaminant. The pattern of contaminant distribution is consistent with the source areas of soil contamination, with the highest concentrations emanating from the sump and pond areas. The direction of contaminant migration is also consistent with the direction of groundwater flow. Groundwater flow moves slowly in a southerly direction.

Extraction of contaminated A-zone groundwater for site remediation is expected to be difficult due to its low permeability and thinness. Slug test results suggest that a yield of less than 100 gallons per day can be expected for wells in this groundwater.

The B-zone groundwater is a potential drinking water source but is not currently used for drinking water. Contamination from all of the key site contaminants were detected in this groundwater. All of the results were relatively low except for 1,2-DCP which was found at over 1,000 ug/l in one well. This chemical was also the most widely detected contaminant in the B-zone. Contamination in the B-zone groundwater is expected to move slowly due its very flat hydraulic gradient. A more detailed analysis of contamination in the B-zone will be the subject of second operable unit RI/FS.

Based on data from the City well closest to the site and from the B-zone well nearest to the City well, B-zone

contamination is not currently impacting drinking water at levels that can be detected, and it is not expected that this will change in the near future.

**BROWN & BRYANT
FEASIBILITY STUDY
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1.0 EXECUTIVE SUMMARY

This report presents the Feasibility Study (FS) for the Brown & Bryant site in Arvin, California. The purpose of the FS is to develop Remedial Action Objectives and Preliminary Remediation Goals, to identify the Applicable or Relevant and Appropriate Regulations, to identify and screen potential technologies, to assemble technologies into comprehensive alternatives, and finally to evaluate the alternatives using the nine criteria presented in the National Contingency Plan. This FS addresses contamination in the surface soil, the subsurface soil (down to the first groundwater), and the first groundwater zone referred to as the A-zone groundwater. These three areas constitute the source area at the site. The goal of the actions proposed in this FS is source control.

The Brown & Bryant facility in Arvin was an agricultural chemical distributor from 1960 to 1988. Accidental spillage and inadequate disposal methods during this time caused soil and groundwater contamination. In 1984, the State of California issued an order to Brown & Bryant to investigate the scope of the contamination problem. Throughout the 1980s the State directed Brown & Bryant to address soil contamination.

In October 1989, the site was listed on the Superfund National Priorities List (NPL) and EPA became involved. In 1990, EPA collected soil samples and installed shallow monitoring wells, identifying areas that needed immediate attention. EPA also set-up a routine sampling program to test all site monitoring wells and the nearby city wells.

In 1991, EPA excavated and treated the most contaminated soil containing the pesticide, dinoseb. In that year, EPA also collected additional soil samples at the site and ordered Southern Pacific Transportation Company and Atchison, Topeka and Santa Fe Railway to install additional monitoring wells, including several wells located between the site and the nearest city well.

Six alternatives have been identified for addressing the soil and A-zone groundwater at Brown & Bryant. All the alternatives, except the no-action one, contain an extraction, treatment and reinjection system in the A-zone groundwater. The extracted A-zone water will be treated using UV/Oxidation. After treatment, the extracted water will be re-injected into the A-zone to help flush out the remaining chemicals.

Another element common to all the action alternatives is a multilayered/basic cap combination. The southern, most contaminated area of the property would be covered with a RCRA-cap and the remainder of the property would be covered with a basic cap, such as asphalt. The purpose of the cap combination is to minimize water infiltration. The RCRA cap also eliminates

potential exposure to hazardous substances. A RCRA cap on the southern portion of the site is required by for all waste ponds and sumps in operation after 1982. In addition to the legal requirements, a RCRA cap makes technical sense because some soil contamination will remain after treatment is completed and a RCRA cap is designed to be protective when contamination remains. To assure that the site remains safe after EPA completes the clean-up, deed restrictions or other institutional controls would be placed on the property to ensure that the cap remains safely intact and that the soil under the cap remains undisturbed in the future.

The alternatives vary primarily with respect to handling the surface soil and subsurface soil. The surface soil will be either consolidated under the RCRA cap, treated and disposed off-site, or treated and disposed on-site. The subsurface soil may be treated using soil vapor extraction.

Alternative 1 - No Action

Superfund regulations require EPA to always include consideration of a no action alternative to compare all other alternatives with. In this proposed plan, EPA presumes that site monitoring would continue if the no action alternative was selected.

Alternative 2 - Consolidation, RCRA/Basic Cap, Extraction and Treatment of A-zone Groundwater

Alternative #2, like all the alternatives except #1, includes a RCRA cap on the southern portion of the site containing the sump and the waste pond and a basic cap on the remaining property. This alternative varies from the other alternatives in its handling of soil containing dinoseb in excess of health-based standards. Such soil will be consolidated on the southern acre of the site under the RCRA cap. Included in this alternative, as well as all others except #1, is an injection and extraction system that will flush the A-zone groundwater and treat it prior to reinjection using UV/Oxidation.

Alternative 3 - Off-site Treatment of Some Surface Soil, RCRA/Basic Cap, Extraction and Treatment of A-zone Groundwater

Alternative #3 also includes a RCRA cap on the southern portion of site containing the sump and the waste pond and a basic cap on the remaining property. This alternative differs from alternative #2 in that any surface soil with dinoseb in excess of health-based standards in the portion of the site not covered by a RCRA cap will be excavated and treated off-site rather than consolidated on-site. Like alternative #2, alternative #3 includes an injection and extraction system that will flush the A-zone

groundwater and treat the extracted water prior to reinjection using UV/Oxidation.

Alternative 4 - On-site Treatment of all Surface Soils, RCRA/Basic Cap, Extraction and Treatment of A-zone Groundwater

Alternative #4 also includes a RCRA cap on the southern portion of site containing the sump and the waste pond and a basic cap on the remaining property. However, unlike consolidation or off-site treatment of some of the soil as envisioned in the earlier alternatives, alternative #4 will treat on-site all surface soil with dinoseb in excess of health-based standards by soil washing. The treated soil will then be replaced back on-site. An injection and extraction system will flush the A-zone groundwater and treat it prior to reinjection using UV/Oxidation.

Alternative 5 - Off-site Treatment of Some Surface Soil, RCRA/Basic Cap, In-situ Treatment of Deeper Soils, Extraction and Treatment of A-zone Groundwater

Alternative #5 also includes a RCRA cap on the southern portion of site containing the sump and the waste pond and a basic cap on the remaining property. Similar to alternative #3, any surface soil with dinoseb in excess of health-based standards in the portion of the site not covered by a RCRA cap will be excavated and treated off-site. This alternative differs from the other alternatives because it also includes a Soil Vapor Extraction system to remove volatile compounds in deeper soil (25 to 40 feet). An injection and extraction system will flush the A-zone groundwater and treat it prior to reinjection using UV/Oxidation.

Alternative 6 - On-site Treatment of all Surface Soils, RCRA/Basic Cap, In-situ Treatment of Deeper Soils, Extraction and Treatment of A-zone Groundwater

Alternative #6 also includes a RCRA cap on the southern portion of site containing the sump and the waste pond and a basic cap on the remaining property. Like alternative #5, this alternative includes a Soil Vapor Extraction system to remove volatile compounds in deeper soil (25 to 40 feet). However, it differs from alternative #5 by opting to wash and replace the dinoseb contaminated soil on-site as described in alternative #4. An injection and extraction system will flush the A-zone groundwater and treat it prior to reinjection using UV/Oxidation.

Nine-Criteria Analysis Summary

All alternatives were compared to each other with respect to the nine criteria presented in the National Contingency Plan. The nine criteria are overall protectiveness, compliance with ARARs, long-term effectiveness and permanence, reduction of toxicity mobility or volume through treatment, short-term effectiveness, implementability, cost, state acceptance and community acceptance.

All the action alternatives eliminate the exposure to the contaminated surface soil and controls the contamination from the A-zone groundwater to the potential drinking water source. Therefore, the overall protectiveness is similar for all the action alternatives.

All the action alternatives comply with the applicable or relevant and appropriate regulations (ARAR). The specific ARARs and TBCs at the site are:

State Resolution 68-16, Anti-degradation policy.

Hazardous Waste Control Laws, Health & Safety Code, Division 20, Ch. 6.5

Section 66265, Article 11 - Closure and Monitoring

Section 66268, Subpart C - Land Disposal Restriction (To Be Considered)

Section 66265, Articles 9 & 10 - Containers and Tanks

40 C.F.R. Subpart S - Corrective Action (To Be Considered)

Safe Drinking Water Act - Underground Injection

The alternatives that treat the greatest amount of contamination will be the most permanent (alternative 5 & 6). However, all the alternatives, except no action, treat the largest source of continuing contamination, the A-zone groundwater. The long-term effectiveness of all the action alternatives depend on the long-term maintenance of the cap.

All the action alternatives reduce the most significant volume of contamination, the A-zone groundwater by extraction and treatment. In respect to the surface and subsurface soil, the alternatives treat an increasing volume of soil with subsequent alternative. Alternative #6 treats the greatest volume of contamination. All the action alternatives control the mobility of the remaining contamination.

The extraction and treatment process for the A-zone groundwater proposed for all the action alternatives does not pose any short-term risk to the workers or the community. There is a short-term risk when contaminated soil is excavated. The volume of soil excavated increases with each subsequent alternative, with alternative #2 have the least volume excavated. There is also a short-term risk associated with transporting contaminated soil off-site which is proposed in alternative #3 and #5.

All the action alternatives that address surface soil use standard, proven technology or innovative technology that has been used at the site. Soil vapor extraction, proposed in alternatives 5 & 6, has been successfully used at other sites. The success of this technology at the site is dependent on the ability to pull air through the silty sand and silt layers found at the site. The extraction process proposed in all the action alternatives is implementable.

The present worth costs for the action alternatives range from \$10,192,000 for alternative #2 to \$11,922,000 for alternative #6, with each subsequent alternative increasing in cost. The no action alternative, alternative #1, costs \$610,000.

The State of California Department of Toxic Substance Control has been involved with this project from the beginning. Their official comments on the RI/FS are anticipated during the public comment period. The issues and concerns of the community will be addressed during the public comment period.

2.0 INTRODUCTION

The Brown & Bryant Operable Unit One Feasibility Study (FS) identifies and evaluates remedial alternatives in accordance with the requirements of the National Contingency Plan (NCP). The FS addresses the contamination in three areas of concern at the Brown & Bryant site in Arvin, California: the surface soil, the vadose zone soils (A-zone soils), and the first water bearing unit (A-zone groundwater). This FS was prepared by the Environmental Protection Agency (EPA), Region IX with support of the EPA's Risk Reduction and Engineering Lab.

2.1 Purpose and Organization of the Report

The purpose of the Feasibility Study is "to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can be presented to the decision maker" (40 CFR §300.430 (e)). This objective will be obtained by completing the following tasks:

- o Develop Remedial Action Objectives, which are clean up objectives that identify contaminants and potential exposure pathways taking into account the Applicable or Relevant and Appropriate Regulations and protection of human health and the environment.
- o Identify, screen and select viable remedial technologies for each medium.
- o Develop and screen remedial action alternatives assembled from the select technologies.
- o Compare the action alternatives for each medium using the nine-criteria required in the NCP (40 CFR §300.430 (e)(9)(iii)).

This report presents the findings of the above-mentioned tasks at the Brown & Bryant Superfund site in Arvin, California. Additional information regarding site characterization and risk assessment can be found in the Brown & Bryant Remedial Investigation Report (U.S. EPA, May, 1992).

2.2 Background Information

2.2.1 Site Description

Brown & Bryant, Inc. (B&B) was a pesticide reformulation and custom applicator facility located in Arvin, California, southeast of Bakersfield (Figure 2.1). B&B also owned and operated a similar facility in Shafter, northeast of Bakersfield. The Arvin facility is on a 5-acre parcel of land at 600 South Derby Road in Arvin (Figure 2.1). The adjacent land is agricultural, light industrial and residential. Arvin is an agricultural community of approximately 9,000 people of which a majority are Hispanic. The site is also located within one-half mile of Sierra Vista School, Haven Drive School and Di Giorgio County Park.

2.2.2 Site History

The B&B Arvin facility formulated agricultural chemicals, including pesticides, herbicides, fumigants and fertilizers, from 1960 to 1989. Prior to this time, the site was used as farmland.

During the site's operational history a number of tanks, sumps and a waste pond were used in various portions of the site operations. The Remedial Investigation report discusses the history of some of the most important on-site features that have had an influence on contamination at the site. The major on-site features are a waste pond, a sump area and a dinoseb spill area.

The waste pond located in the southwest portion of the site (Figure 2.2) was originally excavated as an unlined earthen pond in 1960. The pond was used to collect run-off water from the yard and from two sumps (since excavated). The pond was also used to collect rinse water from rinsing tanks used for fumigants. Excess pond water and rain water run-off also collected in a topographically low area to the east and south of the pond. In addition, ponded water from precipitation and irrigation from the east has occasionally breached the berm in the southeast corner of the pond and drained into the pond (Closure Plan, Canonie). The pond was double lined with a synthetic liner in November 1979. The liner and additional soil were excavated in August 1987. Approximately 640 cubic yards of soil that showed visible signs of contamination were removed from the pond at that time. The depths of this excavation ranged from approximately one and one-half feet on the sides to five feet on the bottom.

In 1960, an unlined earthen sump was constructed in the center of the site (near wells AMW-2P and AMW-4R). The sump was used to collect wash water from a pad where equipment and tanks used for liquid fertilizers and fumigants were washed. Water

from the sump was drained to the pond through an underground pipeline. In 1980, the sump was replaced with two double lined sumps (sumps 1 and 2), and two double lined sand traps were installed west of the pond.

Dinoseb was stored in a smaller tank storage area along the eastern fence, just north of the pond. In 1983, there was a significant dinoseb spill in this area. As a result, this portion of the site has shown the highest concentrations of dinoseb.

2.2.3 Nature and Extent of Contamination

The media and areas of concern at B&B include surface soils, the vadose zone, and three groundwater units. The surface soils are defined as extending from 0 to 7 feet below ground surface (bgs). The vadose zone, or A-zone soils, are from 7 to 65 feet bgs and the A-zone groundwater is from 65 to 85 feet bgs. The second, or B-zone, groundwater unit is located approximately 150 to 210 feet bgs, and the drinking water aquifer is reached approximately 350 feet below ground surface. A schematic cross-section is presented in Figure 2.3. In previous reports the A-zone has been referred to as the "perched aquifer" or "perched zone," and the B-zone has been referred to as the "regional unconfined aquifer." Because these designations did not always accurately describe the hydrogeology of these groundwater units, the "A" and "B" designations were adopted.

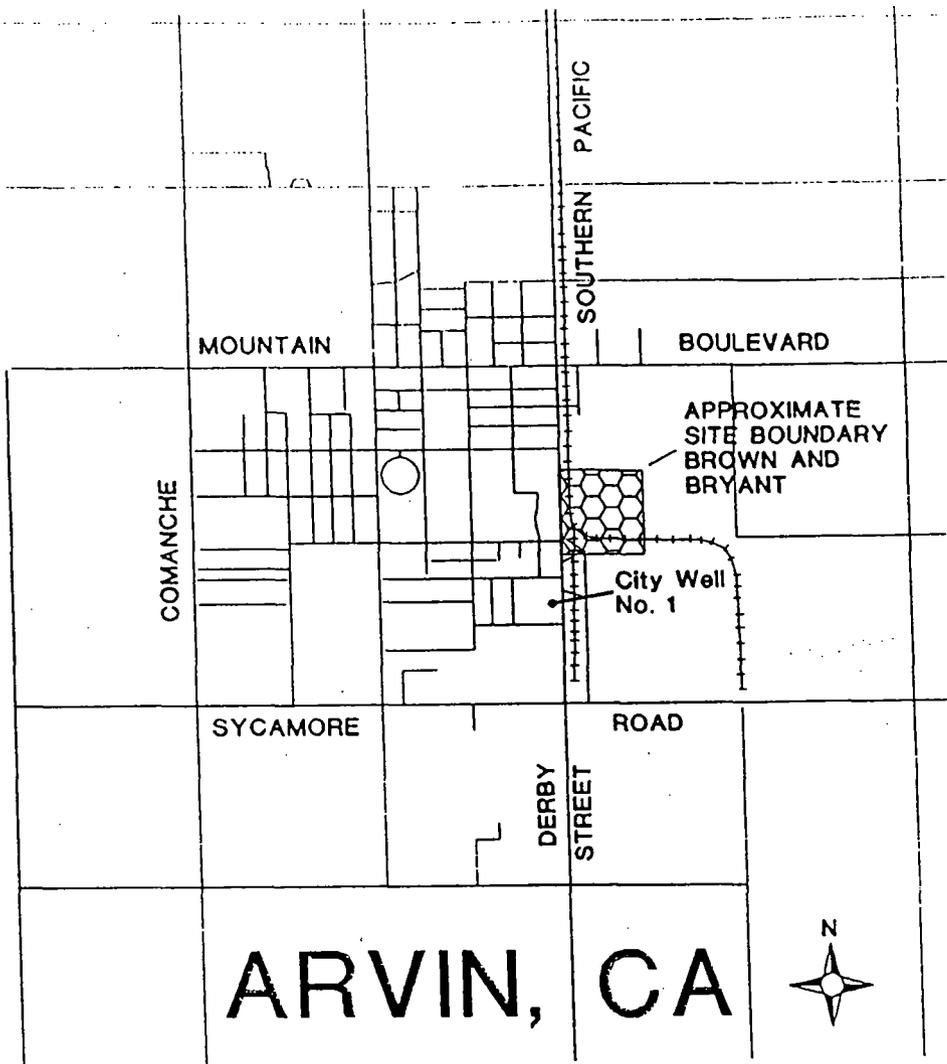
This FS report addresses primarily the contamination in the surface soils, the A-zone soils, and the A-zone groundwater. Surface soil contamination consists of dinoseb and is found throughout the fenced facility. Areas of greatest surface contamination are the former dinoseb tank area, the topographic low area in the southern portion of the site, and the northeast corner. Dinoseb in the soil at depth is found predominately in the dinoseb tank area, and to a lesser extent in the topographic low area in the southern portion of the site.

Volatile organic compounds (VOCs) are also found in the A-zone soils, although at lower concentrations than the dinoseb concentrations. The VOCs are found predominately under the former sump area and to a lesser extent in the topographically low area in the southern portion of the site and around the waste pond. VOCs of concern on the site are 1,2-dichloropropane (DCP), 1,3-DCP, dibromochloropropane (DBCP), ethylene dibromide (EDB) and 1,2,3-trichloropropane (TCP).

The A-zone groundwater is highly contaminated with dinoseb and VOCs in the southern third of the site, the southwest portion of the site and south, southwest off-site. Details on the A-zone groundwater contamination can be found in the Remedial Investigation Report. Based on data available at the time this

report was written, the B-zone groundwater is also contaminated with the same VOCs as are found in the A-zone groundwater. Further characterization of the B-zone contamination is currently being planned by EPA.

Contaminant fate and transport, and risk assessment are fully discussed in the Remedial Investigation Report which can be referenced for information in these areas.



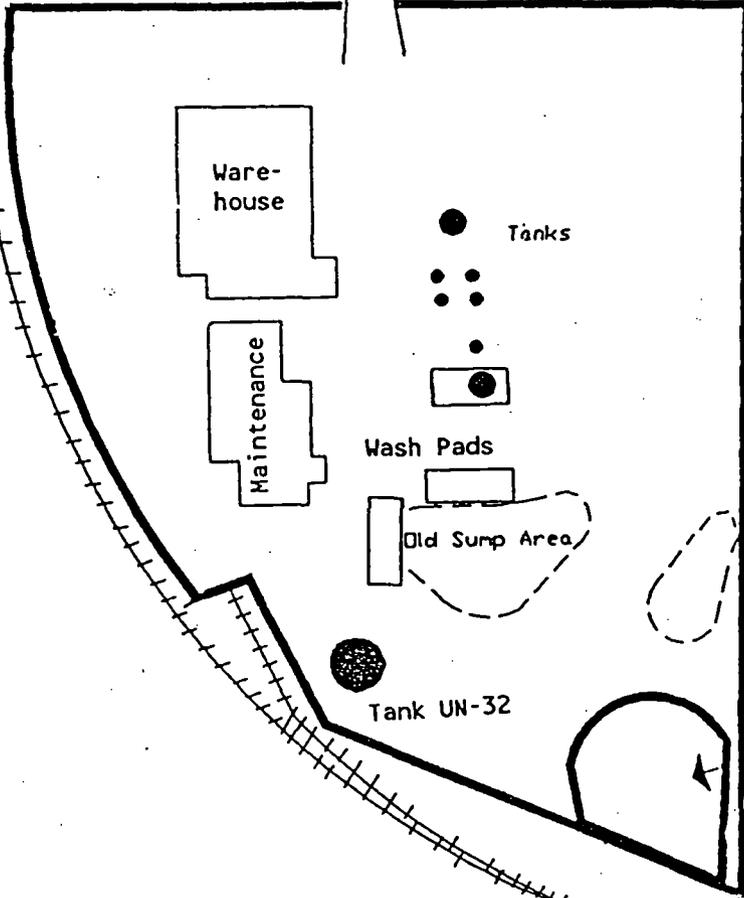
Brown & Bryant, Arvin Calif.

Figure 2.1

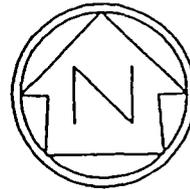
Site Location Map

Brown and Bryant

Derby Street



0 100
Scale in Feet



Brown & Bryant, Arvin Calif.

Figure 2.2.

Site Map

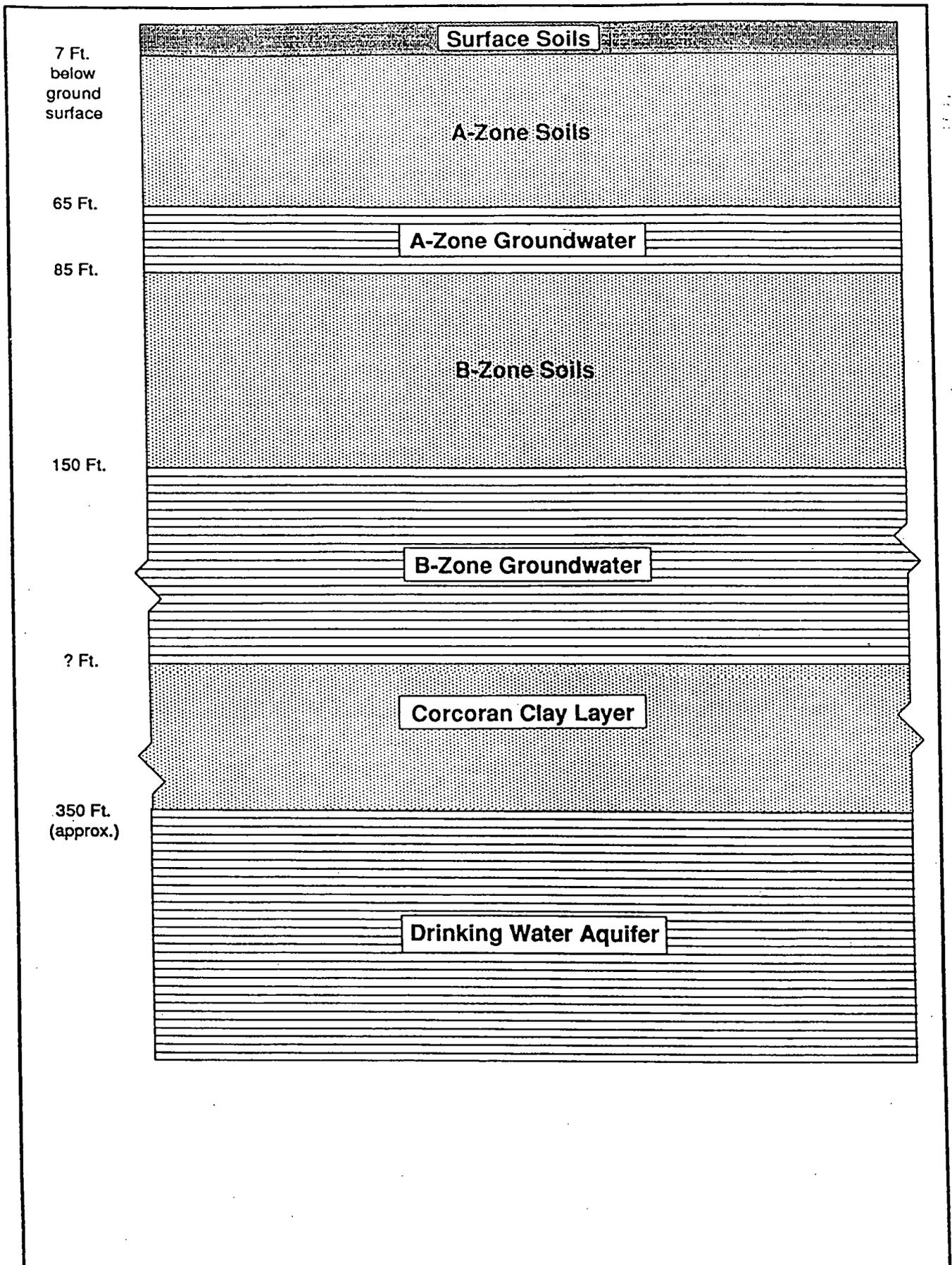


Figure 2.3 Brown & Bryant Media of Concern

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

In this section, potentially applicable treatment technologies/process options for cleaning up the site are identified for each of the media and contaminant types. The technologies/process options are then evaluated and screened based on treatment effectiveness, implementability, and cost. Applicable or relevant and appropriate requirements (ARARs) are identified and compliance with these requirements is addressed. Potentially applicable technologies are identified for each media and screened for technical practicability and cost.

3.1 Remedial Action Objectives

3.1.1 General Remedial Action Objectives

The primary remedial action objective for the site is to protect human health and the environment by reducing the risks and potential risks as identified in the remedial investigation report. The two primary exposure pathways are; (1) exposure to contaminated surface soils and (2) potential exposure to the water in the B-zone aquifer.

Currently, the site is fenced, therefore, there should be no direct exposure contact to contaminated surface soils by nearby residents. Surface soils are defined as soils from ground surface to a depth of seven feet (seven feet is the maximum foreseeable construction depth based on an estimate by the City of Arvin for the maximum depth of sewer lines). Surface soils at the site are contaminated with dinoseb at levels up to 7400 ppm.

During an EPA emergency removal in the Spring of 1991, EPA excavated and treated the most highly contaminated surface soils at the site. Further site investigation after the removal found that there remain other areas of dinoseb contamination. The primary objective for addressing the surface soil is to prevent direct exposure to contaminated soil.

The B-zone groundwater, likewise, is not a current exposure route because it is not being used as a drinking water source (although it is classified by the Regional Water Quality Control Board as a potential drinking water source). Most local wells, while they do not take water from the B-zone, are gravel packed to near the surface and thus provide a possible connection between the B-zone and deeper drinking water sources. Currently contaminants in the B-zone have not reached any existing drinking water wells.

Remediation at the site will address the A-zone soil and A-zone groundwater impact on the potential exposure pathway of ingestion of groundwater from the B-zone. Because the B-zone

water-bearing unit is considered a potential drinking water source and would be subject to state and Federal regulations, it must be protected. In order to protect the B-zone groundwater, the A-zone soils and A-zone groundwater must be either remediated to a protective level or controlled in a way which will prevent levels in the B-zone from exceeding appropriate health-based levels or the contamination must be removed in the B-zone groundwater.

This feasibility study is only for the first operable unit. It addresses surface soils, the A-zone soil and the A-zone groundwater. This feasibility study is an interim action only for the A-zone groundwater and the A-zone soils since the final remediation of the A-zone is dependent on the remediation of the B-zone groundwater. This Feasibility Study addresses the final remedy for the surface soils. Remediation for the B-zone will be addressed in the subsequent RI/FS report for the second operable unit. The RI/FS report for the B-zone will include a comprehensive remediation for the entire site.

3.1.2 Site Specific Remedial Action Objectives (RAOs)

Site specific remedial action objectives specify chemicals and associated pathways to be addressed. The following RAOs are established for the site:

- o Prevent potential human exposure through direct contact to on-site soil containing chemicals of concern that exceed the remediation goals. The major chemical of concern found in the first seven feet is dinoseb.
- o Prevent or control migration of chemicals of concern from the A-zone soils to the B-zone groundwater such that chemical levels in the B-zone groundwater do not exceed appropriate health-based levels. Currently, there are areas in the B-zone groundwater that exceed the Safe Drinking Water Act maximum contamination levels.
- o Prevent or control migration of chemicals of concern from the A-zone groundwater to the B-zone groundwater such that chemical levels in the B-zone groundwater do not exceed appropriate health-based levels.

3.1.3 Preliminary Remediation Goals

Preliminary Remediation Goals (PRG) are medium-specific or pathway-specific chemical concentration goals or performance standards that satisfy the site specific remedial action objectives.

The A-zone soil, excluding surface soil, and the A-zone groundwater are under consideration for remediation because these are sources for contamination of the B-zone. In general, it is usually more efficient to remove contamination at the source (i.e. A-zone) than to capture contamination when it reaches deeper groundwater. The A-zone groundwater is not a potential drinking water source; nor is the A-zone soil (excluding surface soil) a direct ingestion threat. Consequently, clean-up standards are not driven by existing regulatory standards such as the Safe Drinking Water Maximum Contamination Levels (MCLs). Clean-up standards for these zones are developed by weighing the cost-effectiveness of cleaning up the zones to levels where they will no longer be a threat to the B-zone groundwater vs. treating the contamination when it reaches the B-zone groundwater.

In order to calculate a remediation goal in the A-zone, a remediation goal must be established in the B-zone groundwater. Because the B-zone groundwater is classified as a potential drinking water source, EPA will likely establish clean-up levels in that zone that comply with the Safe Drinking Water Act. Therefore, for purpose of evaluating A-zone clean-up options, PRGs for the B-zone groundwater are set at maximum contamination levels (MCLs). PRGs for the B-zone may be modified as a result of OU2 RI/FS.

3.1.3.1 A-zone groundwater

The strictest goal for the A-zone groundwater would be under the scenario where most of the contamination is captured in the A-zone and the remaining contamination would not be a threat to the B-zone groundwater. Two vadose models were run, one to model the volatile movement through the A-zone groundwater to the B-zone groundwater, and one to model the movement of dinoseb. A different model was chosen for dinoseb because it is non-volatile and water-soluble, and therefore has different transport characteristics. (Refer to the Remedial Investigation) Based on these models, clean-up of the A-zone groundwater to between ten and one hundred times the respective MCLs would keep contamination levels in the B-zone at or below MCLs.

Again, the ultimate goal at the site is to protect the B-zone groundwater in the most cost-effective manner. The

final clean-up level for the A-zone groundwater will be determined after the B-zone groundwater investigation is complete and a final remediation plan for the Site is chosen. The final remediation will take into account the cost-effectiveness of meeting the strictest goals in the A-zone.

3.1.3.2 Surface and A-Zone Soils

The PRGs for soils were calculated by two different procedures, one for each site specific remedial action objective for soils. The first site specific RAO addresses the human ingestion pathway concern for surface soils. Dinoseb was the only chemical found in the upper 7 feet in appreciable amounts. Since dinoseb is a systemic toxicant, the PRG was developed based on the most sensitive subgroup to a systemic toxicant, young children. The PRG for dinoseb, 80 milligrams per kilogram, was developed assuming a child ingests 0.2 mg/day of soil over a five-year period using RCRA no-action calculation (Proposed Subpart S - Federal Register Vol. 55, No. 145, July 1990).

A second set of PRGs are needed for the A-zone soils deeper than seven feet where contamination may leach through the soils and A-zone groundwater to the B-zone groundwater. The chemical transport models show that under current conditions, the chemical 1,2-DCP in the A-zone soil may pose a threat to the B-zone groundwater. Whether this impact is significant depends on several input parameters, most notably, the degradation rate. The modeling and the calculation of mass in the A-zone show that the greatest threat to the B-zone groundwater is from the A-zone groundwater, rather than the A-zone soils.

The goal in the A-zone soil is to protect the B-zone groundwater from additional degradation. An evaluation of the cost/benefit analysis will determine which of the following methods are cost-effective: (1) capturing the 1,2-DCP in the vadose zone, (2) capturing it in the A-zone groundwater, or (3) allowing natural processes such as biodegradation to work on the contamination as it migrates to the B-zone groundwater.

The MULTIMED model for dinoseb showed that with the addition of a cap to minimize infiltration, the dinoseb is not a threat to the B-zone groundwater. Under current conditions (no cap), the model indicated a clean-up level of 2 mg/kg would be protective.

3.2 ARARs

3.2.1 ARARs

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) requires that the remedy chosen at a site must attain legally applicable or relevant and appropriate requirements (ARARs) unless the basis for a statutory waiver exists. ARARs are standards, criteria or limits promulgated under Federal or State law. Only those State standards that are more stringent than Federal requirements, are timely identified by the State and that are consistently applied by the State can be considered ARARs.

Applicable requirements are those standards, requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, remedial action, location or other circumstance at a CERCLA site. Relevant or appropriate requirements are those standards, requirements, criteria, or limitations promulgated under Federal or State law that, while not applicable to the site, describe a hazardous substance, remedial action, location or other circumstance, are sufficiently similar to the circumstances at the site that their uses are well suited to the site. In some circumstances, a requirement may be relevant, but not appropriate. If a determination is made that a requirement is relevant and appropriate, such a requirement must be met to the same extent as an applicable requirement.

CERCLA requires that all response actions at a CERCLA site comply with the substantive requirements of the ARARs selected for the remedy. Pursuant to CERCLA §121 (e) administrative requirements, including permitting requirements, are not ARARs and are not required to be met for the on-site portion of any CERCLA response action.

Nonpromulgated policy, advisories or guidance may be considered when developing remediation levels necessary to protect public health. These items are called "To Be Considered" (TBCs) criteria.

Section 121(d)(4) of CERCLA provides an exception to the requirement that ARARs be met for remedial action only if one or more of the following conditions exists:

- 1) The remedial action selected is only part of the total remedial action that will ultimately attain such levels or standards of control when completed;

- 2) Compliance with the ARAR will result in greater risk to human health and the environment;
- 3) Compliance is technically impracticable;
- 4) The remedial action will attain a standard of performance equivalent to an ARAR through use of another method;
- 5) The state has not consistently applied the standard requirement, criteria, or limitations to other similar sites within the state; or
- 6) The ARAR would require too great an expenditure from the Superfund Trust Fund.

3.2.2 Specific ARARs

The specific regulations that are applicable or relevant and appropriate for the Brown & Bryant site can be classified into chemical-specific regulations and action-specific regulations. There are no location-specific ARARs at this site. The chemical-specific ARAR at Brown & Bryant is:

State Resolution 68-16, Anti-degradation policy.

Action-specific ARARs and TBCs at Brown & Bryant are:

Hazardous Waste Control Laws, Health & Safety Code,
Division 20, Ch. 6.5

Section 66265, Article 11 - Closure and Monitoring
Section 66268, Subpart C - Land Disposal
Restriction (To Be Considered)
Section 66265, Articles 9 & 10 - Containers and
Tanks

40 C.F.R. Subpart S - Corrective Action (To Be
Considered)

Safe Drinking Water Act - Underground Injection

Of particular significance in determining clean-up levels that may be applicable to the A-Zone groundwater is whether this zone is classified as a drinking water aquifer. Groundwater classification is covered in the federal Safe Drinking Water Act (40 CFR §141) and by the state's Tulare Basin Plan in conjunction with the California Porter-Cologne Act. An underground drinking water source is defined in 40 CFR §144.4 as having total dissolved solids (TDS) less than

10,000 mg/l and being capable of producing enough water to supply a public water system.

The definition of a public water system (40 CFR §141.2) is a system that supplies either 15 connections or 25 people for 60 days a year. Based on EPA guidance on per capita use, the water bearing unit would need to produce 200 gallons per day to be classified as a underground drinking water source. The Tulare Basin Plan (Resolution 89-098) classifies all groundwater as designated municipal or domestic supply, except when the production is less than 200 gal/day or TDS is greater than 3,000 mg/l. Based on slug tests conducted in the A-zone, the average production of the A-zone is 90 gal/day; therefore, the A-zone is not considered a potential drinking water source by either State or Federal regulations.

Although the A-zone is not a potential drinking water source, water re-injected into the A-zone should be protective, as required by State Board Resolution 68-16. This resolution offers a narrative description of anti-degradation policy. EPA believes that reinjection at the Maximum Contamination Levels (MCLs) under the Safe Drinking Water Act would comply with Resolution 68-16.

The major action-specific regulations are part of the State Hazardous Waste Control Law. (Health & Safety Codes, Division 20, Chapter 6.5), which is the State's RCRA-equivalent regulations. Although Brown & Bryant did not apply for interim status under RCRA, disposal of wastewater into the sump and waste pond at the site constituted RCRA activities. Therefore, Brown & Bryant should have been classified as an interim status facility and the State HWCL would be applicable. Specifically, the waste pond and the sump area are considered RCRA surface impoundment units and must be closed and monitored pursuant to 22 CCR 66265.228.

Land disposal restrictions (LDRs) are applicable whenever there is placement of soil containing listed waste on the land. At Brown & Bryant, the soil contains listed waste. However, LDRs are not applicable if contamination is consolidated in one area of contiguous contamination. The Brown & Bryant facility is considered one area of contiguous contamination because the dinoseb surface contamination is prevalent all over the site without any specific operational boundaries. Therefore, the surface soil can be consolidated within the facility. If the contaminated soil is treated on-site, then the LDR soil clean-up standards can be used as TBCs before the treated soil is replaced into land units. Based on the Superfund LDR Guidance #6A (2nd ed) for obtaining a soil and debris treatability variance, the

following treatment standards would be applicable (all numbers are based on total waste analysis):

1,2 DCP 0.5-2 ppm
dinoseb as nitrated aromatic 2.5 - 10 ppm
dinoseb as herbicides 90 - 99.9 percent reduction
DBCP 0.5-2 ppm
EDB 0.5 - 2 ppm

Other SHWCL requirements for specific treatment units such as tanks, containers, etc. would be applicable, if used. Specific requirements will be identified in the ARAR analysis part of the nine-criteria analysis. The UV/O₃ system would be considered a tank. A variance for the secondary containment requirements in CCR §66266, Article 9 will be invoked when design and placement of the tanks do not pose a substantial hazard to human health and the environment.

Underground injection control regulations under the Safe Drinking Water Act regulates the construction and operation of underground injection wells. The regulation would be relevant and appropriate for reinjection into the A-zone groundwater. Reinjection wells would be classified as Class V.

3.3 General Response Actions

General response actions are general actions that satisfy the remedial action objectives. To address contamination of the surface soils where there is a risk of soil ingestion, the following actions would satisfy the objectives:

- o institutional controls
- o containment (capping)
- o excavation and treatment and/or disposal

For protection of B-zone groundwater from further contamination by the A-zone soil, the following actions would satisfy the objectives:

- o no action (treat contamination when it reaches the B-zone or A-zone groundwater)
- o containment (capping)
- o in-situ treatment

For protection of B-zone groundwater from further contamination by the A-zone groundwater, the following actions would satisfy the objectives:

- o no action (treat contamination when it reaches the B-zone)

- o institutional controls
- o containment
- o extraction and treatment

3.3.1 Volume Estimates

In order to compare alternatives with respect to cost and time to complete remediation, an estimate of the volume of material needed to be treated must be made. If the assumptions used in estimating volumes are critical for design of an alternative then further sampling may be necessary during the remedial design.

The volume of A-zone groundwater to be treated is dependent on final clean-up levels and final design parameters such as flushing rates. The extent of contamination can be estimated based on chemical concentration contour maps from the groundwater sampling. Any area where the groundwater concentration exceeds ten times the respective MCL is included in the area estimate. The area encompassed by the ten times the respective the MCLs would be the largest possible area since the ten times the MCL is the strictest remediation goal.

The chemical with the most widespread contamination, 1,2-DCP, was selected for the area estimate. The estimated area of clean-up is 5.6 acres. Assuming an A-zone groundwater thickness of five (5) feet and a porosity of 0.40, the estimated initial volume of water is 3,650,000 gallons¹. Assuming ten pore volumes will be required for flushing, the final volume estimate is 36,500,000 gallons. Figure 3.1 shows the extent of contamination for 1,2-DCP.

Volume of soil to be remediated was broken into two categories: surface soils and subsurface soils. The surface soils range from zero to seven feet below surface and include dinoseb concentrations exceeding health based levels (80 ppm). The subsurface soils range from seven feet to approximately forty feet in depth.

Among the surface soil samples which exceeded health based levels, three samples were located outside the area where the EPA conducted a removal response to treat the dinoseb (See figure 3.2) . All these samples were surface soil samples (upper 6 inches). A rough estimate of surface soil contamination was made assuming that each hit was in a 30 feet by 30 feet area of contamination and the depth of

¹ (5.6 acres)(43,560 ft²/acre)(5 ft)(7.48 gal/ft³)(0.40) = 3,650,000 gal

contamination was one foot. The estimated volume is 100 cu. yds. In addition, it was estimated that in the dinoseb hot-spot area, the dinoseb contamination extends 50 feet by 50 feet by 7 feet depth. Total volume is 650 cu. yards. EPA's Emergency Response cleaned up 80 cu. yds; therefore, the volume requiring treatment in the dinoseb hot-spot is 570 cu. yards. The combined total surface soil volume is 670 cu. yds.

The majority of contaminated soil which exceeds health-based standards is located in the southern third of the site including the former sump area, the waste pond, the area surrounding the large tank, the dinoseb hot-spot and the surrounding area. If the southern third of the site, where a RCRA cap is required, is excluded from volume calculation, then the total hot-spot volume is estimated to be less than 70 cubic yards.

The volume of A-zone subsoils that may pose a threat to the B-zone groundwater is estimated to be 48,000 cubic yards. The estimate was developed by assuming the sump area is 100' x 100' x 40' and the pond area is 150' x 150' x 40'. Soil samples that exceed 2 mg/kg for dinoseb are shown on figures 3.3 and 3.4. Dinoseb levels did not exceed 2 mg/kg below twenty feet.

3.4 Identification and Screening of Technology

In this section, potential treatment technologies and process options are identified, evaluated and screened based on treatment effectiveness, implementability and costs. Figure 3.5 lists all the potential process options considered at Brown & Bryant for soil remediation. Figure 3.6 lists all potential process options for groundwater remediation. After this initial screening, the process options retained for further evaluation are presented in tables 3.1, 3.2 and 3.3. Since the treatability tests for bioremediation at the site were inconclusive and contradictory, and there are other viable alternatives for remediation, it was decided not to carry any bioremediation alternatives into the further analysis section.

Table 3.1
Summary of Surface Soil Response Action
Retained for Further Analysis

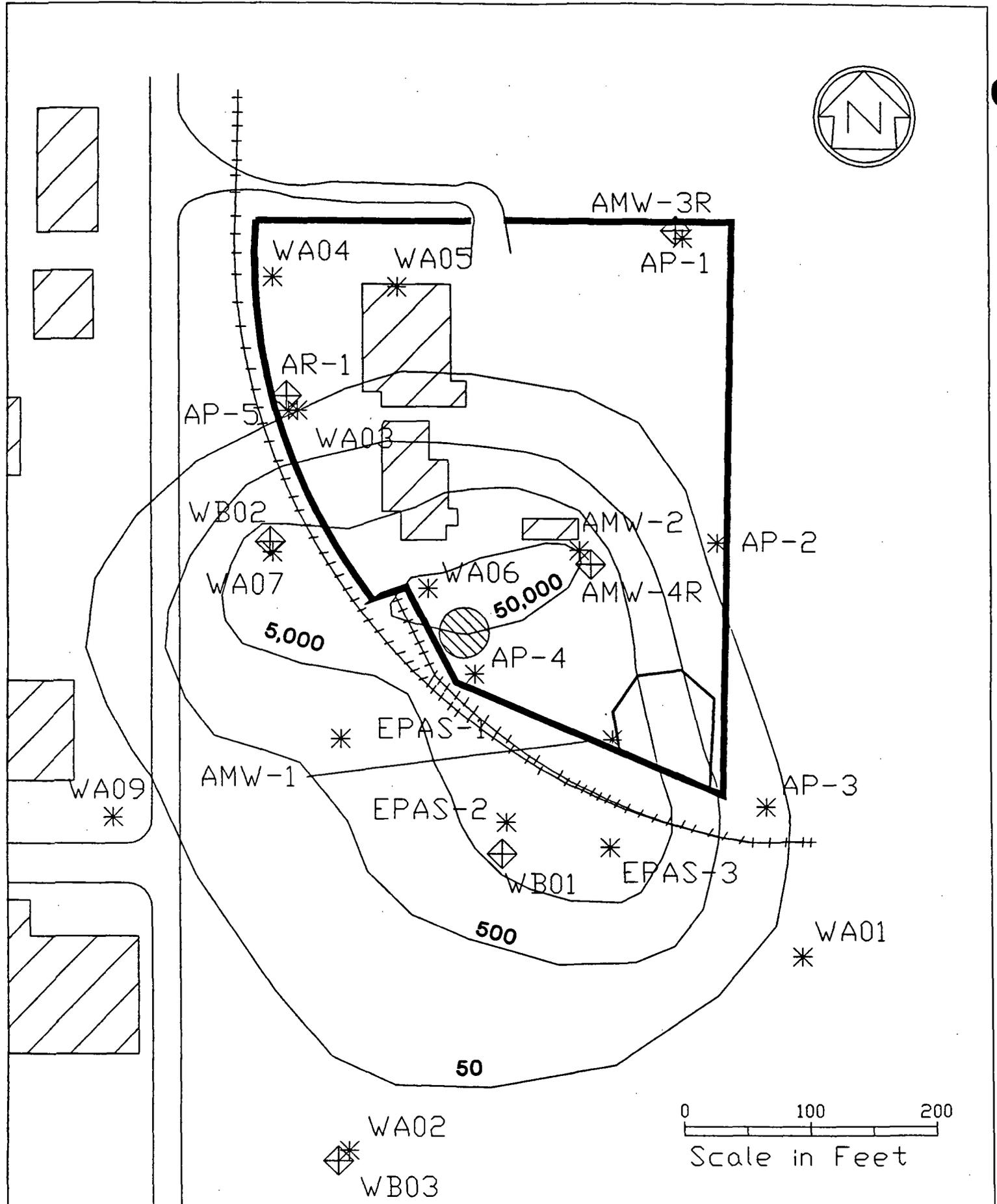
Response Action	Technologies	Process Options
No Action	No Action	No Action
Institutional Controls	Access Restrictions	Deed restrictions
	Monitoring	Groundwater Monitoring
Excavation	Excavation	Excavation - Surface soils
Disposal	Disposal with treatment	On-site treatment/soil backfill
		On-site treatment/off-site disposal
		Off-site treatment/off-site disposal
Containment	Cap	Basic cap with soil treatment
		RCRA cap

Table 3.2
 Summary of A-zone Soil Response Action
 Retained for Further Analysis

Response Action	Technologies	Process Options
No Action	No Action	No Action
Institutional Controls	Access Restrictions	Deed restrictions
	Monitoring	Groundwater Monitoring
Containment	Cap	Basic cap with soil treatment
		RCRA cap
Treatment	In-situ Physical Treatment	Vapor Extraction w/Steam Injection
		Vapor Extraction w/o Steam Injection
		Vertical Soil Flushing
	Ex-Situ Physical Treatment	Soil Washing

Table 3.3
 Summary of Groundwater Response Action
 Retained for Further Analysis

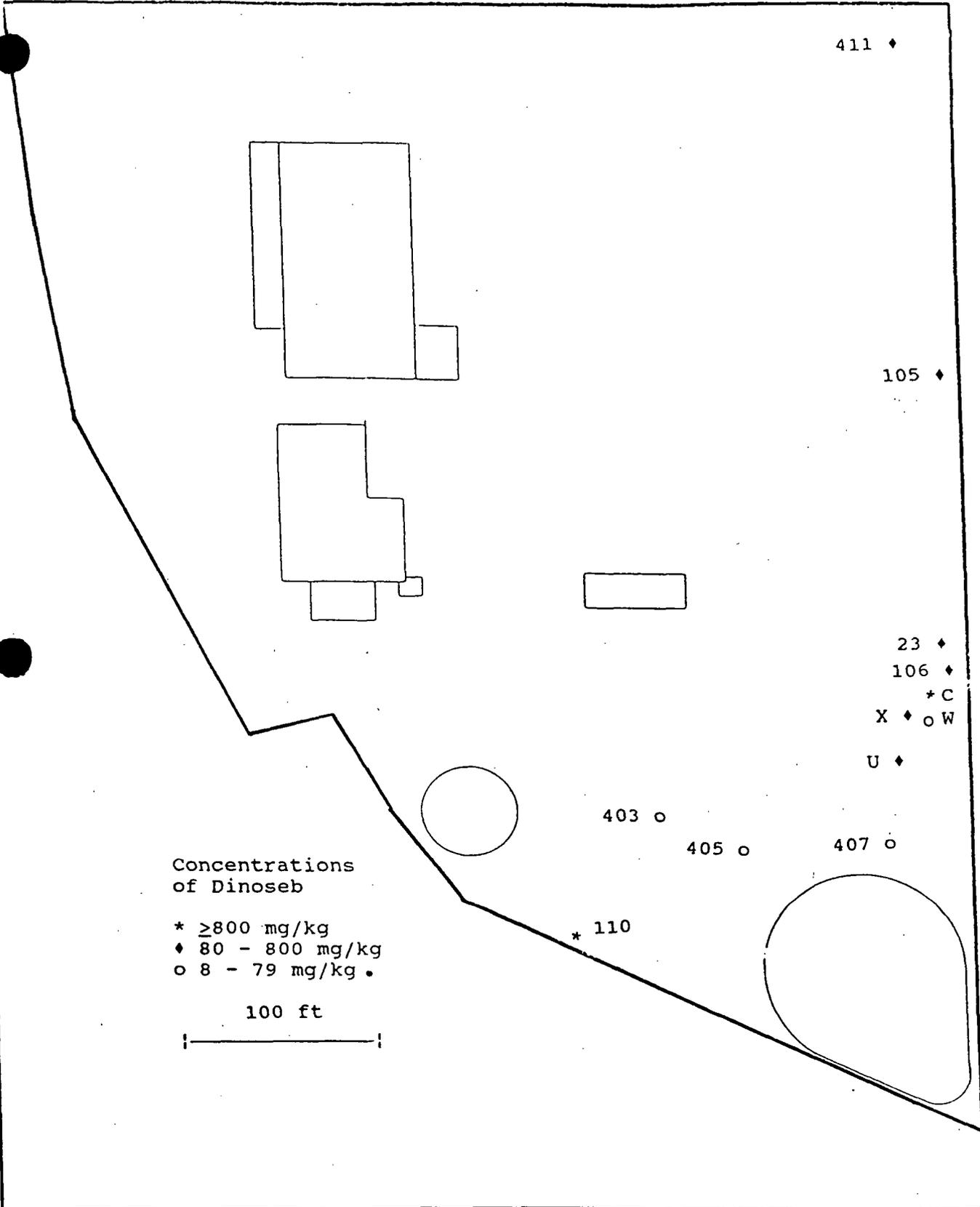
Response Action	Technologies	Process Options
No Action	No Action	No Action
Institutional Controls	Access Restrictions	Well design restrictions
	Monitoring	Groundwater Monitoring
Containment	Cap	Basic cap with soil treatment
		RCRA cap
	Subsurface Containment	Drains/trenches
		Purchase Adjacent Property
Treatment	Physical Removal	Horizontal Soil Flushing
	Chemical Destruction	UV/Oxidation



Brown and Bryant Arvin, California

Figure 3.1

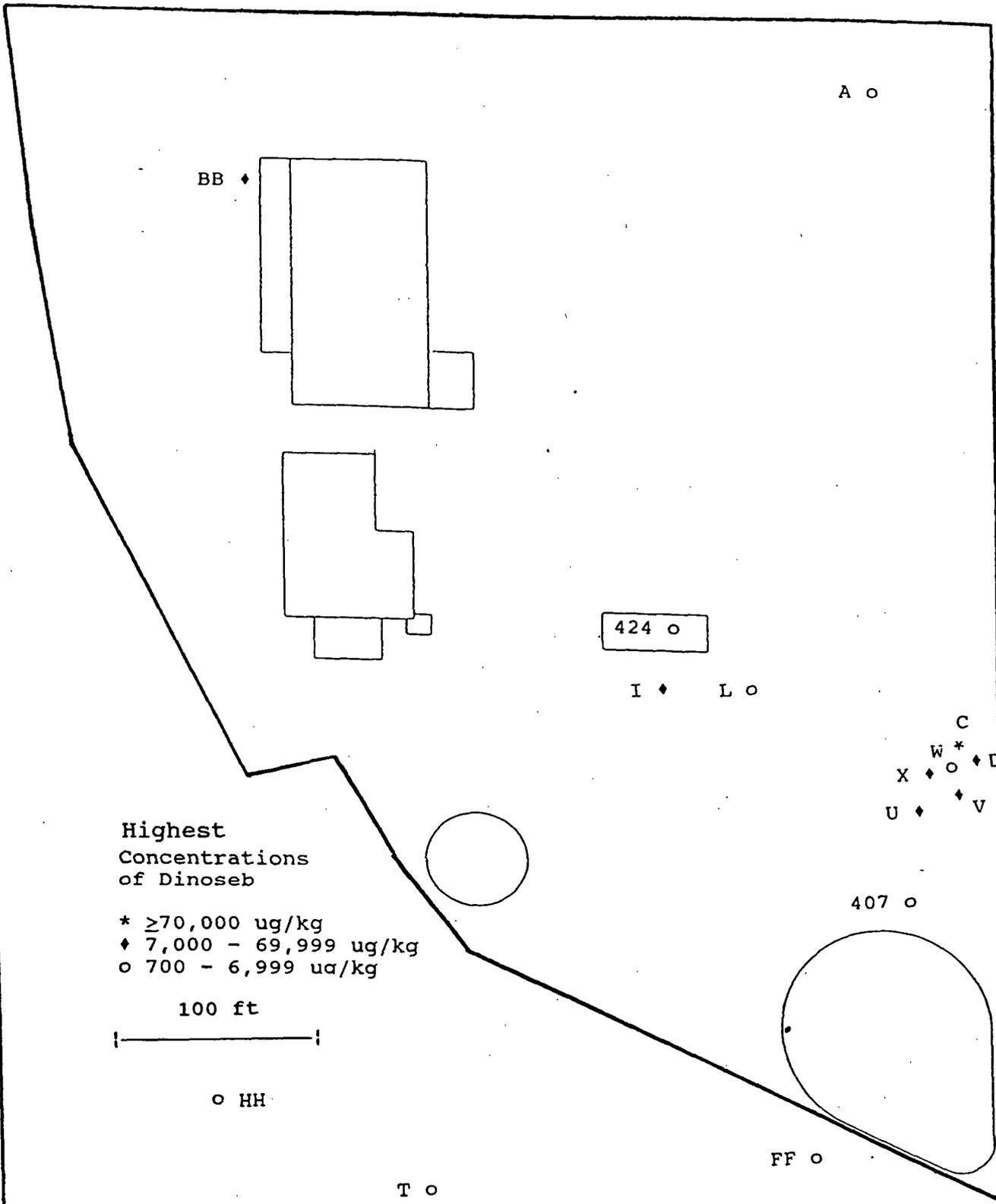
Concentrations of 1,2-DCP in A-Zone Groundwater, 1992 (ug/l)



Brown & Bryant, Arvin Calif.

Figure 3.2

Dinoseb Concentrations in the Top Foot of Soil



Brown & Bryant, Arvin Calif.

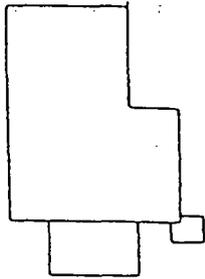
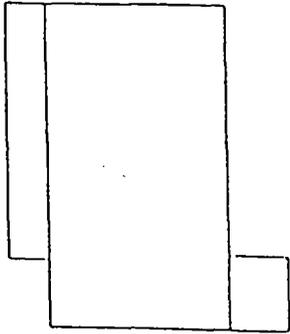
Figure 3.3.

Dinoseb Concentrations in Top 20 feet

Highest Concentrations of Dinoseb

- * $\geq 70,000$ ug/kg
- ♦ 7,000 - 69,999 ug/kg
- o 700 - 6,999 ug/kg

100 ft



424 o

C
W *
X o o
V ♦

405 o

407 ♦

FF o

410 o

o DD

Brown & Bryant, Arvin Calif.

Figure 3.4

Dinoseb Concentrations from 20 to 40 feet

Soil General Response Actions	Remedial Technologies	Process Options	Description of Process Options	Screening Comments
No Action	None	Not Applicable	No action	Required for consideration by the NCP
	Access Restrictions	Deed Restrictions Secure Fencing	Deeds for properties in the area of influence would include restrictions on wells	Potentially applicable
Institutional Actions	Monitoring	Ground Water Monitoring	Ongoing monitoring of wells	Potentially applicable
	Excavation of Surface Soil	Conventional excavation of contaminated surface soils	Excavation of surface contaminated soils from Dinosaur area, Pond Area, etc. using conventional techniques	Potentially applicable
Excavation / Treatment / Disposal	Excavation of hot-spots in Subsurface Soil	Excavation of selected soil hot-spot for ex-situ treatment	Excavation of subsurface contaminated soils in selected hot spots for above-ground treatment/disposal	Potentially applicable
	Disposal After Treatment	On-Site Treatment/Soil Backfill	Excavation of surface and/or subsurface soils followed by complete on-site treatment then soil backfill	Potentially applicable
		On-Site Treatment/Off-Site Disposal	Excavation of surface and/or subsurface soils followed by partial treatment and off-site disposal	Potentially applicable
		Off-Site Treatment/Off-Site Disposal	Excavation of surface and/or subsurface soils followed by complete off-site treatment and disposal	Potentially applicable
Containment	Cap	Clay and Soil	Compacted clay covered with clean soil over areas of contamination to minimize water infiltration	Potentially applicable
		Asphalt	Application of a layer of asphalt over areas of contamination to prevent water infiltration	Potentially applicable
		Concrete	Installation of concrete slabs over areas of contamination to prevent water infiltration	Potentially applicable
		Multimedia Cap	Clay and synthetic membrane covered by clean soil over areas of contamination as a RCRA final cover	Potentially applicable
	Liners	Horizontal Liner	Installation of horizontal liners beneath contaminated soils to minimize vertical migration as RCRA liners	Impracticable for containment of deep soils. VA zone contaminated soils extend to 65' below ground surface.



Screened Out

Figure 3.5, Screening of Soil Remedial Technologies

Soil General Response Actions	Remedial Technologies	Process Options	Description of Process Options	Screening Comments
Treatment	Land-Based/In Situ Bioremediation	Bioventing <i>Innovative Technology</i>	Accomplish biodegradation by injecting air and moisture to subsurface contaminated soil. Exit air may need further treatment	Only be used if principle treatment technology is not sufficient to reach cleanup goals
		Landfarming <i>Innovative Technology</i>	Aeration of contaminated soil by tilling or other cultivating methods with the addition of nutrients and/or microbial cultures for treatment augmentation	May be applicable for shallow contamination in certain areas at BB. Also can be used as secondary treatment technology
		Stimulated Aerobic Bioremediation <i>Innovative Technology</i>	Indigenous or introduced biological detoxification of contaminated soil by stimulating biodegradation processes by adding nutrients and oxygen	Difficulties anticipated in implementation and treatment process control in the subsurface (deeper than 25'). Also large uncertainties
		Enhanced Anaerobic Bioremediation <i>Innovative Technology</i>	Indigenous or introduced biological detoxification of contaminated soil by enhancing anaerobic transformation of xenobiotic compounds in natural environment	Difficulties anticipated in implementation and treatment process control in the subsurface (deeper than 25'). Also large uncertainties
		Composting <i>Innovative Technology</i>	Land based aerobic bio-degradation of contaminants in soil with addition of bulking materials (wood chips, corn cobs, etc.)	May be applicable for shallow contamination in certain areas at BB. Also can be used as secondary treatment technology
		Prepared Bed Systems <i>Innovative Technology</i>	Biological treatment of excavated soil is accomplished in prepared bed(s) with leachate collection system	Not feasible for large volume of contaminated soil. May be appl. for secondary treatment
		Powder Activated Carbon Treatment Wet Air Oxidation <i>Innovative</i>	Process combines biological treatment and powder activated carbon to remove organic contaminants in wastewater as secondary treatment	Potentially applicable as secondary treatment technology or part of a treatment train (treatment of wastewaters from soil washing)
		Composting Systems <i>Innovative Technology</i>	Aerobic/anaerobic degradation of contaminants with addition of bulking material for stimulation in reactor	Not feasible for large volume of contaminated soil. May be appl. for secondary treatment
		Photolysis and Biological Soil Detoxification <i>Emerging</i>	Two-stage in-situ technology: degradation of organic contaminants using UV in 1st stage and enhanced biological detoxification the 2nd stage	Not feasible for deeper soils and VOC contaminated soils. May be applicable to excavated soil contaminated with dioxin
		Soil Detoxification using White Rot Fungus <i>Emerging</i>	Detoxification of contaminated soil with white rot fungus. Fungus grow on wood chips then are transferred to soil	Not feasible for deeper soils and VOC contaminated soils. May be applicable to excavated soil contaminated with dioxin
	Slurry Biodegradation <i>Innovative Technology</i>	Formation of slurry by combining soil and water followed by aerobic degradation of contaminants	Not feasible for deeper soils. potentially applicable for excavated soils contained VOCs and dioxin	
	Above-Ground Bioremediation	Soil Vapor Extraction (SVE) <i>Innovative Technology</i>	In situ process employing vapor extraction wells alone or with air injection wells to remove volatile compounds from contaminated soil followed by vapor treatment	Potentially applicable to treatment of volatile pesticides contained in subsurface soils at the Sump and other areas
	In Situ Physical Treatment Technologies	Steam Injection/Vapor Extraction <i>Innovative Technology</i>	In situ process removing VOCs and semi-VOCs from contaminated soil and groundwater using steam injection and vapor, condensate, and groundwater extraction	Potentially applicable to removal of dioxin, volatile and semi-volatile pesticides from the subsurface soils and the Perch zone
	Soil Flushing <i>Innovative Technology</i>	In situ process extracting contaminants from soil by passing extraction fluid through in-place soils using injection or/and infiltration processes	Potentially applicable for removal of dioxin, volatile and semi-volatile pesticides subsurface soils and the Perch zone	
	Ex Situ Physical Treatment Technologies	Low Temperature Thermal Desorption <i>Innovative Technology</i>	Separation of VOC and semi-VOC from soil using either direct or indirect heat exchange to vaporize the Contaminants followed up by vapor treatment	Potentially applicable for treatment of volatile and semi-volatile pesticides if excavation of soil is selected
	Soil Washing <i>Innovative Technology</i>	Ex situ processes that are aqueous-based using mechanical processes to separate soluble contaminants from soil and debris particles	Potentially applicable for treatment of dioxin other soluble compounds if excavation of soil is selected	
	Solvent Extraction <i>Innovative Technology</i>	Ex situ processes using organic solvents to separate organic contaminants from soils to reduce the volume of hazardous wastes must be treated	Not applicable because of costs and effectiveness	
	Supercritical Fluid Extraction <i>Innovative Technology</i>	Ex situ processes taking advantage of properties of polar or/and nonpolar solvents at critical condition to separate contaminants from soils	Treatability studies needed. Program decision not to do additional treatability studies)	
	Stabilization/Solidification and Encapsulation	Cement-Based Fixation <i>Demonstrated Technology</i>	Ex situ processes stabilizing/solidifying metals and high molecular contaminants in soil/cement-based mixtures to reduce further leaching and migration	Not applicable. Not suitable for wastes at this site; stability/leachability unknown
	Macro Encapsulation Techniques <i>Demonstrated Technology</i>	Ex situ macro encapsulation/overpacking, thermal-plastic and thermal setting processes to encapsulate contaminants to reduce leaching and migration	Not applicable. Not suitable for wastes at this site; stability/leachability unknown	
	Pozzolanic-Based Fixation <i>Demonstrated Technology</i>	Ex situ pozzolanic-based (fly ash, lime based) processes to stabilize/solidify metal or/and high molecular organic contaminants to reduce leaching and migration	Not applicable. Not suitable for wastes at this site; stability/leachability unknown	

Figure 3.5, Screening of Soil Remedial Technologies (Continued)

 Screened Out

Soil General Response Actions	Remedial Technologies	Process Options	Description of Process Options	Screening Comments		
Treatment (cont.)	Stabilization/Solidification and Encapsulation (cont.)	In-Situ Vitrification (ISV) (Innovative Technology)	Formation of a stable glass or crystalline structure by using electrical power to heat and melt contaminated soils at between 2500 to 3000 degrees Fahrenheit.	Not feasible. Costly operation. Application may lead to vapor phase migration of VOCs. Soil lacks silicon and aluminum oxides.		
		Plasma Arc Vitrification (Innovative Technology)	An ex-situ process in plasma centrifugal furnace where organic contaminants are vaporized and reacted at 2000 to 2800 °F and remaining contaminated soil is vitrified.	Not feasible for treatment of deeper soils. Costly for treatment of small volume surface soil. Unknown dioxin leachability.		
		Chemical Bonding/Fixation (Innovative Technology)	An ex-situ process involving chemical bonding of organic contaminants into layers of an aluminosilicate compound and returning treated mixture to excavated areas.	Not feasible for treatment of deeper soils. Unknown dioxin leachability. Treatability study is needed to evaluate performance.		
		Chemical Dehydro/Dehalogenation (Innovative Technology)	Dehalogenation of halogenated pesticides by chemical reaction with AP5G or KPEG as reagents with emission control and neutralization of treated soils (ex-situ).	Engineering difficulties expected in delivering alkali metal hydroxide and tetra-ethylene glycol to deep soil. Dioxin not treated.		
		Base-Catalyzed Dechlorination (Innovative Technology)	An ex-situ process in which excavated contaminated soil is mixed with introduced chemicals and heated to 340 degrees Celsius to destroy halogenated contaminants.	Not applicable for treatment of dioxin and EDB. Engineering and control difficulties expected for treatment in deeper soils.		
		X-Ray Treatment (Emerging Technology)	In- or ex-situ process that employs X-ray to generate a shower of secondary electrons which break up complex molecules and form radicals that react w/contaminants.	Potentially applicable for in situ treatment. Technology developer is still in bench scale phase. Need treatability tests.		
		Photolytic Oxidation/Reduction (Emerging Technology)	An ex-situ process extracts organic compounds into vapor phase. The VOC vapor then is transferred to a photolysis reactor where UV light directly detoxifies the VOCs.	Not applicable for treatment of dioxin.		
Chemical Destruction Treatment Technologies		Ultrasonically Assisted Detoxification (Emerging Technology)	The process uses special solvent and chemical reagents in the presence of ultrasonic irradiation to chemically destroy halogenated organic compounds.	Not applicable for treatment of dioxin.		
		Thermal Desorption/Vapor Phase Combustion (Innovative Technology)	The process is operated at the burner temperature of about 700 degrees Fahrenheit to achieve volatilization of organic contaminants followed by vapor phase combustion.	Potentially applicable to ex-situ treatment of B/B contaminated soils, need treatability study to confirm treatment of dioxin.		
		Pyretron Oxygen Burner (Developed Technology)	The process is a rotary kiln incinerator with two burners (kiln and afterburner) each is operated with two oxidizers allowing pure oxygen and oxygen-enriched air combustion.	Applicable to ex-situ treatment of B/B contaminated soils.		
		Infrared Thermal Destruction (Developed Technology)	A mobile thermal processing system that uses electrical powered silicon carbide rods to heat organic wastes to combustion temperature (up to 1850 degrees Fahrenheit).	Applicable to ex-situ treatment of B/B contaminated soils.		
		Circulating Bed Combustor (Developed Technology)	A thermal process uses high velocity air to entrain circulating solids and create a highly turbulent combustion zone for destruction of toxic hydrocarbons.	Applicable to ex-situ treatment of B/B contaminated soils.		
		Plasma Arc Vitrification (Developed Technology)	A process with plasma centrifugal furnace in which heat transferred from arc plasma creates a molten bath that detoxifies organic contaminants in vapor phase.	Applicable to ex-situ treatment of B/B contaminated soils.		
		Thermo Destruction Treatment Technologies		Pyretron Oxygen Burner (Developed Technology)	The process is a rotary kiln incinerator with two burners (kiln and afterburner) each is operated with two oxidizers allowing pure oxygen and oxygen-enriched air combustion.	Applicable to ex-situ treatment of B/B contaminated soils.
				Infrared Thermal Destruction (Developed Technology)	A mobile thermal processing system that uses electrical powered silicon carbide rods to heat organic wastes to combustion temperature (up to 1850 degrees Fahrenheit).	Applicable to ex-situ treatment of B/B contaminated soils.
				Circulating Bed Combustor (Developed Technology)	A thermal process uses high velocity air to entrain circulating solids and create a highly turbulent combustion zone for destruction of toxic hydrocarbons.	Applicable to ex-situ treatment of B/B contaminated soils.
				Plasma Arc Vitrification (Developed Technology)	A process with plasma centrifugal furnace in which heat transferred from arc plasma creates a molten bath that detoxifies organic contaminants in vapor phase.	Applicable to ex-situ treatment of B/B contaminated soils.

Figure 3. (Continued), Screening of Soil Remedial Technologies

Ground Water Response Actions	Remedial Technologies	Process Options	Description of Process Options	Screening Comments
No Action	None	Not Applicable	No action	Not applicable. Required for consideration by the NCP
Institutional Control	Access Restrictions	Deed Restrictions Secure Fencing	Deeds for properties in the area of influence would include restrictions on wells	Potentially applicable when coupled with remediation
	Monitoring	Ground Water Monitoring	Ongoing monitoring of wells	Potentially applicable as a component of ground water remediation
Containment	Cap	Clay and Soil	Compacted clay covered with clean soil over the entire site to minimize infiltration of surface water	Potentially applicable when coupled with soil remediation
		Asphalt	Application of a layer of asphalt over the entire site to greatly minimize infiltration of surface water	Potentially applicable when coupled with soil remediation
		Concrete	Installation of concrete slabs over the entire site to prevent infiltration of surface water	Potentially applicable when coupled with soil remediation
		Multimedia Cap	Clay and synthetic membrane covered by clean soil over the entire site as RCRA final cover	Potentially applicable when coupled with soil remediation
	Subsurface Containment	Drains/trenches	Drains/Trenches installed perpendicular to the direction of ground water flow to collect contaminated and uncontaminated GW from up and down gradients	May be applicable. May have engineering difficulties for deep soil. Need evaluation before use.
		Slurry Cutoff Trench/Wall	Low hydraulic conductivity material walls installed orthogonal to direction of GW flow to prevent GW flow from up-gradient or to enhance treatment of the perch	Not applicable. Not feasible for deep soil (bottom of perch zone could be as deep as 75 feet from ground surface)
Treatment	Subsurface Containment	Sheet Pile Cutoff Wall	Sheet pile cutoff walls installed at the perch zone to divert clean water from up-gradients to enhance treatment of the perch	Not applicable. Not feasible for deep soil (bottom of perch zone could be as deep as 75 feet from ground surface)
		Grouting	Grouting involves injection of fluid material into up gradient of the perch. The grout fluid permeate voids and set in place to prevent or divert GW movement	Potentially applicable
		Biological Treatment	In Situ Bioremediation	Anaerobic or aerobic degradation/mineralization of contaminants using indigenous or introduced microbes. Need delivery of electron acceptors and nutrients
	Physical Removal	Ex Situ Bioremediation	Anaerobic or aerobic degradation/mineralization of contaminants using indigenous or introduced microbes. Treatment occurs above ground in stirred tanks.	Applicability determination requires extensive treatability studies. Program decision is not to conduct add. treatability studies
		Air Stripping	Transfer volatile compounds from ground water to air in a packed tower(s). The lightly contaminated air stream is then discharged to the atmosphere	Not applicable for dissolved contaminated ground water. Dioxin exhibits very low vapor pressure and Henry's constant
		Liquid Phase Carbon Adsorption	Absorption of organic contaminants onto granulated activated carbon in aqueous phase. The contaminated carbon is regenerated for further use or disposed of	Not applicable. Carbon adsorption does not achieve chemical destruction, also requires additional treatment + disposal of carbon
		Air Stripping Combined with Vapor Phase Carbon Adsorption	The contaminated vapor outlet stream from the air stripping is treated by adsorption of contaminants onto granulated activated carbon matrix	Not applicable for removal of dioxin, also requires additional handling, treatment, and disposal of contaminated carbon
		Enhanced Chemical Mobilization Horizontal Soil Flushing	Mobilizing organic contaminants in the perch zone using surfactants. The mobilized contaminants and spent surfactants are extracted for above ground treatment	Potentially applicable
		Horizontal Flushing of A-Zone Ground Water and Soil (Perch Zone)	Apply gentle horizontal flushing to the A-zone ground water and soil. Enhance flushing techniques may be used. Flushed solution is extracted and treated above-ground	Potentially applicable

Figure 3.6 , Screening of Ground Water Technologies

 Screened out

Ground Water Response Actions	Remedial Technologies	Process Options	Description of Process Options	Screening Comments	
Continued from previous page	Treatment	Chemical Destruction	<p>Super Critical Water Oxidation (SCWO) (Emerging Technology)</p> <p>Vapor Phase Incineration</p> <p>Wet Air Oxidation (WAO) (Innovative Technology)</p> <p>UV/Oxidation (Innovative Technology)</p>	<p>Operated at or above super critical temperature and pressure of water to achieve complete chemical oxidation of contaminants. Addition of fuel is needed.</p> <p>Water is first converted to superheated steam then incinerated at temperatures above 700 degrees Fahrenheit. Addition of fuel is needed.</p> <p>Operate at or near super critical condition of water. Destruction of contaminants is achieved through hydrolysis, oxidation, and other chemical reactions.</p> <p>Accomplished chemical destruction by applying UV-Radiation, and chemical oxidation. Oxidant (H2O2) and catalyst are added. No air emission.</p>	<p>Not applicable. Not feasible for large volume / low concentration ground water (low COD). Lack full scale data.</p> <p>Not applicable. Not feasible for large volume / low concentration ground water (low COD).</p> <p>Not applicable. Not feasible for large volume / low concentration ground water (low COD). Lack full scale data.</p> <p>Applicable. Early action data available. Remedy selection treatability study has been conducted. Report available.</p>
	Combined Process	<p>Powder Activated Carbon Treatment</p> <p>Wet Air Oxidation (Innovative)</p>	<p>Combining biodegradation/mineralization with enhanced activated carbon adsorption. The contaminated carbon with biomass is regenerated by wet air oxidation.</p>	<p>Not applicable. Not feasible for large volume / low concentration ground water.</p>	

Figure 9.8 , Screening of Ground Water Technologies (continued)



4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The purpose of this section is to further develop and screen alternatives for each medium based on the options developed in Chapter 3. Prior to developing the alternatives, a discussion will be presented on each of the innovative technologies retained through the screening of the options. The innovative technologies are Soil Vapor Extraction, Soil Washing and UV/Oxidation.

4.1 Discussion of Innovative Technology Process Options

4.1.1 Soil Vapor Extraction (SVE)

Soil vapor extraction (SVE) is an innovative technology for treatment of soil contaminated with chemicals that have moderate or high vapor pressure at standard temperatures. Treatment is accomplished by removal of contaminants by drawing air through a zone of contaminated soil. Soil vapor extraction is most likely to be successful at sites where highly volatile contaminants are present in soils which are homogenous and highly permeable and porous.

In situ installation and operation requires little handling of contaminated soils hence limits the risk of exposure to workers and the public. SVE has few secondary impacts. Ambient air is used instead of harmful reagents in the removal process.

SVE usually is applicable if the soil air conductivity is greater than 10^{-4} cm/sec which requires a hydraulic conductivity of greater than 6.5×10^{-6} evaluated at 20°C. Site characterization data has shown that the majority of the contamination is bound in clayey-sand and clay heterogeneous material between 25 and 35 feet. The hydraulic conductivities of this relatively impermeable material is estimated to be between 10^{-5} to 10^{-7} cm/sec (Freeze et al., 1979). SVE is estimated to be somewhat successful for these types of materials.

4.1.2 Soil Washing

Soil washing is an innovative technology which has been employed and evaluated for removal of a number of contaminant groups. A soil washing process is often used to mechanically scrub excavated soils to remove hazardous constituents. The process removes contaminants from soils in one of two ways: by dissolving or suspending them in the wash solution or by concentrating the more highly contaminated fines into a smaller volume. The later is accomplished through simple particle size separation techniques.

It was demonstrated during the 1990 and 1991 removal actions that highly contaminated soils from the dinoseb Hot-Spot Area

(from several thousand ppm down to tens of ppm) responded well to soil washing. Refer to Section 6.0, Treatability Tests, for details on the soil washing removal action.

Soil washing is a possible consideration for remediation of soil that is principally contaminated with dinoseb, lightly contaminated with fumigants and other halogenated pesticides, and within reasonable excavation depths.

The small-volume of highly contaminated fine sludge generated from a soil washing process may need to be treated off-site (e.g. at an incineration facility) or possibly with on-site bioremediation. Off-site treatment involves transportation of hazardous waste to an EPA permitted treatment facility. The wash water from the soil washing process will also require above ground treatment such as UV/Oxidation.

4.1.3 UV/Oxidation

UV/Oxidation is an advanced chemical oxidation process designed to destroy dissolved organic contaminants in ground water or waste water. A typical UV/Oxidation process involves ultraviolet radiation and some form of oxidants (e.g. ozone or hydrogen peroxide). Vendors may also use proprietary additives they claim will make the chemical oxidation more effective.

UV light catalyzes the chemical oxidation reaction by its combined effect upon the organics and their reaction with the oxidants. As an initial step of the chemical reaction, organic contaminants adsorb photons from UV light at a narrow range of wave lengths intrinsic to each contaminant and are elevated to molecular excited states (chemical bonds are weakened due to translational, rotational, and vibrational stresses). UV light also catalyzes the reaction of oxidants to form hydroxyl radicals. The hydroxyl radicals, under a right set of condition, react with the organic contaminants. If the conditions of the destruction process are right, the end products would be carbon dioxides, water, salts, inorganic and organic acids. UV/Oxidation produces no air emission.

4.2 Development and Screening of Alternatives

This section develops alternatives for each medium from the retained process options in Chapter 3. The three mediums are surface soil (construction zone), A-zone soil and A-zone groundwater. Alternatives in this section are numbered to reflect the medium that is being addressed. "GW" is used for A-zone groundwater alternatives; "AZS" is used for A-zone soils; and "SS" is used for surface soils. Surface soils and A-zone soils have been separated because there are alternatives unique to the surface soils. However, it is preferred that the final alternative for the site combines as many of the medium alternatives such that there is a minimum number of different technologies.

For some alternatives, one treatment technology was chosen to represent similar process options in order to simplify the development of alternatives. For example, basic capping means a non-RCRA type cap that would limit infiltration. Such cover could be composed of asphalt, concrete or clay/soil. The specific type of cap actually used may not be determined until the remedial design phase.

The alternatives are screened by evaluating the effectiveness, implementability, and cost of each alternative. The effectiveness criterion focuses on the degree which an alternative reduces contaminant toxicity, mobility or volume through treatment; minimizes residual risks and affords long term protection. The implementability criterion focuses on the technical feasibility and administrative feasibility of implementing the alternative. The cost criterion is the cost of an alternative relative to the cost of other alternatives.

4.2.1 Groundwater Alternatives

GW-1 No Action

The no action alternative, the inclusion of which is required by the NCP (40 CFR 300.430(e)(6)), is used as a baseline alternative against which other alternatives are judged. With this alternative, there would be no reduction of toxicity, volume or mobility of contaminants in the A-zone groundwater, and as a consequence, the B-zone groundwater would continue to be impacted.

GW-2 Institutional Controls

This alternative would require well design restrictions to prevent access to the A-zone and B-zone groundwater and groundwater monitoring of the contamination plume and the municipal and agricultural wells in the area. The well design restrictions could include a restriction against well installation into the contaminated zones, well construction standards that would seal off the contaminated water, or mandatory destruction of wells which act as a conduit for contamination to spread vertically. If monitoring of the plume indicates that there is contamination of a well, then the well could be destroyed. There would be no reduction of toxicity, volume or mobility of contaminants.

GW-3 Treatment/Limited Containment

This alternative would include horizontal flushing, extraction and treatment by UV/Oxidation of the A-zone groundwater. A cap would be installed to minimize infiltration into the A-zone groundwater. Because of the geology of the A-zone groundwater, it will not behave as a typical aquifer.

The PRGs for the A-zone groundwater would be to reduce the contamination levels in the most cost-effective manner to protect the B-zone groundwater. The PRG levels for the A-zone groundwater are tentatively estimated at 10 to 100 times the respective MCLs. This would result in a significant reduction in toxicity and volume in the A-zone groundwater, and the remaining contaminants would have reduced mobility since they would primarily be chemicals absorbed to the soil.

The system would include alternating rows of injection wells and extraction wells. If close spacing of the vertical wells is required, a horizontal radial well would be considered in the remedial design phase of the project. The injection rate and extraction rate will be closely monitored and controlled to minimize additional leakage from the A-zone groundwater.

Extracted water will be treated using UV/Oxidation. This system may be more expensive than other conventional technologies such as carbon adsorption and air stripping. However, these conventional technologies do not treat dinoseb due to its high water solubility and non-volatility. UV/Oxidation is an on-site chemical destruction system which does not require any additional off-site treatment. The treated extracted water will be re-injected into the A-zone groundwater by reinjection wells and possibly, percolation ponds.

GW-4 Treatment/Containment

This alternative expands on the previous alternative by reducing the quantity of water flowing laterally into the contaminated section of the A-zone groundwater. Containment could be accomplished by; (1) diversion with either a grout curtain, (2) subsurface drains to prevent migration of up-gradient A-zone water into the A-zone beneath the site, or (3) the purchase of restrictive easements on adjacent lands to eliminate irrigation inputs. In conjunction with a cap, these additional actions would reduce the mobility of the remaining contaminants in the A-zone groundwater by eliminating the driving force, water.

The grout curtain would be essentially a concrete wall constructed 85 feet below ground surface (bsg) extending up to 55 feet bsg, (ie, 30 ft high) and running for a length of 650 feet. The estimated present worth cost of construction and 30 years of maintenance for the grout curtain is \$1,500,000. The benefits derived from the placement of a grout curtain are difficult to determine and with time, other grout curtains have been known to leak. Since a cap would prevent other sources of water intrusion into the A-zone groundwater, it would be possible to better determine the benefit of adding a grout curtain after evaluation of the experience of a cap alone. Therefore, the grout curtain was eliminated from consideration at this time.

Subsurface drains that permit flow from the A-zone groundwater to the B-zone groundwater upgradient from the contamination might degrade the B-zone groundwater due to the high Total Dissolved Solids in the A-zone groundwater. Such drainage should be avoided to protect the B-zone groundwater.

Another possibility to limit the flow of water into the contaminated A-zone groundwater is to restrict the flow of water from irrigation of the adjacent agricultural land. However, this might require long-term maintenance of the property by the State of California. This alternative was eliminated from further consideration.

4.2.2 A-Zone Soils

AZS-1 No Action

The no action alternative is required for consideration under the NCP. It does not reduce the mobility, toxicity or volume of contaminants.

AZS-2 Containment

Alternative AZS-2 includes the installation of a cap over the affected areas to minimize the infiltration of precipitation and to reduce or eliminate direct contact. This would limit the mobility of the chemicals in the deeper soils, especially dinoseb which is water soluble.

The deep soil contamination (below 7 feet) by itself is not a health risk because there is no potential direct exposure. However, there is a potential exposure if the contamination leaches through the A-zone groundwater to the B-zone groundwater. Because a cap would reduce the mobility of deep soil contamination, it would increase protection of human health and the environment.

AZS-3 In-Situ Treatment/Cap

This alternative includes in-situ treatment of the A-zone soils to reduce the toxicity and volume of contamination and installation of a basic cap to minimize the mobility of contamination remaining after treatment. Modeling of the contaminant transport in the A-zone showed that when a cap is installed, the only chemical with a potential to impact the B-zone groundwater is 1,2-DCP. Other technologies considered up to this point, soil flushing and steam injection vapor extraction, are eliminated since dinoseb and other chemicals which are less volatile, are not a threat to the B-zone groundwater if the site is capped. Since 1,2-DCP is volatile, the treatment option is soil vapor extraction (SVE).

SVE will readily remove 1,2-DCP from the sandy zones in the soil profile. The profile at Brown & Bryant is interfingered with silts and silty sands. Even though SVE may not work well in the less conductive zones, it should remove the mass of 1,2-DCP that might migrate.

4.2.3 Surface Soils

SS-1 No Action

The no action alternative for surface soils would not produce a reduction of toxicity, volume or mobility of dinoseb, the only chemical in the surface soils. The sampling and analysis of the surface soil show that the dinoseb concentrations exceed health based levels. In the worst case exposure scenario, the soil concentrations between surface and one foot depth, including samples from the area already remediated, produce a hazard quotient risk of 67. Concentrations in soil between one and seven feet do not pose an unacceptable risk ($HQ < 1$) based on the most likely exposure scenario, on-site construction workers. The no action alternative would keep the existing fence

surrounding the property. The fence, however, does not prevent exposure to workers or trespassers.

SS-2 Containment

This alternative includes the installation of a RCRA-type cap and drainage controls. The cap and drainage controls would eliminate the potential human exposure to the dinoseb-contaminated soil and greatly reduce the potential for migration to groundwater and fugitive dust.

Under the containment option, no soil treatment would precede the cap installation. The alternative is effective because it minimizes the mobility of the chemicals and the exposure risks, thereby protecting the community and the workers. It is especially protective in the short-term because there would be no excavation that would release dust associated with excavation during construction.

SS-3 Excavation/Off-Site Disposal

This alternative would include excavation of the dinoseb-affected soil that exceeds health-based levels and disposal off-site. The excavated soil would be treated off-site prior to disposal as required by RCRA. The RCRA prescribed technology (Best Available Technology) for dinoseb is incineration.

Moreover, this alternative would require special safeguards for excavation and transportation of the contaminated soil, because of the potential short-term risk to the community. After treatment, this material would require disposal in a hazardous waste landfill. This alternative may be the most cost-effective alternative if the final volume of material to be treated is small.

SS-4 Excavation/Treatment

This alternative includes excavation of the dinoseb-contaminated surface soils that exceeds health based levels. The soils would then be washed and replaced on-site, and the rinse water would be treated using UV/Oxidation. The residual fines remaining from the process would be either treated on-site using bioremediation or treated and disposed off-site. The preferred treatment would be on-site treatment using bioremediation. A pilot bioremediation bed (biobed) was established after EPA's emergency removal soil washing action. Results from the biobed activities will be available prior to remedial design.

Based on experience from the removal action that was performed at the site which used similar technology, this alternative is implementable. The alternative is also effective at reducing the volume, toxicity and mobility of contamination.

However, there is an increased short-term risk associated with excavating highly contaminated soil.

SS-5 In-Situ Treatment/Cap

This alternative is similar to the no action alternative where no special treatment process would be performed on the surface soils. Instead, whatever in-situ treatment was chosen for the vadose zone would be used in-situ for the surface soils. After treatment, a basic cap would be installed to minimize water infiltration.

One advantage of the alternative is that no excavation would be required, thereby eliminating short-term dust risks. The additional treatment cost associated with the treatment of additional soil is minimal. This technology would not be appropriate for areas where there is only surface contamination or where levels of contamination in the surface soil are significantly higher than deeper contamination. SIVE would not be applicable at shallow depths.

Table 4.1
Preliminary Screening of Alternatives
A-zone Groundwater Options

Alternative	Effectiveness	Implementability	Cost	Status
GW-1 No Action	No active reduction of mobility, toxicity, or volume of chemicals of concern. Does not meet remediation goals. NCP requires consideration of this option.	Implementable.	Low	Retained
GW-2 Institutional Controls - Well Design Restrictions; Grdwtr Monitoring	Effective in limiting human exposure to chemicals through ingestion. No active reduction of mobility, toxicity, or volume of chemicals of concern.	Implementable.	Low	Not Retained
GW-3 Treatment - Horizontal Flushing; Extraction; UV/Oxidation on Extracted Water	Active reduction in volume and toxicity of chemicals of concern. Remaining concentration has reduced mobility. Remediate source of contamination to B-zone	Implementable. Unknown as to how effective flushing would be in A-zone.	Moderate to High	Retained
GW-4 Treatment/Containment -Horizontal Flushing; Extraction; UV/Oxidation of Extracted Water; Cap	Active reduction in mobility, toxicity and volume of chemicals of concern. Containment options are very unpredictable to their long-term effectiveness.	Unknown as to how effective flushing would be in A-zone.	High	Not Retained

Table 4.2
Preliminary Screening of Alternatives
Surface Soil Options

Alternative	Effectiveness	Implementability	Cost	Status
SS-1 No Action	No active reduction of mobility, toxicity, or volume of chemicals of concern.	Implementable	Low	Retained
SS-2 Containment (RCRA Cap)	Reduction of mobility of chemicals of concern, thereby, reducing exposure risk.	Implementable	Moderate	Retained
SS-3 Excavation/Off-Site Treatment and Disposal/Basic Cap	Reduction of volume, toxicity and mobility of chemicals of concern.	Off-site treatment would be required prior to disposal. Excavation and transportation poses short-term exposure risks.	Moderate to High depending on volume	Retained
SS-4 Excavation/On-Site Treatment/Basic Cap	Reduction of volume, toxicity and mobility of chemicals of concern.	Implementable. Excavation poses short-term exposure risks.	Moderate to High depending on volume	Retained
SS-5 In-Situ Treatment/Cap	Reduction of volume, toxicity and mobility of chemicals of concern.	Not efficient because the contaminated surface areas do not correspond completely with areas of deeper soil contamination.	Moderate	Not Retained

Table 4.3
 Preliminary Screening of Alternatives
 A-zone Soil Options

Alternative	Effectiveness	Implementability	Cost	Status
AZS-1 No Action	No active reduction of mobility, toxicity, or volume of chemicals of concern.	Implementable	Low	Retained
AZS-2 Containment	Minimizes infiltration to A-zone water Thereby reducing mobility.	Implementable	Low	Retained
AZS-3-A In-Situ Treatment/Containment Soil Vapor Extraction	Effective in removing VOCs, especially 1,2-DCP. Not effective removing dinoseb.	Implementable, difficult to capture VOAs in less permeable zones	High	Retained

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 Evaluation Criteria

EPA has developed a set of nine criteria used for detailed comparative analysis of the alternatives retained after the alternative screening portion of the Feasibility Study. The nine criteria are as follows:

- o Overall Protection of Human Health and the Environment
- o Compliance with ARARs
- o Long Term Effectiveness and Permanence
- o Reduction of Toxicity, Mobility and Volume Through Treatment or Recycling
- o Short Term Effectiveness
- o Implementability
- o Cost
- o State Acceptance
- o Community Acceptance

A description of each criterion can be found in the NCP at 40 CFR §300.430 (iii), Nine Criteria for Evaluation.

5.2 Analysis of Alternatives

In addition to balancing the nine criteria for each alternative, EPA has certain expectations for the remedy selected. The NCP states that "EPA expects to use treatment to address the principal threats posed by the site, whenever practicable. Principal threats are characterized as waste that cannot be reliably controlled in place, such as liquids, highly mobile materials (e.g., solvents), and high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure)." (55 FR 8703). The principal threats at Brown & Bryant are exposure to surface soils and the migration of contaminants in the A-zone groundwater to the B-zone groundwater. The A-zone subsurface soil contamination is considered a low level threat because the potential for its migration to the B-zone groundwater is relatively low, given its low mass and significant vertical distance from the B-zone.

The NCP also states that "EPA expects to use engineering controls, such as containment, for wastes that pose a relatively low long-term threat or where treatment is impracticable". In addition, "EPA expects to use a combination of methods, as appropriate, to achieve the protection of human health and the environment. In appropriate site situations, treatment of the principal threats posed by the site, with a priority placed on treating waste that is liquid, highly toxic or highly mobile,

will be combined with engineering controls and institutional controls, as appropriate, for treatment residuals and untreated wastes". (40 CFR §300.430 (iii))

In order to address the site comprehensively, the retained medium-specific alternatives have been assembled into six site alternatives of varying combinations of treatment and engineering controls. These alternatives range from no-action to aggressive action for every specific medium. The alternatives are presented below followed by a section addressing each of the nine criteria.

- o Alternative 1 - No Further Action

- o Alternative 2 - RCRA Cap on Southern Third of Site;
Basic Cap on Remaining Site;
Consolidation of Soil Exceeding Health-based Levels on to Southern Third of Site; Horizontal Flushing and Extraction and treatment of A-zone Groundwater;
Treatment of Extracted Groundwater

This alternative contains a RCRA approved cap on the southern third of the site to minimize infiltration and to prevent exposure to contaminated surface soils. The southern third of the site includes the former sump area, the waste pond, the large tank area, the dinoseb hot-spot and all adjoining areas. There is no treatment for the surface soils or for the A-zone soils. The small volume of contaminated soil in the northern two-thirds of the site that exceeds health-based levels will be consolidated in the southern third. A basic cap will be installed on the northern two-thirds to minimize infiltration. Horizontal soil flushing and extraction of the A-zone groundwater will be used to remove highly contaminated groundwater. Horizontal soil flushing will also treat the readily removable contamination from the soil in the saturated zone. The extracted water will be treated using UV/Oxidation. Treated water will be reinjected into the A-zone groundwater to promote horizontal flushing.

- o Alternative 3 - RCRA Cap on Southern Third of Site;
Basic Cap on Remaining Site; Excavation of Surface Soil Hot-spots in Northern Two-Thirds of Site; Off-site Treatment and Disposal; Horizontal Flushing, Extraction and Treatment of A-zone Groundwater

This alternative contains a RCRA approved cap on the southern third of the site to minimize infiltration and to prevent exposure to contaminated surface soils. This also includes excavation of surface soil hot-spots in the northern two-thirds of the site and off-site treatment and disposal of the contaminated soil. A basic cap will be placed over the soil after removal of hot-spots and regrading, in order to minimize infiltration. There will be no treatment of A-zone soils. Horizontal soil flushing and extraction of the A-zone groundwater will be used to remove highly contaminated groundwater. Horizontal soil flushing will also treat the readily removable contamination from the soil in the saturated zone. The extracted water will be treated using UV/Oxidation. Treated water will be reinjected into the A-zone groundwater to promote horizontal flushing.

- o Alternative 4 - Excavation of All Surface Soil Hot-spots; On-site Treatment and Disposal; RCRA Cap on Southern Third of Site; Basic Cap on Remaining Site; Horizontal Flushing, Extraction and Treatment of A-zone Groundwater

This alternative includes excavation of all surface soil whose concentrations exceed health-based levels and on-site treatment using soil washing. The washed soil will be returned to the excavated units after treatment standards have been met. The rinse water will be treated using UV/Oxidation. A RCRA approved cap will be installed on the southern third of the site and a basic cap will be placed over the remaining site, after removal of hot-spots and regrading, in order to minimize infiltration. There will be no treatment of A-zone soils. Horizontal flushing and extraction of the A-zone groundwater will be used to remove highly contaminated groundwater. Horizontal soil flushing will also treat the readily removable contamination from the soil in the saturated zone. The extracted water will be treated using UV/Oxidation. Treated water will be reinjected into the A-zone groundwater to promote horizontal flushing.

- o Alternative 5 - RCRA Cap on Southern Third of Site; Basic Cap on Remaining Site; Excavation of Surface Soil Hot-spots in Northern Two-Thirds of Site; Off-site Treatment and Disposal; Soil Vapor Extraction (SVE) of A-zone Soils; Horizontal

Flushing, Extraction and Treatment of A-zone Groundwater

This alternative contains a RCRA approved cap on the southern third of the site to minimize infiltration and to prevent exposure to contaminated surface soils. This also includes excavation of surface soil hot-spots in the northern two-thirds of the site and off-site treatment and disposal of the contaminated soil. A basic cap will be placed over the soil after removal of hot-spots and regrading, in order to minimize infiltration. A-zone soils will be treated using soil vapor extraction. Horizontal flushing and extraction of groundwater in the A-zone will be used to remove highly contaminated groundwater. Horizontal soil flushing will also treat the readily removable contamination from the soil in the saturated zone. The extracted water will be treated using UV/Oxidation. Treated water will be reinjected into the A-zone groundwater to promote horizontal flushing.

- o Alternative 6 - Excavation of All Surface Soil Hot-spots; On-site Treatment and Disposal; RCRA Cap on Southern Third of Site; Basic Cap on Remaining Site; SVE of A-zone Soils; Horizontal Flushing, Extraction and Treatment of A-zone Groundwater

This alternative includes excavation of all surface soil whose concentrations exceed health-based levels and on-site treatment using soil washing. The washed soil will be returned to the excavated units after treatment standards have been met. The rinse water will be treated using UV/Oxidation. A RCRA approved cap will be installed on the southern third of the site and a basic cap will be placed over the remaining site, after removal of hot-spots and regrading, in order to minimize infiltration. A-zone soils will be treated using SVE. Horizontal flushing and extraction of the A-zone groundwater will be used to remove highly contaminated groundwater. Horizontal soil flushing will also treat the readily removable contamination from the soil in the saturated zone. The extracted water will be treated using UV/Oxidation. Treated water will be reinjected into the A-zone groundwater to promote horizontal flushing.

**Table 5.1
Summary of Alternatives**

Components/Alternatives	1	2	3	4	5	6
RCRA/Basic Cap	No	Yes	Yes	Yes	Yes	Yes
Surface Soil Treatment	No					
Consolidation under RCRA cap		Yes				
Off-site treatment of portion of soil outside RCRA cap			Yes		Yes	
On-site treatment of all soils				Yes		Yes
Subsurface Soil Treatment	No	No	No	No		
Soil Vapor Extraction					Yes	Yes
Extract and Treat A-zone Groundwater	No	Yes	Yes	Yes	Yes	Yes

5.2.1 Overall Protection of Human Health and the Environment

The overall protection of human health and the environment criterion assesses each alternative to determine its effectiveness in reducing risks at the Site.

Alternative 1 offers no protection other than natural degradation and attenuation. All the other alternatives (2,3,4,5 & 6) contain a technology to remove contamination from the A-zone groundwater in order to protect the B-zone groundwater. Without removing the contamination in the A-zone groundwater, the contamination would need to be captured in the B-zone groundwater. Alternatives 5 and 6 add an incremental protection by treating the A-zone soil. This incremental protection can also be achieved in alternatives 2, 3 and 4 by capturing the contamination when it reaches the A-zone groundwater.

Alternative 2 eliminates the exposure to highly contaminated soil by placing a RCRA cap over the southern third after all contaminated soil had been consolidated beneath the cap. Alternatives 3, 4, 5 and 6 also reduces the potential exposure to surface soils by either treating the highly contaminated surface soils before placing a RCRA/basic cap combination or placing a RCRA cap over the hot-spots. Alternatives 4 and 6 removes and

treats the most highly contaminated soil.

Table 5.2
Detailed Comparison of Overall Protection of
Human Health and the Environment

<p>Alt. 1 - No Action</p>	<ul style="list-style-type: none"> o Existing risk to on-site workers & trespassers remain. o Risk of further degrading B-zone groundwater remains
<p>Alt. 2 - Consolidate Surface Hot-Spots; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Existing risk to on-site workers and trespassers is controlled as long as integrity of cap is maintained o Risk of further degrading B-zone is eliminated by aggressively removing contaminant from the A-zone groundwater o Potential risk of degrading B-zone groundwater from A-zone soil is low level risk; however, capping will lower the risk further by eliminating the vertical water incursion which could carry the contamination down to the B-zone groundwater.
<p>Alt. 3 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p> <p>Alt. 4 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Existing risk to on-site workers and trespassers is eliminated because the soils with concentrations in excess of health-based levels would be treated in Alternative 4. o In Alternative 3, the risk to on-site workers and trespassers is significantly reduced by installation of RCRA-cap over contaminated areas after consolidation. o Risk of degrading B-zone is eliminated by aggressive removal of contaminants from the A-zone groundwater o Risk of further degrading B-zone groundwater from A-zone soil is low level risk; however, capping will lower the risk further.

<p>Alt. 5 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p> <p>Alt. 6 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Existing risk to on-site workers and trespassers is eliminated because the soils with concentrations in excess of health-based levels would be treated in Alternative 6. o In Alternative 5, the risk to on-site workers and trespassers is significantly reduced by installation of RCRA-cap over contaminated areas after consolidation. o Existing risk to on-site workers and trespassers is eliminated because the soils with concentrations in excess of health-based levels would be treated. o Potential risk of degrading B-zone is eliminated by aggressively removing contaminant from the A-zone groundwater o Risk of further degrading B-zone groundwater from A-zone soil is removed because the A-zone soils will be addressed. This risk is a low level risk; therefore, this action does not considerably increase the overall protectiveness.
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5.2.2 Compliance with ARARs

All alternatives, except alternative #1, will comply with the substantive requirements of the identified ARARs. Table 5.3 presents a discussion of each ARAR and how it would apply to the alternatives.

Table 5.3
Compliance with ARARs

ARAR	Discussion
Resolution 68-16, Anti-Degradation	UV/O ₃ system will treat extracted water to SDWA MCLs or below before re-injection into the A-zone groundwater. All alternatives that use re-injection (2,3,4,5&6) will comply.
HWCL - Section 66265 Article 11 Closure and Monitoring	The sump area and the waste pond will require a RCRA cap. A RCRA cap will be installed on the southern third of the site which includes the sump and the waste pond in Alternatives 2,3,4,5 & 6.
HWCL - Section 66268 Subpart C Land Disposal Restrictions (LDRs)	Off-site treatment and disposal (alt. 3 & 5) would meet LDRs at the off-site facility. LDR levels are TBCs when on-site treatment of soil occurs (alt 4 & 6) The soil in alt 4 & 6 will be treated to health-based levels prior to placement and installation of RCRA cap. Consolidation of contaminated soil (Alt 2) would not trigger LDRs because the facility is consider one area of contiguous contamination.

HWCL - Section 66265 Article 9 Containers	Containers used in the remediation of the site will comply with the substantive requirements of Article 9. All alternatives which include treatment of groundwater (alt 2,3,4,5,& 6) will require containers.
HWCL - Section 66265 Article 10 Tanks	Tanks used for temporary storage of hazardous waste and the UV/O ₃ system are considered tanks. A variance allowed in Article 10 for double containment will be invoked for tank systems that are located where a release from such tank would not pose a hazard. Otherwise, all substantive requirements for the tank systems will be met.
SDWA - Underground Injection	Reinjection wells would be classified as Class V.

5.2.3 Long-term Effectiveness and Permanence

Alternatives are assessed for long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will be successful. The alternatives that remove and treat the greatest amount of contamination will be the most permanent (alternative 5 & 6). However, all alternatives, except no action, treat the largest source of continuing contamination, the A-zone groundwater, and leave some contamination in the soil behind. Alternatives 2, 3 and 4, also offer a high degree of long-term effectiveness because the surface soil threat is addressed by removal and treatment or containment of the contamination. Also in alternatives 2, 3 and 4, the A-zone soils are controlled by limiting the movement of contamination in the zone. The long-term effectiveness of the alternatives that leave levels of contamination exceeding health-based levels beneath the RCRA-cap (alternatives 2, 3 & 5) is determined by the long-term maintenance of the cap.

All the alternatives that treat the surface soil (alternatives 3, 4, 5, & 6) have a strong probability of success because the treatment has already been demonstrated to be successful. It is uncertain how the water-bearing zone will respond to the horizontal flushing and extraction component of alternatives 2, 3, 4, 5, & 6. It is anticipated that a significant volume of contamination can be removed. Finally, the effectiveness of the soil vapor extraction component in alternatives 5 and 6 is uncertain due to the heterogeneity of the soil layers.

**Table 5.4
Detailed Comparisons Long-term Effectiveness and Permanence**

<p>Alt. 1 - No Action</p>	<ul style="list-style-type: none"> o No long-term effectiveness or permanence other than natural degradation and attenuation.
<p>Alt. 2 - Consolidate Surface Hot-Spots; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Risk associated with exposure to surface soil will be controlled by capping. Effectiveness is dependent on maintenance of cap. o Waste left in A-zone soil will be controlled by capping to limit mobility. Long-term effectiveness is dependent on maintenance of cap. o Horizontal flushing/extraction will leave behind residual contamination that should not pose a risk to B-zone groundwater due to limited mobility and reduced volume.
<p>Alt. 3 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Risk associated with exposure to surface soil will be controlled by capping. Effectiveness is dependent on maintenance of cap. o Off-site treatment of surface soil where a basic cap will be installed, will reduce contamination to levels acceptable for disposal to a landfill. o Waste left in A-zone soil will be controlled by capping to limit mobility. Long-term effectiveness is dependent on maintenance of cap. o Horizontal flushing/extraction will leave behind residual contamination that should not pose a risk to B-zone groundwater due to limited mobility and reduced volume.
<p>Alt. 4 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Excavation and treatment of highly contaminated surface soil will permanently remove the associated risk. o Waste left in A-zone soil will be controlled by capping to limit mobility. Long-term effectiveness is dependent on maintenance of cap. o Horizontal flushing/extraction will leave behind residual contamination that should not pose a risk to B-zone groundwater due to limited mobility and reduced volume.

<p>Alt. 5 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Ground water; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Risk associated with exposure to surface soil will be controlled by capping. Effectiveness is dependent on maintenance of cap. o Off-site treatment of surface soil where a basic cap will be installed, will reduce contamination to levels acceptable for disposal to a landfill. o SVE would permanently reduce the concentration of volatiles contamination in A-zone soils. o Horizontal flushing/extraction will leave behind residual contamination that should not pose a risk to B-zone groundwater due to limited mobility and reduced volume.
<p>Alt. 6 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Excavation and treatment of highly contaminated surface soil will permanently remove the associated risk. o SVE would permanently reduce the concentration of volatiles contamination in A-zone soils. o Horizontal flushing/extraction will leave behind residual contamination that should not pose a risk to B-zone groundwater due to limited mobility and reduced volume.

5.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

The alternatives are assessed to the degree which they employ recycling or treatment that reduces toxicity, mobility or volume, especially in respect to the principle threats at the site. There are two principle threats at the site, the threat the surface soils pose to human exposure and the threat the A-zone groundwater poses to the B-zone groundwater, which is the first potential drinking water source at the site.

All alternatives except no action, alternative 1, actively address the principal threat to the B-zone groundwater by horizontal flushing and extracting contaminated A-zone groundwater. The extracted water will be treated to destroy the contaminants. The degree of reduction of the contaminants in the A-zone groundwater is unknown due to the uncertainty of the flushing/extraction process in a geologic formation containing clays. It is expected that the contaminated groundwater and the readily removable contamination on the soils in the saturated zone can be removed.

Alternatives 3, 4, 5 and 6, all actively reduce the volume to surface soil contamination by excavating the contamination and either, treating it on-site and returning the treated soil to the

site, or treating a portion off-site and disposing it is a hazardous waste landfill. Alternative 3 & 5 treat a relatively small volume of contaminated soil compared to the volume left beneath the RCRA cap. Alternatives 2, 3 & 5 reduces the toxicity of the surface soil concentration by eliminating potential exposure by installing a RCRA cap. The cap also reduces mobility of the contamination.

Alternatives 2, 3 and 4 reduce the mobility of the contamination in the A-zone soils by reducing infiltration. The A-zone soil contamination is a minor threat to B-zone groundwater. Alternatives 5 and 6 actively reduce the volume of volatiles contamination in the A-zone soil by SVE. The degree of expected reduction in volume by active treatment is difficult to judge because of the heterogeneity of the geological formations in the A-zone soils. SVE will not remove dinoseb.

Table 5.5
Detailed Comparisons of Reduction of
Toxicity, Mobility or Volume Through Treatment

<p>Alt. 1 - No Action</p>	<ul style="list-style-type: none"> • No active reduction of toxicity, mobility or volume of contamination
<p>Alt. 2 - Consolidate Surface Hot-Spots; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Active reduction of toxicity, mobility and volume of A-zone groundwater, the principle threat to the B-zone groundwater • No active reduction in volume to surface soil and A-zone soil contamination; toxicity is controlled by elimination exposure to soils • Reduction in mobility of contaminants in soil due to elimination of infiltration by RCRA cap.
<p>Alt. 3 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p> <p>Alt. 4 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Active reduction of toxicity, mobility and volume to A-zone groundwater, the principal threat to B-zone groundwater • Active reduction of toxicity, mobility and volume of soil surface contamination, a principal threat to human exposure. Alternative 4 reduces the greatest volume. • Reduction in mobility in A-zone soils, due to installation of cap. No reduction in volume of contamination

<p>Alt. 5 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Ground water; Treatment of Extracted Groundwater</p> <p>Alt. 6 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Active reduction of toxicity, mobility and volume of A-zone groundwater, the principal threat to B-zone groundwater • Active reduction of toxicity, mobility and volume of surface soil contamination, a principal threat to human exposure. Alternative 6 reduces the greatest volume. • Active reduction in volume and toxicity of A-zone soil contamination. • Reduction in mobility of contaminants remaining in A-zone soil after treatment.
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5.2.5 Short-term Effectiveness

Short-term effectiveness assesses for each alternative the short-term risks to workers and the community during implementation of an alternative, potential short-term environmental impacts of the alternative and the time until protection from any short-term risk is achieved.

The alternatives that propose excavation of contaminated surface soils (Alternative 2, 3, 4, 5 and 6) may pose a short-term fugitive dust risk to workers and the community. Dust control measures should be implemented. Alternatives 3 and 5 contain off-site transportation of hazardous waste which pose a short-term risk to the communities en route. Alternative 2 requires the minimal amount of soil handling; therefore, poses the least significant risk.

The flushing/extraction process for the A-zone groundwater proposed is alternatives 2, 3, 4, and 5 and 6 poses no short-term risk to the community and the workers. It is estimated that it will take ten years to remediate the A-zone groundwater; however, neither the A-zone groundwater (which is not a potential drinking water source) nor the A-zone soil pose an immediate risk to the community or to the workers.

In-situ installation and operation of SVE in alternatives 5 & 6, requires little handling of contaminated soils, and thereby limits the risk of exposure to workers and the public.

**Table 5.6
Detailed Comparisons of Short-term Effectiveness**

<p>Alt. 1 - No Action</p>	<ul style="list-style-type: none"> • No increased short-term risks
<p>Alt. 2 - Consolidate Surface Hot-Spots; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Installation of cap will requires minimal disruption of contaminated surface soil; therefore minimal short-term risk • A-zone soil and A-zone groundwater do not pose a short-term risk. • Consolidation of hot-spots may pose short-term fugitive dust problems. However, the volume is small.
<p>Alt. 3 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Excavation of contaminated surface soil may pose short-term fugitive-dust problems; however, the volume is small. • Off-site transportation of hazardous waste may pose a short-term risk to communities along route
<p>Alt. 4 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Excavation of contaminated surface soil may pose short-term fugitive dust problem
<p>Alt. 5 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Ground water; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Excavation of contaminated surface soil may pose short-term fugitive-dust problems; however, the volume is small. • Off-site transportation of hazardous waste may pose a short-term risk to communities along route
<p>Alt. 6 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> • Excavation of contaminated surface soil may pose short-term fugitive dust problem

5.2.6 Implementability

The ease or difficulty of implementing the alternatives are assessed with respect to technical feasibility, administrative feasibility and availability of services. All the alternatives that address surface soil contamination use either standard, proven technologies (alternative 2, capping and alternatives 3 & 5, off-site treatment and disposal, and capping), or an innovative technology (alternatives 4 & 6, soil washing) and (alternatives 5 & 6, soil vapor extraction). Soil washing was proven successful at the site by an EPA removal action. All these technologies are implementable.

The horizontal flushing/extraction procedure proposed in alternatives 2, 3, 4, 5 & 6, consists of installing extraction and injection wells. The installation of these wells are standard procedures. However, operation details such as recovery of injected fluid will require adjustment during the operation and may require a longer time for remediation.

The technical feasibility of soil vapor extraction is dependent on the ability to pull air through the silty sand and silt layers in the soil profile. These layers between 25 and 35 feet in depth contain the highest concentrations of 1,2-DCP.

Table 5.7
Detailed Comparisons of Implementability

Alt. 1 - No Action	o Implementable
Alt. 2 - Consolidate Surface Hot-Spots; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater	<ul style="list-style-type: none"> o RCRA cap installation is a standard, proven procedure. o Construction of flushing/extraction system is a standard procedure. It is unknown how quickly the geologic formation will respond to flushing. o UV/Oxidation is an innovative technology; however a treatability test and actual application to the site has been performed. Therefore, there is a high degree of certainty of success. o Treated waste water can be reinjected into the A-zone groundwater for flushing.

<p>Alt. 3 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Off-site treatment and disposal will require permits and approval for other regulatory agencies. o Construction of flushing/extraction system is a standard procedure. It is unknown how quickly the geologic formation will respond to flushing. o UV/Oxidation is an innovative technology; however a treatability test and actual application to the site has been performed. Therefore, there is a high degree of certainty of success. o Treated waste water can be reinjected into the A-zone groundwater for flushing.
<p>Alt. 4 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA/Basic Cap Combination; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o On-site treatment of soil washing has already successfully been implemented at the site. o Construction of flushing/extraction system is a standard procedure. It is unknown how quickly the geologic formation will respond to flushing. o UV/Oxidation is an innovative technology; however a treatability test and actual application to the site has been performed. Therefore, there is a high degree of certainty of success. o Treated waste water can be reinjected into the A-zone groundwater for flushing.
<p>Alt. 5 - Excavation of Surface Hot-spots on Northern 2/3s; Off-site Treatment and Disposal; RCRA/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o Off-site treatment and disposal will require permits and approval from other regulatory agencies. o Technical feasibility of SVE is dependent on the ability to pull air through a heterogeneous soil profile. o Construction of horizontal flushing/extraction system is a standard procedure. It is unknown how quickly the geologic formation will respond to flushing. o UV/Oxidation is an innovative technology; however a treatability test and actual application to the site has been performed. Therefore, there is a high degree of certainty of success. o Treated waste water can be reinjected into the A-zone groundwater for flushing.

<p>Alt. 6 - Excavation of All Surface Hot-spots; On-site Treatment; RCRA-/Basic Cap Combination; Soil Vapor Extraction of A-zone Soils; Horizontal Flushing and Extraction of A-zone Groundwater; Treatment of Extracted Groundwater</p>	<ul style="list-style-type: none"> o On-site treatment of soil washing has already successfully been implemented at the site. o Technical feasibility of SVE is dependent on the ability to pull air through a heterogeneous soil profile. o Construction of horizontal flushing/extraction system is a standard procedure. It is unknown how quickly the geologic formation will respond to flushing. o UV/Oxidation is an innovate technology; however a treatability test and actual application to the site has been performed. Therefore, there is a high degree of certainty of success. o Treated waste water can be reinjected into the A-zone groundwater for flushing.
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5.2.7 Cost

Cost estimates for the six alternatives are presented in Table 5.8. Details of the cost estimates can be found in Appendix A. A cost estimate to evaluate the cost-effectiveness of treating the A-zone soil by soil vapor extraction vs. capturing and treating the contamination once it reached the A-zone groundwater. It was determined that capturing the contamination in the A-zone groundwater is half the expense of soil vapor extraction.

5.2.8 State Acceptance

The State of California Department of Toxic Substance Control has been involved with this project from the beginning. They have received a draft of the RI/FS and their comments are anticipated during the public comment period.

5.2.9 Community Acceptance

The issues and concerns of the community will be addressed after the public comment period on the proposed plan is completed.

TABLE 5.8 COST OF ALTERNATIVES

Alt.	Item	Up-front Costs (\$ 000)	Annual Cost (\$ 000)	Present Worth (\$000)
1	On-going Monitoring (30 yrs)	---	50	610
2	RCRA/Basic Cap (maintenance - 30 yrs)	1,072	50	1,632
	Consolidation of Hot-spots	12		10
	Horizontal Flushing & Extraction of A-zone Groundwater	1,900	330	4,100
	UV/Oxidation of Extracted Water	650	540	4,270
	Limited On-going Monitoring (30 yrs)	---	16	180
	TOTAL	3,634	936	10,192
3	Excavation of Surface Soil Hot-spots in Northern 2/3 site	12	---	12
	Off-site Treatment and Disposal	225	---	225
	RCRA/Basic Cap (maintenance - 30 yrs)	1,072	50	1,632
	Horizontal Flushing & Extraction of A-zone Groundwater	1,900	330	4,100
	UV/Oxidation of Extracted Water	650	540	4,270
	Limited On-going Monitoring (30 yrs)	---	16	180
	TOTAL	3,859	936	10,419

TABLE 5.8 COST OF ALTERNATIVES

Alt.	Item	Up-front Costs (\$ 000)	Annual Cost (\$ 000)	Present Worth (\$ 000)
4	Excavation of All Surface Soil Hot-spots	140	---	140
	Soil Washing	870	---	870
	Additional UV/Oxidation	80	---	80
	RCRA/Basic Cap (maintenance - 30 yrs)	1,072	50	1,632
	Horizontal Flushing & Extraction of A-zone Groundwater	1,900	330	4,100
	UV/Oxidation of A-zone Groundwater	650	540	4,270
	Limited On-going Monitoring (30-year)	---	16	180
	TOTAL	4,712	936	11,272
5	Excavation of Surface Soil Hot-spots in Northern 2/3 site	12	---	12
	Off-site Treatment and Disposal	225	---	225
	RCRA/Basic Cap (maintenance - 30 yrs)	1,072	50	1,632
	Horizontal Flushing & Extraction of A-zone Groundwater	1,900	330	4,100
	UV/Oxidation of Extracted Water	650	540	4,270
	SVE of Sump and Waste Pond Areas (1 year)	550	100	650
	Limited On-going Monitoring (30 yrs)	---	16	180
	TOTAL	4,409	1,036	11,069

TABLE 5.8 COST OF ALTERNATIVES

Alt.	Item	Up-front Costs (\$ 000)	Annual Cost (\$ 000)	Present Worth (\$ 000)
6	Excavation of All Surface Soil Hot-spots	140	--	140
	Soil Washing	870	--	870
	Additional UV/Oxidation	80	--	80
	RCRA/Basic Cap (maintenance - 30 yrs)	1,072	50	1,632
	Horizontal Flushing & Extraction of A-zone Groundwater	1,900	330	4,100
	UV/Oxidation of Extracted A-zone Groundwater	650	540	4,270
	SVE of Sump and Waste Pond Areas (1 year)	550	100	650
	Limited On-going Monitoring (10-year)	--	16	180
	TOTAL	5,262	1,036	11,922

6.0 SUMMARY OF TREATABILITY STUDIES

This section is the summary of the remedy screening and selection tests performed before the removal clean-up in 1991, the findings of the removal clean-up in 1991, and remedy screening tests performed during the remedial investigation. This section will present a summary of tests performed and the conclusions. Additional information can be found in the relevant reports which will be cited in each section.

6.1 Pre-Removal Treatability Tests

During the early phases of the removal in 1989, EPA determined that an imminent and substantial endangerment existed in the surface soils due to the high levels of dinoseb contamination. Consequently, EPA conducted several remedy screening tests to determine the feasibility of different technologies in treating high levels of dinoseb contamination in the soil. All the remedy screening tests in this phase only addressed dinoseb.

A summary and evaluation of the remedy screening tests conducted in the pre-removal phase can be found in Draft Review of Existing Data Report for Brown & Bryant Technology Evaluation Process, Vance Fong, EPA, March 21, 1991.

6.1.1 Bioremediation Tests

In July 1989, U.S. EPA tasked its Response, Engineering and Analytical Contract (REAC) contractor to collect soil from the Brown & Bryant site and perform bioremediation tests on the soil. Shaker flask, soil column, and plate count biotreatment tests were conducted. The results showed that the soil was sterile, making bioremediation a nonviable technique for remediating the site.

Additional information can be obtained in the Phase I - Final Report for Remediation Study of Brown & Bryant Site, Arvin, Kern County, California, Weston, Nov. 3, 1989.

6.1.2 Soil Washing Test/Carbon Adsorption

It was noticed in the bioremediation treatability study that, although bioremediation is not a viable technology to cleanup dinoseb contaminated soils, soil washing may be applicable. Per request of the OSC, REAC submitted a soil washing/carbon adsorption report and a soil washing alternative evaluation report to EPA on December 8, 1989 and on August 31, 1990, respectively.

The purpose of the soil washing treatability study was to quantitatively characterize the reduction of dinoseb

concentrations in soil as a result of soil washing.

The results from this remedy screening soil washing test indicate that soil washing is potentially a viable treatment technology for removal of dinoseb from contaminated surface soil. The results also show, that dinoseb removal rate is a function of pH in the washing solution. The test seems to conclude, although not clearly due to being weakly acidic, that a basic solution may be desirable. The conclusion is consistent with the well documented chemical properties of a phenolic compound in spite of the limitations associated with the test a) dinoseb concentrations were only measured for the aqueous phase and not the soil phase hence b) no mass balance was performed. Dinoseb was the only compound evaluated by the test.

It was believed at this point that once dinoseb is leached from the soil into the water phase, granulated activated carbon (GAC) can be used to adsorb dinoseb as a method of water treatment. The purpose of the treatability testing was to determine the feasibility of using GAC to separate dinoseb and leachate as a two step cleanup of soil (soil washing followed by GAC adsorption).

Carbon adsorption test results show that dinoseb can be removed from contaminated aqueous phase when granular activated carbon is used as an adsorbent. The test was run in a neutral condition. Dinoseb removal rate may be changed significantly with pH. It was suggested that liquid phase GAC be used as a "polishing" treatment step.

6.1.3 UV/Ozone Test

Although carbon adsorption was demonstrated in the previous treatability study as a viable technology, it is only a separation process (dinoseb is not chemically destroyed, it adsorbs onto the GAC). The contaminated carbon from the process needs regeneration or disposal.

Thus, in order to address the CERCLA preference for on-site destruction of contaminants, treatment of dinoseb containing leachate using ultra-violet/ozone chemical oxidation (UV/O3) was evaluated. The results from the UV/Ozone pilot test indicate destruction of dinoseb in the treated liquid. However, desirable removal rates were not attained. Destruction rate of higher than 70% by mass required unreasonable reaction time. This limitation may be attributed to low quality instrument and lack of treatment knowledge.

6.2 Removal Clean-up Results

In the spring of 1991, EPA conducted a removal at the site

by excavating 80 cubic yards of dinoseb-contaminated soil, washing the soil, returning the washed soil to the excavated area, and treating the rinsewater with UV/Ozone.

6.2.1 Soil Washing

Approximately 80 cubic yards of dinoseb-contaminated soil was washed in a cement-mixer modified specifically for washing soil. On average, eight cubic yards were washed per day. The soil was washed until a dinoseb concentration of 10 ppm or less was reached in the final washing solution. After adjusting the number of rinse cycles, it was determined that the soil could be effectively washed with six rinse cycles. More information can be found in the Federal On-Scene Coordinator's Report, C. Weden Emergency Response Section, EPA Region IX, August 27, 1991

6.3 RI/FS Remedy Screening Tests

There were three remedy screening tests and one remedy selection test performed for Brown & Bryant. The three remedy selection tests were soil washing, soil vapor extraction and soil flushing. The soil vapor extraction remedy screening test was to be performed assuming there were significant areas where there were only volatiles and not dinoseb (dinoseb is non-volatile). Although the samples collected for the soil vapor extraction and the soil washing remedy screening tests were collected in areas known to be contaminated, unfortunately, the samples did not contain measurable quantities of volatiles and the tests could not be performed.

A remedy selection test was performed using UV/Oxidation on groundwater extracted from the A-zone. EPA was confident the UV/Oxidation would work well on dinoseb, but it was not known how well it would work on the other volatiles. The results of the soil flushing and UV/Oxidation tests are discussed below.

6.3.1 Soil Flushing

EPA's Risk Reduction and Engineering Lab in Edison, N.J. performed the soil flushing remedy screening tests on two two-foot samples collected from the sump area at a depth of 20 to 26.5 feet. The sump area was the known area with greatest VOC concentrations. However, VOCs were not detected in the collected samples in appreciable concentrations. Dinoseb was detected at about 3 ppm level. Although, there was some uncertainty with some of the lab analyses, the report concluded that soil flushing appeared to be effective in removing dinoseb from the soil.

Details on the soil flushing remedy screening test can be found in the Final Report on Treatability Screening Tests for the Brown & Bryant Site, RREL Edison Laboratory, June 22, 1992.

6.3.2 UV/Oxidation

In 1992, EPA contracted with Solarchem to determine the most cost-effective way to destroy the volatile compounds and dinoseb found at the site to maximum containment levels. The study focused on 1,2-DCP, 1,3-DCP, DBCP, EDB, 1,2,3-TCP and dinoseb. Groundwater samples were taken from the A-zone groundwater and sent to Solarchem. The study found that all chemicals were destroyed to levels below their respective MCLs. The study also provided cost estimates. Details on the remedy screening can be found in Design Test Report on the Rayox Enhanced Oxidation Treatment of Brown & Bryant EPA Superfund Site Arvin CA. Groundwater, Solarchem, June 1992.

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Handbook of Environmental Degradation Rates, P.H. Howard et al., 1991.

Quality Assurance Project Plan for the Brown & Bryant Site Remedial Investigation and Feasibility Study, EPA Region 9, March 1991.

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"July Groundwater Sampling at the Brown and Bryant Site," Memorandum from Robbie Hedeem to Cynthia Wetmore, 7/25/91.

Field Sampling Plan for Soil Sampling, Brown & Bryant, Arvin, CA, EPA Region 9, September 23, 1991.

"Amendment to Field Sampling Plan for Quarterly Monitoring and Surface Soil Sampling, Brown and Bryant Site," Memorandum from Robbie Hedeem to Cynthia Wetmore, 11/30/91.

"Technical Definition Memorandum #9 for Contractor Assistance" (includes SOW for Slug Tests), Prepared by Cynthia Wetmore, EPA, December 6, 1991.

IRIS, Integrated Risk Information System (a risk information data base), USEPA, 1992.

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Final Report, Task 6 -- Soil Sampling, Brown & Bryant, Arvin, CA, Prepared for EPA by Ecology and Environment, April 22, 1992.

"Revised Amendment to the FSP for Quarterly Groundwater Monitoring, Brown & Bryant Site, Arvin, CA, March, 1992 Revision," Memorandum from Tina Diebold to Cynthia Wetmore, 7/13/92.

Final Report, Task 9 -- Slug Testing, Brown & Bryant, Arvin, CA, Prepared for EPA by Ecology and Environment, July 17, 1992.

Preliminary Screening Level Modeling to Establish Soil Cleanup Levels at Brown & Bryant Site, Region IX, prepared for EPA by ASci Corp., July 20, 1992.

Activity Summary and Data Report, Appendices B & C, Prepared for Southern Pacific Transportation Co. and The Atchison, Topeka & Santa Fe Railway Co. by Kennedy/Jenks Consultants, August 1992.

Preliminary Remedial Goals (DRAFT), USEPA Region 9, January 30, 1993.

B-2 Aquifer Test Report, Task 11, Brown & Bryant, Arvin, California, Prepared for USEPA by Ecology and Environment, March 31, 1993.

"Micromedix TOMES (Toxicology, Occupational Medicine and Environmental Series) (R) Data Base System," vol 15, Micromedix, 1993.

Draft Review of Existing Data Report for Brown & Bryant Technology Evaluation Process, Vance Fong, EPA, March 21, 1991.

Phase I - Final Report for Remediation Study of Brown & Bryant Site, Arvin, Kern County, California, Weston, Nov. 3, 1989.

Federal On-Scene Coordinator's Report, C. Weden Emergency Response Section, EPA Region IX, August 27, 1991

Final Report on Treatability Screening Tests for the Brown & Bryant Site, RREL Edison Laboratory, June 22, 1992.

Design Test Report on the Rayox Enhanced Oxidation Treatment of Brown & Bryant EPA Superfund Site Arvin CA. Groundwater, Solarchem, June 1992.

APPENDIX A

**ASSUMPTIONS
FOR
COST OF ALTERNATIVES**

RCRA CAP

RCRA cap construction cost based on design (see FIG. 2.2) and Best And Final Offer (BAFO) for contract to provide similar RCRA cap at Selma Superfund site (July 1992).

$\$136.30/\text{yd}^2 = \$660,000/\text{acre} \times 1.2 \text{ acres} = \$ 792,000$

Engineering Fee - RCRA Cap (10%) \$ 80,000

Up-Front Cost **\$ 872,000**

BASIC CAP ²

Assume Asphalt cover

(3.0 acres) (4,840 yd²/acre) (\$6/yd²) = \$ 87,000

15% Engineering Fee = \$ 13,000

Up-Front Cost = **\$ 100,000**

TOTAL UP-FRONT COST = **\$1,072,000**
($\$100,00 + \$872,000 + \$100,000$)

Annual Cost (maintenance) **\$50,000**

Present Worth
 $\$1,072,000 + \$560,000 =$ **\$ 1,632,000**
($\$50,000, 8\%, 30\text{yrs}$)

² Ibid.

2.3 HORIZONTAL FLUSHING & EXTRACTION

Basic Assumptions

- A-zone GW area = 5.6 acres = 244,000 ft²
- Area of influence of each well = 2,500 ft²
- Theoretical number of wells ≈ 100
- Assuming 75% actually required ≈ 75 wells
- Installation cost/well = \$20,000³
- Wells in 8 rows, 400' long, 9 wells ea. row
- Separate piping system for extraction and injection for each well

Well Installation Cost
(75 wells)(\$20,000/well) = \$1,500,000

Well Field Piping, Pumps, Tanks
(2" pipe @ \$10/ft)(8 rows)(400')(2) = \$ 65,000
(4" pipe @ \$15/ft)(1 row)(400')(2) = \$ 12,000
Pumps, controls, tanks
(100% of piping cost) = \$ 77,000
Sub Total = \$1,650,000

15% Engineering Fee = \$ 250,000

Up-front Cost Total = \$1,900,000

Annual Cost - O & M⁴ = \$ 330,000

Present Worth
\$1,900,000 + \$2,200,000 = \$4,100,000
((\$330,000, 8%, 10 yrs)

2.4 UV/O₃ TREATMENT OF EXTRACTED A-ZONE WATER⁵

Up-Front Cost
Treatment system Capital Cost = \$ 650,000

Annual Cost (O & M) = \$ 540,000

Present Worth
\$650,000 + \$3,620,000 = \$4,270,000
((\$540,000, 8%, 10 yrs)

³ "Brown & Bryant Feasibility Study Costs" memo, M. Simon to C. Wetmore, 11/30/92

⁴ Ibid.

⁵ "Cost Analysis on UV Oxidation Treatment" memo, V. Fong to C. Wetmore, 11/20/92

2.5 MODIFIED ON-GOING MONITORING

Analytical Costs
(6 wells) (2 samples/well) (\$1000/sample) \$ 12,000

Labor
(2 people) (\$50/hr) (8hr/dy) (2.5dys/yr) \$ 4,000
Annual Cost \$ 16,000

Present Worth
(\$16,000,000, 8%, 30 yrs) \$ 180,000

3.0 EXCAVATE SOILS IN NORTHERN 2/3 SITE & OFF-SITE DISPOSAL OF SOIL HOT-SPOTS; RCRA/BASIC CAP; TREAT A-ZONE GW

3.1 EXCAVATE SOIL HOT-SPOTS (TO 1 FEET) ⁶

Excavation (77 yds³) (\$100/yd³) = \$ 8,000
Air Monitoring/ Dust Control = \$ 2,000
15% Engineering Fee = \$ 1,500

Up-Front Cost = \$ 11,500

3.2 OFF-SITE TREATMENT & DISPOSAL ⁷

Hauling
(77 yds³) (1.5 tons/yd³) (\$2300/load) = \$ 14,000
(20 tons/load)

Treatment & Disposal
(77 yds³) (1.5 ton/yd³) (\$1700/ton) = \$ 200,000

Up-Front Cost = \$ 225,000

⁶ Ibid.

⁷ Ibid.

4.0 EXCAVATION & ON-SITE TREATMENT OF SOIL HOT SPOTS; RCRA/BASIC CAP; FLUSHING & TREATMENT OF A-ZONE GW

4.1 EXCAVATE SOIL HOT-SPOTS (TO 7 FEET) ⁸

Excavation (670 yds ³) (\$100/yd ³)	=	\$ 70,000
Air Monitoring/ Dust Control	=	\$ 50,000
15% Engineering Fee	=	<u>\$ 20,000</u>
Up-Front Cost	=	\$ 140,000

4.2 SOIL WASHING ⁹

Site Preparation	=	\$ 80,000
Regulatory Compliance	=	\$ 45,000
Equipment	=	\$ 65,000
Startup	=	\$ 90,000
15% Engineering Costs	=	<u>\$ 40,000</u>
Startup Cost	=	\$ 320,000

Soil Washing Operating Costs (80 days)

Labor (6 people) (\$400/dy) (80dys)	=	\$ 190,000
Supplies	=	\$ 100,000
Utilities & Fuel	=	\$ 100,000
Facilities	=	\$ 20,000
Analytical Costs	=	<u>\$ 50,000</u>
Total	=	\$ 460,000

Off Site Disposal of Fines

(5% fines) (670 yd ³) (1.5ton/yd ³) (\$1700/ton)	=	\$ 85,000
Hauling (50 ton) (1 trip/20 ton) (\$2,000/trip)	=	<u>\$ 5,000</u>
		<u>\$ 90,000</u>

Up-Front Cost (Treatment and Disposal) = \$ 870,000

4.3 ADDITIONAL UV/OXIDATION ¹⁰

Up-front Cost = \$ 80,000

⁸ Ibid.

⁹ Ibid., M. Simon to C. Wetmore

¹⁰ Ibid., V. Fong to C. Wetmore

5.0 EXCAVATION & OFF-SITE DISPOSAL OF SOIL HOT SPOTS; BASIC CAP;
SOIL VAPOR EXTRACTION OF A-ZONE SOIL; FLUSHING & TREATMENT
OF A-ZONE GW

5.1 Soil Vapor Extraction¹¹

Up-front Cost	=	\$550,000
O & M	=	<u>\$100,000</u>
Present Worth	=	\$650,000

6.0 EXCAVATION & ON-SITE DISPOSAL OF SOIL HOT SPOTS; BASIC CAP;
SOIL VAPOR EXTRACTION OF A-ZONE SOIL; FLUSHING & TREATMENT
OF A-ZONE GW

¹¹ " Cost Estimate for Soil Vapor EXtraction", memo, V. Fong
to D. Roberts, 3/09/93, plus attached calculation

MISCELLANEOUS COST ESTIMATES

GROUT CURTAIN ¹²

30 ft high (between 50' and 80' below ground surface)
650 ft long; \$45/ft²

Construction cost (30')(650')(\$45)	=	\$ 880,000
15% Engineering Fee	=	\$ <u>130,000</u>
Up-Front Cost	=	\$1,010,000
Annual Cost (O & M)	=	\$ 40,000
Present Worth		
\$1,010,000 + \$450,000	=	\$1,460,000
((\$40,000, 8%, 30 yrs)		

IN-SITU VERTICAL FLUSHING OF A-ZONE SOIL ¹³

Grade Surface (0.6 acres)(4,840 yds/acre)(\$2/yd ²)	≈	\$ 5,000
Gravel (2,900 yd ²)(0.33yds)(\$6/yd ³)	≈	\$ 5,000
Vertical Flushing		
Piping	=	\$ 60,000
Pumps, 2 @ \$15,000 ea.	=	\$ 30,000
Control & Monitoring	=	\$ <u>40,000</u>
		\$ 140,000

Kerfing Up-Front Costs (Assumes use of 20 A-zone GW wells w/ modified casings)
(2,900 yd²)(9ft²/yd²)(4 ft)(\$6.60/ft³) = \$ 690,000

UV/O₃ Treatment Up-Front Costs
Treatment System (20gpm/ 18 lamp/ meet MCLs) \$1,060,000

Total Up-Front Costs = **\$1,890,000**

Annual Costs

Lamps, Chemicals Power	=	\$ 680,000
Operators	=	\$ <u>250,000</u>
Total Annual Cost	=	\$ 930,000

Present Worth

\$1,890,000 + \$2,400,000		
(\$930,000;8%;3 yrs)	=	\$4,290,000

¹² "Brown & Bryant Feasibility Study Costs" memo, M. Simon to C. Wetmore, 11/30/92

¹³ Ibid., M. Simon to C. Wetmore

March, 1973

Cost Comparison for SVE versus Operating the A-Zone Pump and Treat System for an additional 10 years.

SVE Cost: \$600,000

Pump and Treat Cost for Sump and Pond Area:

Volume of A-zone water under sump equals:
100 ft x 100 ft x 5 ft (A-zone thickness) x .4 (porosity)
Total Sump Volume: 20,000 cu ft

Volume of A-zone water under pond area equals:
150 ft x 150 ft x 5 ft (A-zone thickness) x .4 (porosity)
Total Pond Area Volume: 45,000 cu ft

Additional A-Zone Water Contaminated over 10 years under sump:

velocity in A-zone = 2.69 ft/yr
100 ft x 5 ft x .4 x 2.69 ft/yr x 10 yrs = 5,200 cu ft

Additional A-Zone Water Contaminated over 10 years under pond area:

velocity in A-zone = 2.69 ft/yr
150 ft x 5 ft x .4 x 2.69 ft/yr x 10 yrs = 8,070 cu ft

Total Maximum Volume of A-Zone Water Requiring Treatment for 10 years: 78,270 cu ft or 585,415 gals

Cost to treat 585,415 gals:

UV Oxidation cost = \$83.18/1000 gals
(\$83.18/1000 gals) x 585,415 gals = \$48,694

Operator Costs to Treat 585,415 gals:

To treat 3,500,000 gals the annual operator costs are \$250,000/yr. To treat 585,415 gals or 16.7% of the previous volume, the operator costs are \$250,000 x .167, or \$41,815/yr.

Total Cost to Treat 585,415 gals:
\$41,815 + \$48,694 = \$90,500 per year

Assume that at most the treatment must be repeated every other year for 10 years for an average annual cost of \$45,250.

Present Worth Value = \$45,250(p/a, 8%, 10)
= \$45,250 x 6.7101
= \$303,632



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
RISK REDUCTION ENGINEERING LABORATORY
CINCINNATI, OHIO 45268



DATE: February 12, 1993

SUBJECT: Revision 2.0 of Brown & Bryant Feasibility Study Costs

FROM: Michelle Simon *Michelle Simon*
Chemical Engineer, Regional Support Section
Technical Support Branch
Superfund Technology Demonstration Division

TO: Cynthia Wetmore, Region 9 Remedial Project Manager, H-6-2
David Roberts, Region 9 Remedial Project Manager, H-6-2

CC: Vance Fong, Region 9 Treatment Engineer, H-9-3
Tom Huetteman, Remedial Project Manager, H-6-2
Ed Bates, Regional Support Section Chief
Gordon Evans, SITE Demonstration Section

Please find the revised feasibility cost numbers for Brown & Bryant based on our February 11, 1993 phone call.

Please let me know if these costs or their documentation require any changes.

Attachments



BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

1. On-going Monitoring (Bases on Current Region 9 Costs)

Analytical Costs	
23 Wells * (2 Samples/well) * \$1000/sample	\$ 46,000
Labor	
2 Persons * \$50/hr * (8 hr/day) * 10 days	\$ <u>8,000</u>
Total	\$ 54,000
Net Present Value $\$54,000 * (P/A, 8\%, 30)$ (11.2578)	\$ <u>610,000</u>

BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

2. RCRA Cap

(Reference: Best and Final Offer by Chemical Waste Management for Selma Remedial Action (July 1992))

Site Preparation + Cap
 $\$136.30/\text{yd}^2 = \$660,000/\text{acre}$

Total Cap
4.2 acre * \$660,000/acre \$ 2,770,000

Annual Cost for RCRA Cap \$ 50,000

Net Present Value

NPV = $\$2,770,000 + \$50,000(P/A, 8\%, 30)$ \$ 3,300,000
(11.2578)

BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

3. Horizontal Flushing

Wells (Costs from Soil Vapor Extraction Reference Handbook, pp. 106-107)

Cost in \$/ft

PVC 6 in Casing	\$	12.00
PVC 4 in Tubing	\$	<u>3.50</u>
Total	\$	15.50
Per 85 foot A-Zone Well		
Casing & Tubing	\$	1,300
Gravel Pack		
\$20/yard ³ * Length * Area of Gravel Pack	\$	5,000
Length = 20 ft, Radius = 10 ft		
Area = π * Radius ²		
PVC 6 in Screen 20 ft * \$15/ft		
2 PVC 4 in Valves	\$	600
Submersible Pump	\$	3,700
Miscellaneous	\$	1,500
(Controller, Sampling Port, Instrumentation, Surface Seals, Etc.)		
Drilling Rig		
3 days * \$1000/day	\$	3,000
Labor	\$	<u>4,800</u>
4 Persons * \$50/hr * (8 hr/day) * (3 days/well)		
Total Cost per Well	\$	20,000
Total Wells		
75 Wells * \$20,000	\$	1,500,000

BROWN & BRYANT FEASIBILITY STUDY COSTS

3. Horizontal Flushing, Continued:

Extraction Field Piping and Surface Equipment

(75 wells arranged in 8-400 ft rows, 9 wells each row
Each well will used for both extraction and injection,
Separate piping system to each well for extraction
& injection)

2 in piping @ \$10/ft installed	
8 rows * 400 ft * \$10/ft * 2 sets	\$ 65,000
4 in piping @ 12/ft for collection & distribution manifolds	
1 row * 400 ft * \$15/ft * 2 sets	\$ 12,000
Pumps, electrical controls, tanks (100% Piping Costs)	\$ 77,000
Total Capital Piping	\$ 160,000
Engineering Fee for Wells & Piping 15 % of \$1,500,000 + \$160,000	\$ <u>250,000</u>
Total Capital for Wells + Piping	\$ 1,910,000
UV/O ₃ Treatment of Extracted A-Zone Water (Based on Vance Fong's 11/20/92 Memo, 10 gpm System to Non-Detect)	\$ <u>650,000</u>
Total Capital Cost	\$ 2,560,000

Annual O & M Costs:

Extraction System - O & M Costs	
1 person * \$50,000/year	\$ 50,000
\$3000/well(maintenance & costs) * 75 wells	\$ 230,000
Power, Miscellaneous	\$ <u>50,000</u>
Total Extraction System O & M	\$ 330,000
UV/O ₃ System	
\$290,000 (lamps) + \$250,000 (operator)	\$ <u>540,000</u>
Total Extraction & UV/O ₃ O & M	\$ 870,000

Net Present Value

NPV = \$1,910,000 (wells) + 650,000 (UV/O ₃ System)	
+ 870,000(P/A,8%,10)	\$ <u>8,400,000</u>
(6.7101)	

BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

4. Grout Curtain
(Reference: Contaminates and Remedial Options at Solvent Contaminated Sites p. 3-7)

30 ft * 650 ft = 19,500 ft ² * \$45/ft ² (50 to 80 foot depth)	\$ 880,000
15% Engineering Fee	\$ <u>130,000</u>
Total Grout Curtain Capital Costs	\$ 1,010,000
Annual O & M Costs	\$ 40,000
Net Present Value	\$ <u>1,460,000</u>
NPV = \$1,010,000 + \$40,000*(P/A,8%,30) (11.2578)	

BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

5. Excavation of Surface Soil Hot Spots and On Site Treatment of Soil & Extraction Water

(Reference: Ultrox International Ultraviolet Radiation/Oxidation Technology Application Analysis Handbook, p. 21)

Excavation Costs	
Volume = 670 yard ³ * \$100/yard ³	\$ 70,000
Air Monitoring/Dust Control	\$ <u>50,000</u>
Total Capital Costs	\$ 120,000
15% Engineering Fee	\$ <u>20,000</u>
Total Excavation Cost	\$ 140,000

Soil Washing Costs
(Reference: THAN Feasibility Study Report)

Site Preparation	\$ 80,000
Regulatory Compliance Costs	\$ 45,000
Supporting Equipment Costs	\$ 55,000
Startup Costs	\$ 90,000
Major Equipment Costs*	\$ <u>10,000</u>
* From Vance Fong's 11/20/92 Memo	
Total Capital Costs	\$ 280,000
15% Engineering Costs	\$ <u>40,000</u>
Total Soil Washing Costs	\$ 320,000

O & M Annual Costs

Labor - six persons * 80 days * \$400/day	\$ 190,000
Supplies	\$ 100,000
Utilities & Fuel	\$ 100,000
Facilities Costs	\$ 20,000
Effluent Waste & Disposal**	\$ 170,000
Analytical Costs	\$ <u>50,000</u>
Total O & M Costs	\$ 630,000

** See next page

BROWN & BRYANT FEASIBILITY STUDY COSTS

5. Excavation of Surface Soil Hot Spots and On Site Treatment of Soil & Extraction Water, Continued

**Effluent Treatment & Disposal Notes

On Site Treatment of Soil and Water
(From Vance Fong's 11/20/93 Memo)

Cost of Treatment of Wash Solution \$ 80,000

Off Site Disposal of Fines (Assumed 5% Fines)
(Based on Brown & Bryant Costing Notes)

$670 \text{ yard}^3 * 1.5 \text{ ton/yard}^3 * 0.05 = 50 \text{ tons}$

50 tons * \$1700/ton (disposal) \$ 85,000

50 tons * 1 trip/20 tons * \$2300/trip \$ 5,000
to Hazardous Waste Disposal

Total Offsite Disposal Costs \$ ~~90~~,000

**Total Effluent Treatment & Disposal Costs \$ 170,000

Net Present Value

NPV = \$140,000 (Excavation) + \$950,000 (Soil Washing)
\$ 1,090,000

BROWN & BRYANT FEASIBILITY STUDY COSTS

Notes on Costs:

6. Off Site Treatment & Disposal Costs for Entire Surface Hot Spot Soils Excavated to 7 ft (Based on Brown & Bryant Costing Notes)

Disposal Costs 670 yard ³ * 1.5 ton/yard ³ * \$1700/ton	\$ 1,710,000
Trucking Costs 1005 tons * (trip/20 ton) * \$2300	\$ <u>120,000</u>
Total	\$ 1,830,000
Net Present Value	\$ <u>1,830,000</u>

BROWN & BRYANT FEASIBILITY STUDY COSTS

8. In Situ Soil Flushing

(Reference: 1992 Means Construction Costs)

Flushing

Regrading

Surface Area = 0.6 acres = 26,136 ft² \$ 6,000
 = 2904 yard² * \$2/yard²

Gravel

26,136 ft² * 1 ft = 26,136 ft³
968 yard³ * \$6/yd³ \$ 6,000

Vertical Flushing System

Piping \$ 60,000
Pumps, 2 @ \$15,000 \$ 30,000
Control & Monitoring System \$ 43,000

Total Flushing System \$ 150,000

Kerfing

(Costs from PPC Report, pp. 21-22)
26,136 ft² * 4 ft * \$6.60/ft³ \$ 690,000

Treatment of Extracted Waters

(From Vance Fong's 11/20/93 Memorandum)

Capital Costs for UV/O₃ \$ 1,060,000

Total Capital Costs \$ 1,900,000

15% Engineering Fee \$ 280,000

Total Up Front Costs \$ 2,180,000

BROWN & BRYANT FEASIBILITY STUDY COSTS

8. In Situ Soil Flushing, Continued

UV/O₃ System
(From Vance Fong's 11/20/93 Memorandum)

Annual O & M Costs \$ 930,000

Present Worth

\$2,180,000 + 2,400,000 \$ 8,370,000
((\$930,000, 8%, 3 yrs)
2.5764

References:

Beat and Final Offer Bid by Chemical Waste Management for Selma Remedial Action (July 1992).

Brown & Bryant Cost Accounting Notes, October, 1992. (attached).

Fong, V., Cost Analysis on UV Oxidation Treatment. November 20, 1992 (attached).

Contaminants and Remedial Options at Solvent Contaminated Sites, September 1992. (Page 3-7 attached).

Soil Vapor Extraction Reference Handbook, EPA/540/2-91/003, February 1991.

Supplemental Feasibility Study Report for the Petroleum Products Corporation Site, Pembroke Park, Broward County, Florida, March 1992. (Pages G-21-22 attached).

THAN Feasibility Study Report, July 1992.

Ultrox International Ultraviolet Radiation/Oxidation Technology Application Analysis Report. EPA/540/A5-89/012, September 1990.

11/20/92

MEMORANDUM

SUBJECT: Cost Analysis on UV Oxidation Treatment of:

- a. A-Zone Water,
- b. Contaminated Water Resulting From Washing of Surface Soils, and
- c. Contaminated Water Resulting From Vadose Zone Soil Flushing

FROM: Vance Fong, Treatment Engineer, H-9-3

TO: Cynthia Wetmore, Remedial Project Manager, H-6-2
David Roberts, Remedial Project Manager, H-6-2

cc: Tom Huetteman, Remedial Project Manager, H-6-2
Michelle Simon, START, RREL, Cincinnati

Based on the information you've provided (3,500,000 gallons of A-zone ground water per year over 10 years, 645 cubic yards of dinoseb contaminated surface soil to be washed, and 0.6 acre and 40 feet deep of vadose soil to be flushed), I have performed the following cost analysis. It is my understanding that the above numbers were estimated for the feasibility study purposes and were based on assumptions. These assumptions include and are not limited to the 1,2 DCP concentration isopleth at ten times the MCL value for that compound, the thickness of the A-zone aquifer of ten feet, the soil porosity of 0.5, rough estimates of soil volumes for soil washing and flushing.

Attached please find cost analysis of UV/oxidation performed for three remedial scenarios: (a) treatment of A-zone ground water, (b) treatment of dinoseb contaminated waters resulting from washing of surface soils, and (c) treatment of contaminated water resulting from vadose-zone soil flushing operation.

The cost analysis was based on the Design Test Report on the RAYOX Enhanced Oxidation Treatment of Brown & Bryant EPA Superfund Site, Arvin, CA. Ground Water, Solarchem, November 1992, the attached Arvin RAYOX Results table provided recently by Solarchem, and consensus reached in our 11/20/92 meeting. If you have any questions please drop by or contact me at 4-2311.

Total Vol. of water in A-zone that needs treatment:

$$3.5 \times 10^6 \text{ gal/yr} \times 10 \text{ yrs} = 3.5 \times 10^7 \text{ gal}$$

Volumetric flowrate calculation:

$$3.5 \times 10^6 \text{ gal/yr} \times 1 \text{ yr}/365 \text{ days} \times 1 \text{ day}/24 \text{ hrs} \times 1 \text{ hr}/60 \text{ min} \\ = 6.7 \text{ gal/min}$$

Two standard UV/Oxidation systems (at near this flowrate) are available:

5 gpm and 10 gpm systems. Since the 3.5×10^6 gal/yr number may be over estimated to be conservative, cost info. for the 5 gpm system is also provided here should it becomes useful at a later time.

Costs associated with 5 gpm system:

Meeting non-detect level in effluent (EDB is limiting chemical):

6 lamps system:

$$+ \text{ Operating cost/yr} = \$83.18/1000 \text{ gal} \times 3.5 \times 10^6 \text{ gal/yr} \\ = \$291,130/\text{yr over 10 yr}$$

$$\text{Present worth value} = \$291,130(p/a, 8\%, 10) \\ = \$291,130(6.7101) \\ = \$1,950,000$$

Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour

$$+ \text{ Capital cost} = \$340,000$$

+ Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included.

$$\text{Operator cost} = \$250,000/\text{yr over ten years} \\ \text{present worth value} = \$250,000(6.7101) \\ = \$1,680,000$$

$$+ \text{ Total cost} = \$1,950,000 + \$340,000 + \$1,680,000 \\ = \$3,970,000$$

Meeting 10 times MCL level in effluent (EDB is limiting chemical):

4 lamps system:

$$+ \text{ Operating cost/yr} = \$59.27/1000 \text{ gal} \times 3.5 \times 10^6 \text{ gal/yr} \\ = \$207,445/\text{yr over 10 yr}$$

$$\text{Present worth value} = \$207,445(p/a, 8\%, 10) \\ = \$207,445(6.7101) \\ = \$1,390,000$$

Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour

$$+ \text{ Capital cost} = \$240,000$$

+ Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included.

$$\text{Operator cost} = \$250,000/\text{yr over ten years} \\ \text{present worth value} = \$250,000(6.7101) \\ = \$1,680,000$$

$$+ \quad \text{Total cost} = \$1,390,000 + \$240,000 + \$1,680,000 \\ = \$3,310,000$$

Meeting 30 times MCL level in effluent (EDB is limiting chemical):

3 lamps system:

$$+ \quad \text{Operating cost/yr} = \$47.32/1000 \text{ gal} \times 3.5 \times 10^6 \text{ gal/yr} \\ = \$165,620/\text{yr over 10 yr} \\ \text{Present worth value} = \$165,620(p/a, 8\%, 10) \\ = \$165,620(6.7101) \\ = \$1,110,000$$

Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour

$$+ \quad \text{Capital cost} = \$192,000$$

$$+ \quad \text{Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included.} \\ \text{Operator cost} = \$250,000/\text{yr over ten years} \\ \text{present worth value} = \$250,000(6.7101) \\ = \$1,680,000$$

$$+ \quad \text{Total cost} = \$1,110,000 + \$192,000 + \$1,680,000 \\ = \$2,980,000$$

Costs associated with 10 gpm system:

Meeting non-detect level in effluent (EDB is limiting chemical):

12 lamps system:

$$+ \quad \text{Operating cost/yr} = \$83.18/1000 \text{ gal} \times 3.5 \times 10^6 \text{ gal/yr} \\ = \$291,130/\text{yr over 10 yr} \\ \text{Present worth value} = \$291,130(p/a, 8\%, 10) \\ = \$291,130(6.7101) \\ = \$1,950,000$$

\$ 290,000

Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour

$$+ \quad \text{Capital cost} = \$642,580 \quad \approx \$650,000$$

$$+ \quad \text{Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included.} \\ \text{Operator cost} = \$250,000/\text{yr over ten years} \\ \text{present worth value} = \$250,000(6.7101) \\ = \$1,680,000$$

\$ 250,000/yr

$$+ \quad \text{Total cost} = \$1,950,000 + \$642,000 + \$1,680,000 \\ = \$4,272,000$$

Total O&M = \$540,000

Meeting MCL level in effluent (EDB is limiting chemical):

9 lamps system:

$$+ \quad \text{Operating cost/yr} = \$65.25/1000 \text{ gal} \times 3.5 \times 10^6 \text{ gal/yr} \\ = \$228,375/\text{yr over 10 yr}$$

Present worth value = \$228,375(p/a,8%,10)
= \$228,375(6.7101)
= \$1,530,000

- Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour
- + Capital cost = \$492,666
 - + Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included. Operator cost = \$250,000/yr over ten years
present worth value = \$250,000(6.7101)
= \$1,680,000
 - + Total cost = \$1,530,000 + \$492,000 + \$1,680,000
= \$3,700,000

Meeting 30 times MCL level in effluent (EDB is limiting chemical):

6 lamps system:

- + Operating cost/yr = \$47.32/1000 gal X 3.5X10⁶gal/yr
= \$165,620/yr over 10 yr
Present worth value = \$165,620(p/a,8%,10)
= \$165,620(6.7101)
= \$1,110,000
- Operating cost include lamp replacement, hydrogen peroxide, ENOX 510, and power at 10 cent per KW-hour
- + Capital cost = \$342,000
- + Operator cost include 4 one hour visit per day including weekends. Operator is allowed an hour each visit to travel to and from site. Vehicle cost and overhead also included. Operator cost = \$250,000/yr over ten years
present worth value = \$250,000(6.7101)
= \$1,680,000
- + Total cost = \$1,110,000 + \$342,000 + \$1,680,000
= \$3,130,000

Cost for Treatment of Spent Washed Solution

Total volume of spent washed solution needs UV/oxidation treatment:

645 yd³ soil X (1/2 pore vol.) (8 pore vol.) = 2,580 yd³ of solution
2,580 yd³ X 202 gal/yd³ = 521,160 gal

Total time required for treatment using 10 gpm system:

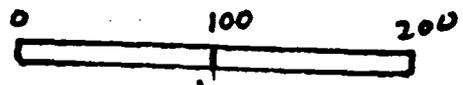
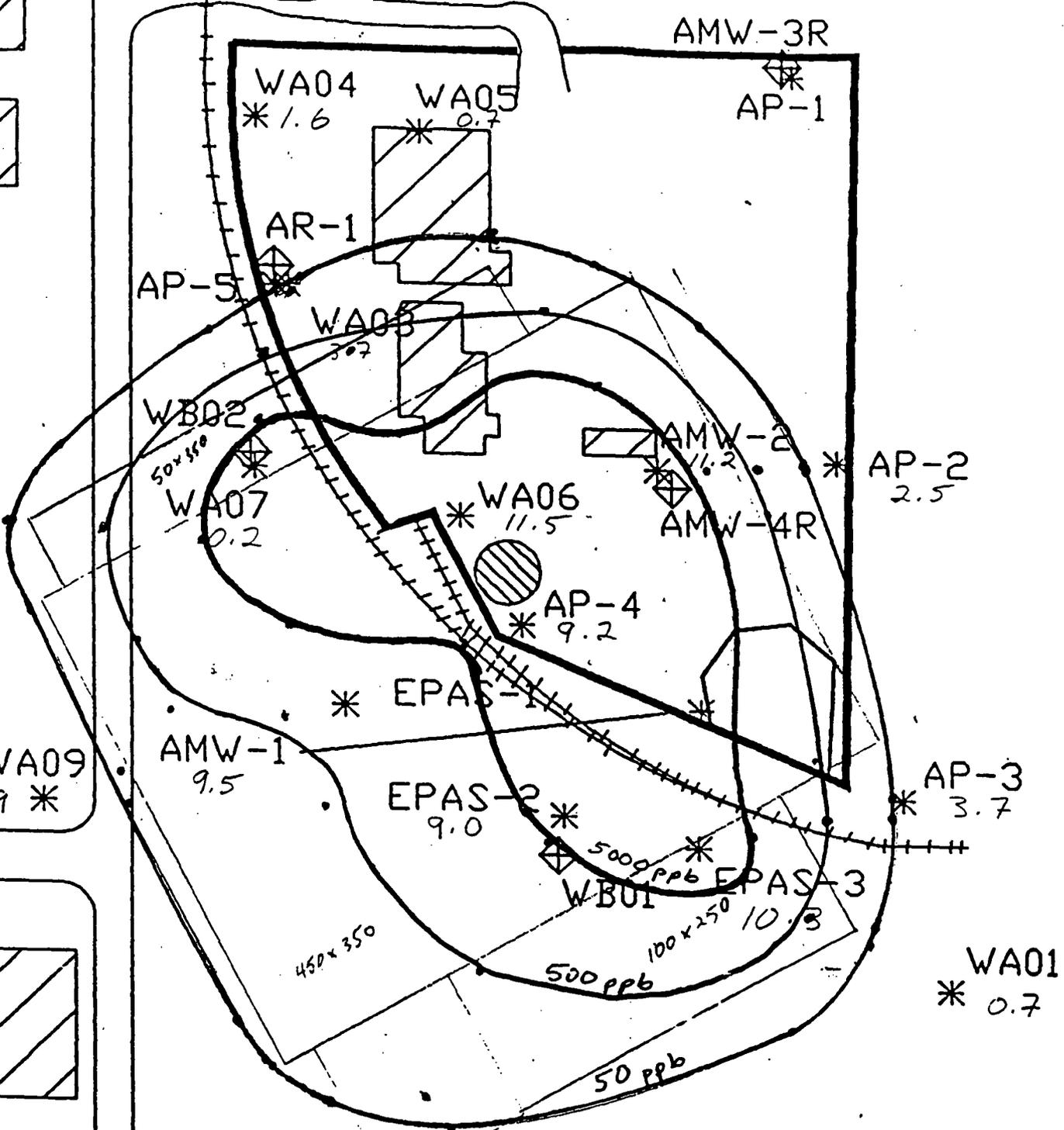
521,160 gal X (1/3.5x10⁶ gal/yr) = .15 yr

Estimated Cost:

- + Total operating and operator costs for the A-zone system ^{Per Year} over ten years:
~~\$1,950,000~~ + ~~\$1,680,000~~ = \$3,630,000 (based on 10 gpm system & ND in effluent)
\$ 290,000 + \$ 250,000 = \$ 540,000

1,2 DUCF
 BROWN & BRYANT COSTING
 NOTES

ln 50 = 3.9
 ln 500 = 6.2
 ln 5000 = 8.5



Porosity = .40
 thickness = .10 ft or 3 meters

11350 sq meters per pore volume
 (27,250,000 liters) / 244750 ft²
 (7,250,000 cals) 5.619 acres

BROWN & BRYANT COSTING NOTES

ON-SITE VS OFF-SITE ALTERNATIVES FOR SURFACE SOIL COMPARISON

1) On-site Treatment
Excavation, Soil Washing, Treatment of Rinseate using
UV/Oxidation

A) Excavation & Soil Washing Costs

Est. Cost = $\$115,333^1 / 80 \text{ CY}^2 = \$1450/\text{CY}$

B) UV/Oxidation

Est. Cost = treatment cost + capitol cost +
operating cost
= $\$65/1000\text{gal}^3 * 1250 \text{ gal}/\text{CY}^4 +$
 $\$119,000^5 + \$500/\text{day}^6 *$
 $\text{day}/1000\text{gal}^7 * 1250 \text{ gal}/\text{CY}$
= $\$81/\text{CY} + \$119,000 + \$625/\text{CY}$
= $\$710/\text{CY} + \$119,000$

C) Residual Off-site treatment and disposal cost

Est. Cost = $10\% * \text{total volume} * \text{off-site}$
disposal cost (see 2)

¹ Federal On-Scene Coordinator's Report; Brown & Bryant; 27 March - 27 August 1991; Appendix 1, page 7, ERCs estimated cost

² OSC Report (see Footnote 1), volume of soil treated was 80 cy

³ Design Test Report on the RAYOX Enhance Oxidation Treatment of Brown & Bryant EPA Superfund Site Arvin, Ca. Groundwater; Solarchem, June 1992; page 16

⁴ OSC report (see Footnote 1); Appendix 1, page 5; 100,000 total gals treated for 80 cy of soil = 1250 gal/cy

⁵ Solarchem report (See Footnote 3); page 12

⁶ Engineering Estimate for operator(s) of system

⁷ OSC Report (See Footnote 1); estimated from data given on page 10

2) Off-site treatment costs

A) Transportation Cost

B) Off-site Treatment and Disposal Cost

$$\text{Est. Cost} = \begin{array}{l} \$2000/\text{ton} * \text{ton}/2200 \text{ lbs} * 120 \\ \text{lbs}/\text{cf} * 27 \text{ cf}/\text{cy} \end{array}$$

=

3/09/93

MEMORANDUM

SUBJECT: SVE Costs
FROM: *Vance Fong*
Vance Fong, Treatment Engineer, H-9-3
TO: Dave Roberts, Remedial Project Manager, H-6-2
Acting for Cynthia Wetmore, B&B RPM, H-6-2
Tom Huetteman, Remedial Project Manager, H-6-2
cc: Greg Baker

Attached please find my detail cost estimates for a soil vapor extraction (SVE) system with vapor treatment suitable for remediation of the VOC contaminated soils in the unsaturated zone under the Sump Area at Brown and Bryant. These cost estimates are based on a 100'X100' area.

The cost estimates are also based on the assumption that the entrained water and/or residual liquid waste from the SVE system will be treated in an UV/oxidation unit which is a part of the remedy. The SVE system has extra capacity to remediate the Pond Area, if needed, with relatively small additional piping and vapor well costs.

Typical cleanup time will be from 6 months to 2 years. After rigorous SVE treatment, the system could be modified and converted to a long termed, low flow bioventing mode for further remediation of semivolatiles and dinoseb. The regenerable GAC unit would be available for other uses at that time (e.g. treatment off gas from air stripping of the B-zone ground water).

You will notice that the cost for pneumatic fracturing has been lowered. This is due to further cost information received from the developers.

Before a preliminary design is performed, these estimates remain to be approximations.

SVE Costs

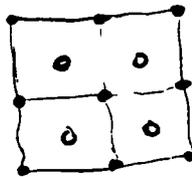
The following cost estimates for an SVE system is based on remediation of A zone soil under the Sump Area. Contaminated area required treatment is approximately 100'X100'. If SVE will be used for other areas at B&B, additional costs are expected.

Site characterization cost: has been completed	0
Plot test cost: accounted for in capital costs	0
Pneumatic fracturing (Region 9 estimate):	25,000
Capital costs	
+ Vapor Capture:	
* Extraction/injection well installation (30 feet deep wells with 4" ID SCH 40 PVC piping)	
4 extraction wells X \$3,000/well	12,000
9 injection wells X \$3,000/well	27,000
* impermeable surface seals	
Asphalt paving (2" layer) 100'X100'	
1110 yd ² X \$9.25/yd ²	10,300
* Ground water level control	0
(not needed for the sump area, perch water table is deeper - 65-70')	
+ Vapor Removal:	
* Vacuum pumps/blowers	
30 hp blower	6,000
* Piping	
SCH 40 PVC 6" OD pipes, 1000' X \$5.25/ft	5,250
* Valves/joints	5,000
* Mufflers	
* Operation control system/instrumentation	2,000
* Flame arrestor	1,000
+ Vapor treatment/emission control:	
* Air/water separator	2,000
(100 gal. knockout drum)	
* Entrained water & GAC bed regen liquid	1,000
(using existing UV/oxidation)	
* Soil vapor treatment	150,000
(regenerable beds)	
* Diffuser stack (carbon steel)	100
+ Other system requirements	
* Housing	8,000
* Concrete pad	1,000
* Soil gas probes	500
* Sampling ports	200
Design and engineering fees (10% of system costs)	23,000
Permit costs (vendor may need permit to operate SVE)	
Operation, maintenance, monitoring costs (rough):	100,000
* Power costs	
* Labor costs	
* System monitoring	
* Cleanup attainment sampling/analysis cost	
Total cost:	\$380,000

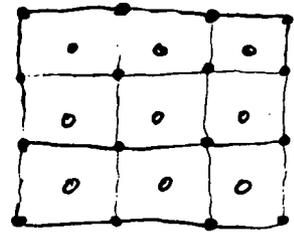
SVE COSTS

3-3-93

RRR



Sump



Waste Pond

CAPITAL

Vapor Capture

• Sump Area (100'x100')

4 extraction wells @ \$3,000 ea \$ 12,000

9 injection wells @ \$3,000 ea. \$ 27,000

Asphalt paving surface seal
(100'x100') (~~1.03~~) (\$1.03/ft²) \$ 10,000

49,000

• Pond Area (150'x150')

9 extraction wells @ \$3,000 ea \$ 27,000

16 injection wells @ \$3,000 ea \$ 48,000

Asphalt paving surface seal
(150'x150') (\$1.03/ft²) \$ 23,000

\$ 98,000

Vapor Removal

• Vapor Removal

Blower \$ 6,000

Piping ~~2,250'~~ 2,250' @ \$5.25/ft \$ 12,000

Valves & fittings \$ 11,000

Controls & instrumentation \$ 5,000

Flame arrester \$ 1,000

\$ 35,000

• Vapor Treatment

Air/water separator 2,000

Entrained water, GAC bed regen liquid 1,000

Soil vapor treatment (GAC beds) 150,000

153,000

• Other

Enclosure structure 8,000

Concrete pad 1,000

Misc. (soil gas probes, sampling ports) 1,000

10,000

Capital Sub-Total \$ 345,000

Design & Engineering (#10% of system cost) \$ 35,000

Capital Total \$ 380,000
~~total up-front~~ 60,000

Total Up-Front \$ 440,000

O & M (1 year) \$ 100,000

Pneumatic Fracturing

Sump Area

Pond Area

25,000

~~75,000~~

35,000

~~95,000~~

\$ 170,000

60,000

~~up-front total~~

~~\$ 550,000~~

3/9/93

DCR

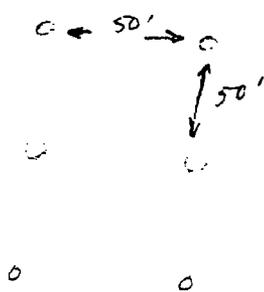
3/8/93

Cynthia Whitmore
Calculations

Nov. 5, 1992

Assume 25' radius of influence

- spacing = 50'



Area = 5.6 acres

$$\text{Area} = 5.6 \text{ acres} \times \frac{43560 \text{ sq. ft}}{\text{acre}} = 243,936 \text{ sq. ft.}$$

$$\text{Length} = \sqrt{243,936} \times \sqrt{243,936}$$
$$= 490' \times 490'$$

which means a grid of $\frac{490}{50} \times \frac{490}{50}$
 $\approx 9 \times 9$ to 10×10
81 to 100 wells

$$\text{Pore volume} = 3.142 \times (25)^2 \times 5 \times 0.4 \times 7.48 = 29,400 \text{ gal.}$$

$$\text{Time} = 29,400 \text{ gals} \times \frac{1}{0.1 \text{ gpm}} \times \frac{\text{hr}}{60 \text{ min}} \times \frac{\text{day}}{24 \text{ hr}} = 204 \text{ days.}$$

\therefore Ten pore volumes in 5-6 years

Note: If a design could be contemplated for a 75 foot spacing; the number of wells need would be 36 to 49 wells. The time would increase to 12 to 13 years.

MEMORANDUM

From: Ralph Lambert, Ecology & Environment, Inc.

To: Cynthia Wetmore/Tom Heutteman-EPA

Date: November 3, 1992

Subject: B&E Arvin, Aquifer/well properties

Using the values for variables as listed below I calculated the radius of influence of a pumping well in the A-zone two ways. When reviewing this information please keep in mind that the value for many of these variables are estimates only, also that the water bearing zone at B&E does not meet many of the conditions that these formula were based on.

1) Using the modified nonequilibrium equation of Cooper & Jacob for unconfined aquifers a value of 24.9 feet for the radius of influence (R) is calculated. The R in this case is defined as the point where 0.1 ft of drawdown occurs after 14 days of pumping at .1 gpm.

2) Using the equilibrium well equation the calculated value is:

16.1 ft assuming a three foot drawdown and an eight inch diameter well; or

28 ft with a four foot drawdown (8" well), or 21 ft in a six inch diameter well.

Q = pump rate at an est. 0.1 gpm (actually a little high based on the slug test results).

K = hydraulic conductivity of 4×10^{-4} cm/sec based on slug tests, also equal to 2.48 gpd/sqft.

b = Saturated thickness of the water bearing zone, est at 5 ft,

T = Transmissivity, = Kb = 42.4 gpd/ft,

t = time since pumping started = 14 days,

s = drawdown in feet at any point r, to define the radius of influence this was set = to 0.1 ft.,

r = distance in feet from where s is measured, defined as R here,

R = radius of influence in feet,

h = b-draw down, in #2 above draw down was first assumed to be 3 ft so $h = 5-3 = 2\text{ft.}$,

rw = effective radius of well in feet, calculations are given for both r = 3 and 4 inches (.25 and .33 ft.).

Some other comments to the prior estimator from the EPA;

Travel time and fluid velocity should include porosity in the calculation as follows: $Vel = Ki/n$ where i is the gradient and n is the formation porosity (Driscoll pg 93).

The volume of a right circular cylinder is $= \pi r^2 h n$ 7.48 or
 $= 3.142 * 20^2 * 15 * 0.4 * 7.48 = 19,800$ gallons.
where n or porosity is assumed to be 40% and 7.48 is a conversion
factor from cubic feet to gallons. At a pump rate of 0.1 gpm a
well could pump this volume of water in 130 days.

Using the Modified Nonequilibrium Equation (Cooper & Jacob) - for unconfined

$$\textcircled{1} \quad \Delta = \frac{264Q}{T} \log\left(\frac{0.3Tt}{r^2S}\right)$$

when $u < 0.05$, and $u = \frac{1.87r^2S}{Tt}$ (valid when $r < 9$ feet)

$$\textcircled{2} \quad \text{Solving } \textcircled{1} \text{ for } r^2 = \frac{0.3Tt}{S \cdot 10^{\frac{\Delta T}{264Q}}}$$

ck
Driscoll pg 218
219

where $Q =$ pump rate in gpm est at 0.1 gpm
 $T =$ transmissivity in gpd/ft², $T = kb = 4 \times 10^{-4} \text{ cm/s} (5 \text{ ft}) =$
 $t =$ time since pumping started in days, say 14 days
 $S =$ coefficient of storage, est/assumed to be 20% ie 0.2
 $\Delta =$ drawdown in ft at point r , for edge of influence let's say drawdown = 0.1
 $r =$ distance from well in ft where Δ is measured.

Conversion factor k to T

$$1 \text{ cm/s} = 2.121 \times 10^{-4} \text{ gpd/ft}^2$$

$$\text{so } 4 \times 10^{-4} (2.121 \times 10^4) = 8.48 \text{ gpd/ft}^2$$

$$\text{and } T = \frac{8.48 \text{ gpd/ft}^2}{\text{day ft}} (5 \text{ ft}) \text{ if } b = 5'$$

$$T = 42.4 \frac{\text{g}}{\text{day ft}}$$

Radius at point where drawdown = 0.1 ft after 2 weeks pumping at 0.1 gpm

$$r^2 = \frac{0.3 (42.4) 14}{(0.2) 10^{\frac{0.1 (42.4)}{264 \cdot 0.1}}} = \frac{178}{(0.2) 10^{-16}} = 615 \quad r = \underline{\underline{24.8 \text{ ft}}}$$

if we calculate $u = \frac{1.87 (24.8)^2 \cdot 0.2}{42.4 (14)} = 0.39$ since this is greater than

0.05 there are additional errors in this method.

Using The Equilibrium well equation (see Driscoll pg. 213)

$$③ \text{ of } Q = \frac{k(H^2 - h^2)}{1.055 \log \frac{r}{r_w}} \text{ and solving for } r$$

$$④ \quad r = r_w \sqrt{10 \frac{k(H^2 - h^2)}{Q 1.055}}$$

where $H = 6$, static saturated thickness in feet

$h = H - \text{drawdown, in feet}$, let's assume three ft drawdown, then $h = 2.5 - 3$

$r_w = \text{radius of well in feet}$. Assume that w/ filter pack $r = 4'' = 0.33'$

$$r = 0.33 \sqrt{10 \frac{8.48(8^2 - 2^2)}{(1) 1.055}} = 0.33 \sqrt{10 \frac{8.48(21)}{105.5}}$$

$$= \underline{\underline{16.1 \text{ ft}}} \text{ w/ } 3 \text{ ft drawdown}$$

$$\text{or } = 28 \text{ ft w/ } 4 \text{ ft drawdown or } 21 \text{ ft in } 6'' \text{ diam well}$$

$$\text{or } = 6.4 \text{ ft w/ } 2 \text{ ft } \quad \text{or } = 4.8 \text{ ft in } 6'' \text{ diam well}$$

↑
5" diam well

Other items

Travel time and velocity should include porosity in the formula. - fluid flow only takes place in the pore space.

ck. Driscoll pg. 83

$$\text{velocity} = \frac{k i}{n}$$

where i = gradient and n = porosity. The Tortuosity (how crooked the path is) will slow it down.

$$\text{Volume of a right circular cyl} = \pi r^2 h (n)$$

if $h = 5'$, $n = 40\%$, $r = 20$ feet

$$\sqrt{1.4^3} = 7.48 \text{ gal}$$

Then Vol for 1 well's area of influence (at 20') = 18,800 gal

at 0.15 gpm = 144.19 pday, this volume can be pumped in 130 days - one

Rick, call if you have questions,

Jim

Tabulated here are interest factor values when interest is compounded once each period. (If interest is compounded more or less frequently or if the continuous cash-flow assumption is present, refer to Chap. 3 and Appendix B or C.) The computational forms of the factors are given here.

Factor	Notation	Formula
Single-payment compound amount	$(F/P, i\%, n)$	$(1+i)^n$
Single-payment present worth	$(P/F, i\%, n)$	$\frac{1}{(1+i)^n}$
Sinking fund	$(A/F, i\%, n)$	$\frac{i}{(1+i)^n - 1}$
Uniform-series compound amount	$(F/A, i\%, n)$	$\frac{(1+i)^n - 1}{i}$
Capital recovery	$(A/P, i\%, n)$	$\frac{i(1+i)^n}{(1+i)^n - 1}$
Uniform-series present worth	$(P/A, i\%, n)$	$\frac{(1+i)^n - 1}{i(1+i)^n}$

$$\frac{1.1529}{0.1727} = 6.710$$

$$\frac{1.2597 - 1}{0.08} = \frac{0.2597}{0.08} = 3.246$$

TABLE A - 7

DISCRETE CASH FLOW
5.00% DISCRETE COMPOUND INTEREST FACTORS

SINGLE PAYMENTS			UNIFORM SERIES PAYMENTS				
N	COMPOUND AMOUNT F/P	PRESENT WORTH P/F	SINKING FUND A/F	COMPOUND AMOUNT F/A	CAPITAL RECOVERY A/P	PRESENT WORTH P/A	N
1	1.0500	0.9524	1.00000	1.000	1.05000	0.9524	1
2	1.1025	0.9070	0.48780	2.050	0.53780	1.8594	2
3	1.1576	0.8638	0.31721	3.152	0.36721	2.7232	3
4	1.2155	0.8227	0.23201	4.310	0.28201	3.5460	4
5	1.2763	0.7835	0.18097	5.526	0.23097	4.3295	5
6	1.3401	0.7462	0.14702	6.802	0.19702	5.0757	6
7	1.4071	0.7107	0.12282	8.142	0.17282	5.7864	7
8	1.4775	0.6768	0.10472	9.549	0.15472	6.4632	8
9	1.5513	0.6446	0.09069	11.027	0.14069	7.1078	9
10	1.6289	0.6139	0.07950	12.578	0.12950	7.7217	10
11	1.7103	0.5847	0.07039	14.207	0.12039	8.3064	11
12	1.7959	0.5569	0.06283	15.917	0.11283	8.8633	12
13	1.8856	0.5303	0.05646	17.713	0.10646	9.3936	13
14	1.9799	0.5051	0.05102	19.599	0.10102	9.8986	14
15	2.0789	0.4810	0.04634	21.579	0.09634	10.3797	15
16	2.1829	0.4581	0.04227	23.657	0.09227	10.8378	16
17	2.2920	0.4363	0.03870	25.840	0.08870	11.2741	17
18	2.4066	0.4155	0.03555	28.132	0.08555	11.6896	18
19	2.5270	0.3957	0.03275	30.539	0.08275	12.0853	19
20	2.6533	0.3769	0.03024	33.066	0.08024	12.4622	20
22	2.9253	0.3418	0.02597	38.505	0.07597	13.1630	22
24	3.2251	0.3101	0.02247	44.502	0.07247	13.7986	24
25	3.3864	0.2953	0.02095	47.727	0.07095	14.0939	25
26	3.5557	0.2812	0.01955	51.113	0.06955	14.3752	26
28	3.9201	0.2551	0.01712	58.403	0.06712	14.8981	28
30	4.3219	0.2314	0.01505	66.439	0.06505	15.3725	30
32	4.7649	0.2099	0.01329	75.299	0.06328	15.8027	32
34	5.2533	0.1904	0.01176	85.067	0.06176	16.1929	34
35	5.5160	0.1813	0.01107	90.320	0.06107	16.3742	35
36	5.7919	0.1727	0.01043	95.836	0.06043	16.5469	36
38	6.3855	0.1556	0.00928	107.710	0.05928	16.8679	38
40	7.0400	0.1420	0.00828	120.800	0.05828	17.1591	40
45	8.9350	0.1113	0.00626	159.700	0.05626	17.7741	45
50	11.4678	0.0872	0.00478	209.348	0.05478	18.2559	50
55	14.6356	0.0683	0.00367	272.713	0.05367	18.6335	55
60	18.6792	0.0535	0.00293	353.584	0.05283	18.9293	60
65	23.8399	0.0419	0.00219	456.798	0.05219	19.1611	65
70	30.4264	0.0329	0.00170	588.529	0.05170	19.3427	70
75	38.8327	0.0258	0.00132	754.654	0.05132	19.4850	75
80	49.5614	0.0202	0.00103	971.229	0.05103	19.5965	80
85	63.2544	0.0158	0.00080	1245.087	0.05080	19.6838	85
90	80.7304	0.0124	0.00063	1594.607	0.05063	19.7523	90
95	103.135	0.0097	0.00049	2040.694	0.05049	19.8059	95
100	131.501	0.0076	0.00038	2610.025	0.05038	19.8479	100