CDM Camp Dresser & McKee

Stead Solvent Site

Final – Record of Decision

July 21, 2000

Record of Decision

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1.0 Introduction

This document has been prepared based on the available federal guidance on the development of decision documents used to support the selection of remedial actions under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. This decision document, and the investigations and evaluations conducted in support of this decision document, were completed in a manner not inconsistent with the National Contingency Plan (NCP).

The purpose of the Record of Decision (ROD) document is to describe the technical parameters of the remedy, specifying the methods selected to protect human health and the environment including treatment, engineering, and institutional control components, as well as cleanup levels. In addition, the ROD document provides the public with a consolidated summary of information about the Stead Solvent Site (Site) and the chosen remedy, including the rationale behind the solution.

2.0 Declaration for the Record of Decision

Site and Location

Stead Solvent Site
Facility ID Number - D-001280
Operable Unit 1
Stead, Washoe County, Nevada (Figure 2-1)
Facility Identification Number: D-001280

Statement of Basis and Purpose

This decision document presents the selected remedial actions for the Stead Solvent Site (Site), Operable Unit 1 (OU1), located in Stead, Nevada. The remedial actions were selected in accordance with the requirements of the CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP under the direct guidance and supervision of the Nevada Division of Environmental Protection (NDEP). The selected remedial actions also were selected based on their adherence to NAC Section 445A.226 through 445A.22755. This decision document explains the factual and legal basis for selecting the remedy for the Site. NDEP concurs with the selected remedy.

The information supporting the remedial action decision, which is contained in the administrative record maintained at NDEP's offices in Carson City, are summarized in the attached Decision Summary.

Assessment of the Site

Hazardous substances at the Site, if not addressed by implementing the remedial actions selected in this ROD, may endanger the environment, public health, or welfare of the citizens of the State of Nevada.

Description of the Remedy

The remedial actions selected for OU1 of the Site (i.e., Alternative 5A from the Feasibility Study) include the following:

- Source Area Controls: The source area is the area where cancer risks associated with trichloroethene (TCE) in groundwater for future onsite construction workers range from 1×10^{-4} to 1×10^{-5}, (i.e., one additional cancer in an exposed population of 10,000 to 100,000 people). The selected remedial action is dual-phase extraction with treated discharge to the publicly owned treatment works (POTW).

- Plume Area Controls: The plume area is the area outside of the source areas where concentrations of TCE in groundwater are greater than the alternative concentration limit (ACL) of 37.5 micrograms per liter (µg/L). In this area, groundwater will be extracted to create a hydraulic barrier to contaminant migration. Extracted groundwater will be treated and discharged to the POTW enhanced with phytoremediation in selected areas where technically feasible and monitored natural attenuation. Implementation will be coordinated with Sierra Pacific Power Company's agency-approved aquifer management program.

- Institutional controls that currently exist include deed restrictions and zoning ordinances on the airport and for the surrounding properties. Fencing around treatment equipment, where appropriate, would be installed. In addition, Lemmon Valley is certificated for all groundwater use such that the State Engineer would not allow new production of groundwater for potable and non-potable uses. Any modifications to the institutional controls will require acceptance through the post-ROD modification process as defined in U.S. Environmental Protection Agency (EPA) guidance.

Implementation of the selected remedial actions will be performed in accordance with all applicable federal, state, and local requirements.

Declaration of Statutory Determinations

The selected remedies will meet the requirements for remedial actions set forth in CERCLA 121, 42 USC 9621 and NAC 445A Section 445A.226 through 445A.22755 in that they:

- Are protective of human health and the environment
- Attain a level or standard of control of the hazardous substances, pollutants and contaminants, which at least attain the legally applicable or relevant and appropriate requirements (ARARs) under the Federal, State, and local laws
- Are cost-effective
- Utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable
- Satisfy the statutory preference for remedies that employ treatment to reduce the toxicity, mobility, or volume of the hazardous substances, pollutants or contaminants at the site

Based on the applicable or relevant and appropriate regulations, the following findings have been made relative to the design, construction and operation of the selected remedy:

- Maximum contaminant levels (MCLs) may not be appropriate groundwater action or remediation levels given site conditions and the nature of the contaminants
- Alternative concentration limits (ACLs) as specified in Section 3.13 of this document will be used as the basis for design of the remedy

- Final groundwater clean-up standards will be in accordance with NAC 445A Sections 445A.226 through 445A.22755, as such sections exist as of the date of execution of this document, after appropriate monitoring and evaluations of the remedy have been performed.

According to CERCLA 121 and 42 USC 9621, this Record of Decision can be re-opened based on facts acquired in the future that indicate that there are significant differences between the physical system as characterized by the feasibility study and as may exist.

Allen Biaggi, Administrator NDEP — Date 8/8/00

3.0 Decision Summary

The Decision Summary provides an overview of the site characteristics, alternatives evaluated, and the analysis of those options. It also identifies the Selected Remedy and explains how the remedy fulfills statutory and regulatory requirements. Although some of the information in the Decision Summary is similar to that in the Declaration, this section discusses the topics in greater detail and provides the rationale for those "summary declarations."

3.1 Potentially Responsible Parties and Summary of Past Site Investigations

The Stead Solvent Site Feasibility Study (FS) is the culmination of 6 years of site investigations, environmental monitoring, risk assessment, and remedial alternative evaluation conducted on behalf of the Stead Funding Parties (comprised of the Airport Authority of Washoe County, City of Reno, Lear Entities, and the U.S. Army Corps of Engineers [COE]) working in close cooperation with NDEP. The FS has been prepared in accordance with the provisions of the Superfund Amendments and Reauthorization Act of 1986 (SARA), the CERCLA (42 USC 960.1, et seq.), and the NCP. Guidance was provided via EPA Office of Solid Waste and Emergency Response (OSWER) Directives or *Interim Guidance of Superfund Selection of Remedy* (EPA 1986) and EPA Guidance on Feasibility Studies Under CERCLA (EPA 1988).

3.2 Site Name, Location, and Brief Description

The Stead Solvent Site is located in the northwest portion of the former Stead Air Force Base (AFB). The base was constructed in the early 1940s. Prior to its construction, the area was primarily utilized for ranching. The site was operated as a military aviation facility until 1958. After 1958, the area was used as a military training facility, light aircraft airport, and for light industrial and manufacturing activities. Acreage from the original Stead AFB was gradually sold or deeded to various parties between 1958 and the present. The general location of the Stead Solvent Site is shown on Figure 2-1. A more detailed map of the Site, showing the location of monitoring wells, is provided as Figure 3-1.

3.3 Site History and Enforcement Activities

Solvent use on the Stead Solvent Site could extend back to 1944 when the AFB was constructed and used as a military facility. Bulk solvents were reportedly stored at the former military fuel depot structure located southwest of the intersection of Mt. Anderson Street and Alpha Avenue. In addition, small quantities of solvents were reportedly used at the two hangars at the north of the study area. Lear Fan, one of the post-military base industrial tenants with several facilities, may have used solvents in plating operations. Precision Rolled Products on Cocoa Avenue was cited by the NDEP for mishandling sludge containing 1,1,1-trichloroethane (1,1,1-TCA) on their property. Other facilities within the study area may also have used solvents in their operations (CDM 1994a).

Concerned over the possible risk from these chemicals to drinking water supplied from deep aquifers in the area, the Funding Parties established a cooperative effort to perform a site investigation and risk assessment. In April 1994, the Funding Parties entered into an Interim Agreement with NDEP and COE to facilitate definitive investigation of the site. The purpose of the Interim Agreement was to cooperatively perform an investigation of the suspected soil and groundwater solvent contamination affecting the site.

3.4 Community Participation

NDEP and the Funding Parties held two workshops in the Site area to: (1) inform the community and local governments of current Site status and upcoming activities, (2) answer questions and respond to concerns, and (3) distribute fact sheets and other Site information. The two workshops were held in the Stead area on July 15 and 29, 1999. Then, the public was permitted a 30-day public comment period, which was followed by a formal public meeting. The public meeting was held on August 12, 1999 and allowed the public to submit written comments on the selected remedy. Public documents including the FS can be found in NDEP's file and in the information repository maintained at the North Valleys/Peavine Branch of Washoe County Library.

3.5 Scope and Role of Operable Unit or Response Action

Based on the site investigation activities, a single operable unit, OU1, was identified for characterization and remedial action evaluation. Operable Unit 1 (OU1) is shown in Figure 3-1. OU1 includes only groundwater contained beneath the site that is contaminated with organic solvents. Soils and groundwater contaminated with constituents other than solvents contained within the operable unit are not included, with the following exceptions:

- Groundwater containing fuel related constituents in the MW-105 area
- Soils in the LDI-1A Area

These areas are considered to be areas of concern. Areas of concern (AOCs) are those areas within the influence of remedial actions that may be planned for OU1 but are not directly addressed by the planned actions.

A third AOC has also been identified adjacent to OU1. This AOC consists of tetrachloroethene (PCE) groundwater contamination found in a localized area just south of OU1.

3.6 Site Characteristics

Fuel-related and chlorinated solvent constituents have been detected in the groundwater beneath and in the vicinity of the site. Fuel-related constituents that have been detected include benzene, toluene, ethylbenzene, and xylenes (BTEX), ethylene dibromide (EDB), and various tentatively identified compounds (TICs), some of which are indicative of weathered or degrading fuel products. Chlorinated solvents detected beneath the site include tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1,2-trichloroethane (1,1,2-TCA), 1,1-dichloroethene (1,1-DCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), 1,1-dichloroethane (1,1-DCA), and 1,2-dichloroethane (1,2-DCA). Some of these chlorinated solvents are related to one another by biological and abiotic degradation.

Chemicals of potential concern (COPCs) at the Stead Solvent Site are those chemicals that have been detected above respective MCLs. Chlorinated solvents that are COPCs include PCE, TCE, 1,1,1-TCA, 1,1,2-TCA, 1,1-DCA, 1,2-DCA, and 1,1-DCE. Petroleum related compounds that are COPCs include benzene and EDB.

This section presents a brief, yet comprehensive overview of the Stead Solvent Site. Included are Sections on the following:

- Site Conceptual Model (SCM)
- Site Overview
- Sampling Strategy
- Sources of Contamination
- Extent of Contamination

3.6.1 Site Conceptual Model

The site conceptual model for a site describes potentially exposed population and illustrates potential exposure pathways for the site. Only exposure pathways that are complete and may contribute significantly to overall risk are evaluated quantitatively. For the Stead Solvent Site, the site conceptual model is presented as Figure 3-2.

3.6.2 Site Overview

The following sections describe the environmental setting at the Stead Solvent Site. Specifically, site physiography and surface features, meteorology, and surface water features are described in detail.

3.6.2.1 Physiography and Surface Features

The Stead Solvent Site is located within the 93-square-mile Lemmon Valley, northwest of Reno, Nevada. The valley is partially developed, with the Reno Stead Airport to the northeast of the intersection of Alpha Avenue and Mt. Anderson Street, vacant land to the northwest of the intersection, and light industrial operations south and southeast of the intersection (Figure 3-1). Housing developments are located approximately 1 mile west and 1/2 mile southeast of the site. The vacant land northwest of the intersection is covered by native vegetation, primarily consisting of rabbitbrush. The airport area consists of asphalt-covered ground and hangar structures. Southwest of the Alpha Avenue and Mt. Anderson Street intersection is the Michelin Warehouse building, which covers approximately 400,000 square feet. Near the southwest corner of the Michelin Warehouse is a former landfill, with a topographic relief of approximately 10 feet. The buildings southeast of the intersection of Alpha Avenue and Mt. Anderson Street are former Stead AFB structures that have been converted into light industrial operations.

3.6.2.2 Surface Water Features

Silver Lake and numerous other dry lakes in the valley are playa lake systems. These lakes contain seasonal water after high precipitation events and wet periods. The lakes contain Quaternary playa mud deposits, and are surrounded by Quaternary beach deposits. In the Pleistocene, the valley was filled by Lake Lemmon, which had a maximum surface area of 24 square miles and was up to 130 feet deep (Soeller 1978).

Another occasional surface water feature is stormwater runoff directed through unlined drainage ditches. The main channel runs east to west near MW-108, and then turns to the south following a line along a fault trace. At least one other storm drain originating on the airport tarmac, as shown on Figure 3-1, also drains to this main channel. Although soil permeabilities above the water table are low, perhaps impeding significant surface water infiltration. The storm drain channel system could have an important influence on the shallow flow system, especially beneath the Airport Authority property.

3.6.2.3 Meteorology

Lemmon Valley is in the rain shadow of the Sierra Nevada Range, and typically receives precipitation from eastward-moving storm systems that cross the mountains (Soeller 1978). The average annual precipitation is approximately 8 inches. Winter to spring monthly precipitation can be expected to be twice as much as during summer and fall months, with the maximum precipitation in January and approximately the minimum precipitation in August. Temperatures in the summer reach over 100 degrees in the afternoon, with common daily variations of approximately 50 degrees. Temperatures reach into the teens in winter months, but snow in the valley generally melts within a few days after falling (Soeller 1978).

3.6.2.4 Local Geology

The Stead Solvent Site is located in eastern Lemmon Valley, a structural depression filled with approximately 2,600 feet of unconsolidated to semiconsolidated lacustrine and alluvial deposits. These deposits typically consist of interbedded silts, clays, sands, and gravels. Numerous faults are present in Lemmon Valley with a principal north-to-south orientation. The U.S. Geological Survey (USGS) (1980), Nevada Bureau of Mines and Geology (NBMG) (1980), and Kleinfelder (1993) have identified an inferred fault, oriented north-to-south across the Site (see Figure 3-3). The inferred fault may be connected with surface-expressed faults further to the north and to the south approximately 1,100 feet west of Mt. Anderson Street (Figure 3-1). Previous investigators indicated that this fault may have formed an offset between lithologies to the east and west of the fault, which may affect the local hydrogeological system.

East of the fault, previous investigations identified lithologies in the shallow subsurface (<42 feet below ground surface [bgs]) that consisted primarily of interbedded sands, silts, and clays (Kleinfelder 1993). CDM also characterized site geology to a depth of up to 70 feet bgs. CDM identified lithologies that consist of interbedded sands, silty sands, and silts (USGS codes of SW, SM, and ML, respectively). Lithologies were generally coarser east of the fault, as opposed to lithologies west of the fault.

West of the fault, a consistent clay layer at approximately 20 to 25 feet bgs was encountered (Kleinfelder 1993). Soils at boring CDM-104, west of the fault, had a higher silt content than the other borings. This location was also noted as having a low permeability zone, which appeared to create a confining unit comprised mostly of silt from 28 to 56.5 feet bgs. This silt was harder and stiffer than silts encountered in other borings. Thin, slightly plastic silty clay layers at this location were also noted. CDM-104 may represent a different depositional environment. The area west of the fault may be more representative of a lacustrine depositional environment, and the area east of the fault, predominantly a fluvial depositional environment.

3.6.2.5 Local Hydrogeology

Lemmon Valley contains thick, unconsolidated alluvial deposits within the upper 120 feet of the shallow groundwater flow system. Within these deposits, a high degree of interbedding with stratigraphic units interfingering occurs. The interbedding consists of alluvial fan deposits, lake sediments (beach, forebeach, and lake deposits), and reworked sediments. Sediments consist of unconsolidated to partially cemented sands, silts, and clays.

The interbedded nature of the alluvial deposits make it possible for groundwater to flow beneath the site along preferentially horizontal bedding planes. Buried channels of more permeable sands could exist immediately adjacent to silty and clayey materials of significant lateral extent. This is important to note because the lithologic characteristics of the saturated zone may include more permeable "channels" or features that are in essence preferred pathways for groundwater flow, and therefore, contaminant migration. By their very nature, these small-scale features are difficult to characterize in the field. Just the same, these features may influence contaminant migration through the shallow groundwater flow field.

Although the groundwater beneath the site appears to occur at variable depths, the upper water bearing zone, referred to as the "A" horizon, appears to have continuity on a local scale beneath the site, based upon the potentiometric surface presented on Figure 3-4. This figure, presenting data collected synoptically from both the site and from the Dermody monitoring wells in February 1999, illustrates that groundwater east of the fault generally flows from east to west with an average hydraulic gradient of 0.002 feet per foot (ft/ft). However, a significant variation in the observed hydraulic gradient occurs in the vicinity of the inferred fault.

In addition, vertical gradients in the western portion of the site have been observed. Wells screened in deeper portions of the aquifer, the "B" and "C" horizon wells have shown a vertically downward trend in selected well nests.

3.6.3 Sampling Strategy

Contamination at the Stead Solvent Site was initially discovered during a 1989 pre-acquisition site assessment of former Union Pacific Realty property west of Mt. Anderson Street and south of Echo Avenue. Subsequent investigations, discussed below, expanded the area of known contamination.

December 1989 through June 1993: Dermody Properties (Dermody) of Reno, Nevada conducted a series of pre- and post acquisition environmental site assessments on property located in the southwest corner of the former Stead AFB. Dermody acquired the former Stead AFB property for warehouse and industry development, and this area is now known as the Silver Lake Business Center. The assessments included installation and sampling of approximately 40 monitoring wells, excavation of test pits, limited soil vapor sampling, and collection of groundwater samples using nonpermanent points. Limited hydraulic testing was completed during this time, and a groundwater remediation plan prepared.

July through August 1994: Phase I field investigation activities were conducted by Camp Dresser & McKee Inc. (CDM 1994a). The investigation activities included sampling and analysis of soil gas, subsurface soil, and groundwater, and limited hydrologic testing. The field activities and rationale for samplings were developed using the Scope of Work contained in the Interim Agreement. The field activities were also detailed in the project Work Plan (CDM 1994c) and Chemical Data Acquisition Plan (CDAP) (CDM 1994b), prepared in May 1994. The CDAP is a combination of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) specified in the CERCLA act of 1980.

May through July 1995: Phase II field investigations were conducted by CDM. The investigation activities included drilling seven pilot holes, using geophysical borehole techniques to differentiate saturated zone lithologies, installing 16 new monitoring wells, sampling each newly installed well twice, and collecting water levels both manually and with pressure transducers during the test pumping of the Silver Lake Water Distribution Company Water Supply Well No. 4 (SLWDC-4) water supply well.

April 1996: An intrinsic bioremediation analysis of the site was completed using the results from 31 groundwater samples. The groundwater samples were analyzed for dissolved oxygen, nitrate, ferrous iron, sulfate, methane, total organic carbon (TOC), and chloride concentrations. In addition, groundwater alkalinity, temperature, pH, and specific conductivity measurements were recorded.

April 28-29, 1997: Two deep monitoring wells, with depths of 121 feet bgs, were drilled in the vicinity of LDI-1A and MW-114A. The wells were designated as LDI-1B and MW-114B. They were installed in response to a NDEP directive to better define the vertical extent of contamination.

June 7-21, 1997: An aquifer test using a pumping well (MW-115A) and five observation wells (MW-101A, MW-101B, MW-28, MW-29, and MW-109A) was performed at the Stead Solvent Site. The test was conducted to obtain data on the hydraulic properties of the alluvial aquifer.

December 21, 1998 (Final Report): A pilot test of density-driven convection (DDC) and soil vapor extraction (SVE) remediation technologies was performed at the Stead Solvent Site. The pilot test was operated from late June 1998 until early October 1998 in the vicinity of the LDI-series wells. Based on the results of the test, both technologies appeared capable of effectively treating the types and levels of contaminants found in soil and groundwater at the site.

February 26, 1999 (Final Report): Five new monitoring wells were installed in December 1998. The wells were designated MW-112B, MW-116A, MW-116C, MW-117A, and MW-118A. The wells were installed as an effort to better define the horizontal and vertical extent of contamination downgradient of current monitoring points.

1994 to Present: Long-term monitoring has been completed at the Stead Solvent Site. Long-term monitoring activities and quality assurance are according to the Field Sampling Program and Quality Assurance Project Plan (CDM 1999).

3.6.4 Sources of Contamination

The distribution of the detected organic contaminants can provide insight into the nature and perhaps location of source areas. Similarly, the rate and direction of groundwater flow also help to characterize contaminant source locations. This discussion attempts to identify general source areas based upon contaminant "fingerprint" and the direction of groundwater flow.

Based upon the distribution of contamination discernable from current data, several potential sources appear to be influencing local groundwater quality. The chlorinated solvent sources can be differentiated by distinctive contaminant compositions, or fingerprints at various wells. Figure 3-5 presents a rough depiction of the different contaminant distribution that may be impacting the shallow groundwater flow system based upon the observations. The depiction was generated by circling groups of wells with similar contaminant fingerprints, which are linked by the observed groundwater hydraulics. Each "circle" potentially represents a different contaminant plume and, therefore, different potential source. These potential source areas are listed below.

1. The observed contaminant composition, and ratio of degradation parent to daughter products is similar for MW-12, MW-29, CDM-101, LDI-1A, MW-115A, and MW-117A. This similarity, plus the fact that these wells lie along a similar hydraulic flow line, suggests that these wells contain contamination emanating from the same source. The source appears to be located near the LDI well cluster

and contains elevated concentrations of TCE, 1,1,1-TCA, and perhaps 1,1-DCE (which could also be a degradation product).

2. MW-30 contains only trace levels (1.9 µg/L) of TCE, and high concentrations of 1,1-DCE and 1,1,1-TCA (40 and 11 µg/L, respectively). An industrial metals manufacturer, located east of Mt. Anderson Street and north of Cocoa Avenue, is reported to have used 1,1,1-TCA as a degreaser. This solvent was detected in trace concentrations (3.3 µg/L) in MW-13, approximately 450 feet directly downgradient of the facility.

3. MW-23 contains concentrations of TCE and its preferred degradation product *cis*-1,2-DCE (37 and 12 µg/L, respectively) and no 1,1,1-TCA. MW-23 is located approximately 400 feet west of the Cocoa Avenue and Mt. Anderson Street intersection.

4. MW-102A has a different source of contamination than the neighboring wells, such as MW-12, MW-29, and MW-101A, based on the lack of detected chlorinated solvent constituents at MW-102A other than TCE. The TCE source detected in MW-102A could contribute TCE to those concentrations observed in MW-101A, but it does not appear to be the source of all the TCE found in this area since MW-12 and MW-30 are upgradient and crossgradient of MW-102A.

5. MW-104B, located nearly 800 feet west of MW-101 on the other side of the fault, contains trace levels of 1,1,1-TCA and 1,1-DCE (4.6 and 9.3 µg/L, respectively), as well as chloroform. Groundwater quality in this well could be influenced by seasonal pumping at SLWDC #4. Pumping at SLWDC #4 may draw constituents east of MW-104 down to the "B" horizon in this area.

6. The chlorinated constituents observed at well nests MW-109 and MW-110 have been present at roughly the same ratios of TCE, 1,1-DCE, 1,1,1-TCA, and 1,1-DCA. Since MW-110 is hydraulically downgradient of MW-109, and contains lower concentrations of these constituents, it is likely that the same source of contamination impacts these wells. MW-109, the upgradient well between the two, is located approximately 400 feet west of the southwest corner of the airport tarmac.

7. CDM-105A is located on the southwest corner of the Airport Tarmac. CDM-105A contains BTEX indicative of weathered fuels. Fuel-related constituents were also detected at MW-113A, although most recent sampling has shown nondetectable concentrations of all constituents. These two wells may be related since CDM-105A is upgradient of MW-113A.

8. Fuel-related constituents detected in MW-102B and C, and MW-108B and C have consistent compositions and distributions, perhaps indicative of their relationship to a similar source. MW-102 is upgradient of MW-108B.

9. TCE and chloroform have been detected in MW-114A and MW-105B. MW-105B is located downgradient from MW-114. In addition, neither TCE nor chloroform have been detected in MW-105A. This may suggest that TCE and chloroform in MW-105B may have migrated from lateral groundwater flow, possibly from the area around MW-114A.

It is possible that additional diffuse source areas exist beyond those identified on this figure. It is also possible that wells that have been grouped together have been impacted by different sources. The grouping of wells and the preparation of this graphic emphasizes the large number of seemingly unrelated potential source areas that may exist at the Stead Solvent Site, and the general distribution of contamination relative to those potential sources.

3.6.5 Affected Media

Figures 3-6 and 3-7 show interpolated groundwater concentration contours for TCE and 1,1-DCE, respectively. These concentration contours were estimated based on analytical data from the May 1998 and December 1998 sampling events. The contour lines were used to estimate the area within identified concentration ranges. The volume of groundwater within the concentration ranges was estimated assuming a porosity of 0.4 and that constituents were within a 20-foot depth range. The mass of TCE and 1,1-DCE were estimated by assuming an average constituent concentration within each concentration range. Results are listed in Table 3-1 for TCE and Table 3-2 for 1,1-DCE. An estimated 308.2 pounds (25.2 gallons) of TCE and 55.7 pounds (5.5 gallons) of 1,1-DCE are within the aquifer at the Stead Solvent Site. The volume of COPCs other than 1,1-DCE and TCE is only a fraction of the 1,1-DCE and TCE volumes, and is generally co-located with 1,1-DCE and TCE. Therefore, only 1,1-DCE and TCE volumes were quantified.

3.6.6 Local Hydrology

The interbedded nature of the alluvial deposits make it possible for groundwater to flow beneath the site along preferentially horizontal bedding planes. Buried channels of more permeable sands could exist immediately adjacent to silty and clayey materials of significant lateral extent. This is important to note because the lithologic characteristics of the saturated zone may include more permeable "channels" or features that are in essence preferred pathways for groundwater flow, and therefore, contaminant migration. By their very nature, these small-scale features are difficult to characterize in the field. Just the same, these features may influence contaminant migration through the shallow groundwater flow field.

Although the groundwater beneath the site appears to occur at variable depths, the upper water bearing zone appears to have continuity on a local scale beneath the site, based upon the potentiometric surface presented on Figure 3-4. This figure, presenting data collected synoptically from both the site and from the Dermody monitoring wells in February 1999, illustrates that groundwater east of the fault generally flows from east to west with an average hydraulic gradient of 0.002 ft/ft.

However, a significant variation in the observed hydraulic gradient occurs in the vicinity of the inferred fault.

Groundwater flow directions on the east side of the fault are mainly to the west, with north or southward components. South of the Airport property line, there appears to be an east-west trending groundwater divide. The divide appears to be a persistent feature throughout different seasons of the year. North of the groundwater divide, groundwater flows from the southeast to northwest in the vicinity of CDM-101, MW-29, and MW-12. South of the divide, groundwater trends toward the southwest.

Water level time trends can be used to evaluate vertical gradients that may occur naturally. Significant downward gradients have been observed at selected areas at the site. For example, February 1999 water levels indicated a significant downward gradient at well nests MW-104, MW-111, MW-112, and MW-116, ranging from 2.3 feet to 16.5 feet. These observed vertical gradients were probably the result of a locally extensive aquitard and lower permeability or highly anisotropic materials interceding between screened zones, as opposed to indications of preferential flow pathways. Although there is currently a lack of vertical hydraulic conductivity data available to estimate the rate of vertical groundwater flow seepage, the possibility exists that vertical leakage does occur both during pumping and nonpumping conditions at SLWDC-4. However, the depositional environment and the interbedded nature of the aquifer materials seem to indicate that the majority of the groundwater flow will be horizontal through the saturated zone. Calculations of groundwater seepage rates, and subsequent estimates of contaminant migration potential, focus upon lateral flow within the shallow aquifer system.

3.6.7 Extent of Contamination

The discussion of the distribution of VOCs in the groundwater beneath the site has been focused to include only those constituents that are above maximum contaminant levels (MCLs), given concerns associated with the impact of site conditions on local public water supply wells, and those other constituents that have been determined to be important in helping to characterize contaminant fate and extent. The following figures were prepared to show the distribution of selected constituents:

Figure 3-6: TCE concentration contours
Figure 3-7: 1,1-DCE concentration contours

These figures and other site data were used to assist with the following observations:

- Chlorinated solvents are detected on both sides of the fault, but were above MCLs only on the east side and at MW-110A, MW-117A, and MW-104B.
- Fuel-related constituents were detected only on the east side of the fault.
- Chlorinated solvents were found at their highest concentrations in the "A" zone wells, decreasing in concentration with depth, except at MW-105 where TCE was

only detected in the "B" zone. (This observation assumes that MW-104A is screened above the shallow aquifer system and therefore represents a perched water zone.)

- Fuel-related constituents were generally detected at their highest concentrations below the "A" zone, except at MW-105 where benzene was only detected in the "A" zone.

- The TCE found in MW-102B and MW-102C is probably related to that found in MW-102A, given the elevated concentration of TCE found in the shallow well. Although the TCE concentration measured in MW-102A is not by itself indicative of contamination that might migrate due to density differences, the possibility exists that dissolved contaminants have migrated downward into the aquifer near MW-102 impacting MW-102B and MW-102C. It is also possible that this same contaminant migration process has impacted MW-101B.

- Given that MW-101B may have been impacted by contaminants migrating from near MW-102A or LDI-1A, and that MW-104B contained some of the constituents detected at MW-101A, it is possible that multiple, unrelated solvent spills and/or discharges have affected groundwater quality along this area, one superimposed on another.

- The chlorinated solvent plumes detected at well nests MW-101 and MW-102 appeared to be well bounded by the monitoring well network. The deepest wells ("C" horizon) at both of these locations contain concentrations below the MCLs, as do all downgradient wells (i.e., MW-108C and MW-104C).

- The fuel-related constituent plume detected at well nests MW-102 and MW-108 appears to be well defined horizontally, given that the MW-110, MW-109, and MW-104 well nests contained no detectable levels of benzene or EDB. However, MW-108C contained groundwater with benzene and EDB concentrations above MCLs.

- Chlorinated solvent concentrations detected in MW-109A, MW-109B, and MW-110A have not been well bound horizontally by the existing monitoring well network. TCE above the MCL has been detected in MW-109B, and 1,1-DCE above the MCL has been detected in all three monitoring wells. Neither MW-109C nor MW-110C had chlorinated solvent constituents concentrations above MCLs.

- MW-105B contained TCE above the MCL and trace amounts of carbon tetrachloride and chloroform. This well appears to have contained constituents that may have emanated from the area around MW-114.

3.7 Current and Potential Future Site and Resource Uses

The current Stead Solvent Site land use is light industrial and commercial. Future land uses are not expected to differ from current land uses.

3.8 Summary of Site Risks

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of the baseline risk assessment for the Stead Solvent Site using 1995 data and updated with 1997/1998 data. The summary of site risks includes identification of chemicals of concern, an exposure assessment, a toxicity assessment, and risk characterization. An ecological risk assessment was not completed because no receptors were identified as part of the OU1 area.

3.8.1 Identification of Chemicals of Concern

Tables 3-3 and 3-4 present the chemicals of potential concern (COPC) and exposure point concentrations, based on the 1995 data, for each of the COPC detected in groundwater and soil gas, respectively. Table 3-5 again shows the groundwater COPCs based on 1995 data with the range of concentrations detected, the frequency of detection (i.e., the number of times the chemical was detected in the samples collected at the site), the risk based concentration, and the carcinogen classification.

The COPCs were later re-evaluated based on data collected in 1997/1998. The re-evaluation was necessary because additional wells had been installed and maximum detected concentrations increased. Some of the additional wells were placed in what is now referred to as the source area.

To re-evaluate COPCs for the site, all chemicals positively detected in groundwater during sampling/analysis in 1997 and 1998 were extracted from the database and the maximum detected concentration for each of these chemicals determined. These maximum concentrations were then compared to maximum concentrations for the COPC selection performed with 1995 data, and if the new maximum was higher than the previously used maximum, the value was compared to MCLs. Only one new COPC is selected for the site based on exceedances of MCLs (Table 3-6). In 1997/1998, the maximum concentration of PCE significantly exceeded its MCL, while only very low concentrations of this chemical were detected in 1995. The highest concentrations of this chemical were found in MW-07, MW-01, and MW-1A.

Maximum concentrations for several COPCs increased in the 1997/1998 data set. For example, the maximum concentration of 1,1,1-TCA increased from 420 to 6,200 µg/L and that for TCE increased from 2,600 to 9,200 µg/L. Generally, these increases can be ascribed to higher concentrations of chemicals in monitoring wells that did not previously exist, especially well LDI-1A. Maximum concentrations of 5 of 8 COPCs for the site were found in this source area well. Maxima for two other chemicals, DBE and benzene also occurred in source area wells (MW-105A and MW-102B, respectively). Higher concentrations in source areas are not surprising, since concentrations of chemicals in such areas can be expected to vary significantly over short distances.

3.8.2 Exposure Assessment

The SCM, presented previously was used to determine reasonable exposure scenarios and pathways of concern. The scenarios and pathways were quantitatively analyzed for the Stead Solvent Site human health risk assessment and are listed below.

- Soil Gas Inhalation by a Future Onsite Worker
- Groundwater Dermal Contact by a Future Onsite Worker
- Volatilized COC from Groundwater by a Future Offsite Resident
- Groundwater Ingestion by a Future Offsite Resident
- Groundwater Dermal Contact by a Future Offsite Resident

Other potential exposure pathways were not considered because they were screened out for being incomplete or for not contributing significantly to overall risk.

Exposure assumptions for future onsite workers and future offsite residents are listed in Tables 3-7 and 3-8, respectively.

3.8.3 Toxicity Assessment

The purpose of the toxicity assessment is to evaluate the potential for each COPC to cause adverse effects in exposed individuals. Adverse effects include both noncarcinogenic and carcinogenic health effects in humans. This section explains how toxicity criteria for carcinogens and noncarcinogens are developed and expressed, and summarizes toxicity values for each COPC. The general basis for the development of toxicity values for carcinogens and noncarcinogens is presented in subsections 3.8.3.1 and 3.8.3.2, respectively, along with a summary of the toxicity values for all COPCs.

3.8.3.1 Carcinogens

EPA has developed a classification system for carcinogens to characterize the overall weight of evidence of carcinogenicity based on the availability of human, animal, and other supportive data.

- The quality of evidence from human studies

- The quality of evidence from animal studies

- Other supportive data that are assessed to determine whether the overall weight of evidence should be modified

EPA classification system for the characterization of the overall weight of carcinogenicity has the following five categories:

- **Group A - Human Carcinogen.** This category indicates that there is sufficient evidence from epidemiological studies to support a causal association between an agent and cancer.

- **Group B - Probable Human Carcinogen.** This category generally indicates that there is at least limited evidence from epidemiological studies of carcinogenicity to humans (Group B1) or that, in the absence of adequate data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

- **Group C - Possible Human Carcinogen.** This category indicates that there is limited evidence of carcinogenicity in animals in the absence of adequate data on humans.

- **Group D - Not Classified.** This category indicates that the evidence for carcinogenicity in animals is inadequate.

- **Group E - Evidence of Noncarcinogenicity to Humans.** This category indicates that there is evidence for noncarcinogenicity in at least two adequate animal tests in different species or in both epidemiological and animal studies.

Data from animal or epidemiological studies are used to determine slope factors, which are expressed as $(mg/kg\text{-}day)^{-1}$. The cancer slope factor (CSF) describes the increase in an individual's risk of developing cancer over a 70-year lifetime per unit of exposure where the unit of exposure is expressed as mg/kg-day. CSFs for carcinogenic COCs for the Stead Solvent Site are listed in Table 3-9.

3.8.3.2 Noncarcinogens

Reference doses (RfDs) are toxicity values developed by EPA for chemicals exhibiting noncarcinogenic effects. RfDs are usually derived from no-observable-adverse-effect levels (NOAELs) taken either from human studies, often involving workplace exposures, or from animal studies, and are adjusted downward using uncertainty or modifying factors.

The RfD is intended as an estimate of the daily exposure to a COC that would not cause adverse effects even if exposure occurs continuously over a lifetime. RfDs are presented in units of mg/kg-day for comparison with estimated chronic daily intake into the body. Intakes that are less than the RfD are not likely to cause adverse health effects. Chronic daily intakes that are greater than the RfD indicate a possibility for adverse effects. Whether such exposures actually produce adverse effects, however, is a function of a number of factors such as accuracy of uncertainty factors applied to the NOAEL, appropriateness of animal models used in studies extrapolated to humans, and potential for the chemical to cause effects in organs or systems (e.g., reproductive and immune systems) that have not been adequately studied. It is generally accepted, that protective assumptions made by EPA in deriving RfDs will, in most cases, mean that exposures slightly in excess of the RfD will be associated with a low risk for adverse effects, with the probability of adverse effects increasing with increasing exposure.

RfDs for COCs for the Stead Solvent Site are presented in Table 3-10.

3.8.4 Risk Characterization

In the risk characterization, chemical intakes calculated in the exposure assessment are combined with the toxicological criteria presented in the toxicity assessment to estimate carcinogenic risks and noncarcinogenic hazards for the Stead Solvent Site.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} * \text{CSF}$$

where: risk = A unitless probability of an individual's developing cancer
CDI = Chronic daily intake averaged over 70 years (mg/kg-day)
CSF = Cancer slope factor, expressed as $(\text{mg/kg-day})^{-1}$

These risks are probabilities that usually are expressed in scientific notation. An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period with a reference dose (RfD) derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient (HQ). An HQ <1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all chemicals of concern that affect the same target organ or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI <1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI >1 indicates that site-related exposures may present a risk to human health.

The HQ is calculated as follows:

$$\text{Noncancer HQ} = \text{CDI/RfD}$$

where: CDI = Chronic daily intake
RfD = Reference dose

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

The following tables summarize carcinogenic and noncarcinogenic risk for the specified scenarios:

Table 3-10	Carcinogenic risks for the future onsite construction worker were calculated for dermal exposure to groundwater and inhalation of ambient air.
Table 3-11	Carcinogenic risks for the future offsite residential scenario were evaluated for exposure from groundwater ingestion, dermal contact with groundwater, and inhalation of volatile chemicals during domestic use of groundwater.
Table 3-12	Noncarcinogenic exposures for the future onsite worker scenario were evaluated for dermal contact with groundwater and inhalation of ambient air.
Table 3-13	Noncarcinogenic hazard estimates for the future offsite residential scenario were evaluated for exposure scenarios included ingestion of groundwater, dermal contact with groundwater, and inhalation of COCs in groundwater.

Rather than recalculating risks based on the 1997/1998 data, the 1997/1998 data were used to estimate a range of risks based on average concentrations in wells across the site, and maximum detected concentrations. Average concentrations represent exposure concentrations that might apply to excavations that are widely distributed across the site. The maximum concentration might represent a larger excavation at a source area. Risks for other types of excavation would likely fall somewhere between these possibilities.

Average concentrations are estimated as the upper 95 percent confidence interval (UCL) of the arithmetic mean. UCLs are calculated assuming both normal and lognormal data distributions and the higher value used in risk calculations.

Toxicity criteria and exposure parameters are kept the same to allow comparison of past and current risk estimates. Exposure parameters for a future on site worker scenario (Table 3-7) were selected to provide a conservative, but realistic, estimate of upper range risks that could be incurred during excavation work. Thus, it is appropriate to continue to use these parameters in risk recalculations.

Cancer risks calculated from 1997/1998 data are somewhat higher than those estimated for the four wells used for the original calculations (Table 3-14). For example, average and maximal risks for exposure to TCE ranged from 1×10^{-9} to 2×10^{-6} using 1995 data (Table 3-11). Using the 1997/1998 data, average and maximal risks were estimated to be 9×10^{-7} and 8×10^{-6}, respectively. Total possible cancer risks for direct contact with groundwater are also slightly higher. Total risks range from 2×10^{-7} to 3×10^{-6} using 1995 data. Average and maximal risks using 1997/1998 data are 1×10^{-6} and 1.5×10^{-5}, respectively. Note that these risks do not include risks from exposure to ambient air (Table 3-11). Inhalation risks are estimated to be about 5×10^{-6} due mainly to exposure to 1,1-DCE. If these risks were included, total cancer risks (dermal contact and inhalation) for updated calculations would range from 6×10^{-6} to 2×10^{-5}.

All risks estimated fall within EPA's risk range of 1×10^{-6} to 1×10^{-4}. Significant risks to construction workers seem unlikely, unless a great deal of time is spent in excavations in the most contaminated areas.

Noncancer hazards calculated from 1997/1998 data for direct contact with contaminated groundwater are substantially higher than those previously estimated (Table 3-14). Most of these differences are due to the current availability of an interim reference dose for TCE. Hazard indices for the four wells assessed originally were all below 1, suggesting negligible risk for noncancer effects. However, the maximal hazard index for exposure to TCE alone exceeds one. Excavation in source areas could be associated with some hazard due to exposure to TCE.

Exposure point concentrations for future offsite residents in the original assessment were calculated using maximum detected concentrations of COPCs and simple conservative groundwater transport modeling between source areas and municipal well SLWDC-4. Risks associated with domestic use of water from this well were then estimated from modeled groundwater concentrations using exposure parameters from Table 3-8 and toxicity criteria from EPA (Table 3-9 and 3-10). To update these risks, it is reasonable to assume that exposure point concentrations at SLWDC-4 will vary in direct proportion to source area concentrations. That is, updated cancer risks or hazard indices can be calculated as:

> Updated Risk or HI = 1997/1998 maximum concentrations/1995 maximum concentration * 1995 cancer risk or HI

Although this calculation may not be completely accurate, the simple groundwater modeling used to predict SLWDC-4 concentrations in the future will be linear over the range of assumptions and concentrations discussed. Thus, for the level of sophistication of modeling used, the above calculation is acceptable.

Overall, cancer risks implied by new data suggest risks are somewhat lower than those predicted on the basis of the 1995 data (Table 3-15). The reduction in risk is due to the lower maximum concentration reported for 1,2-dibromoethane (EDB). EDB is assessed as a potent carcinogen and most of the risk associated with the future offsite resident scenario was due to this COPC in the original calculations. A significant reduction in EDB concentrations, then, result in an overall reduction in total cancer risks.

On the other hand, hazard indices increase somewhat when the newer data are used to update noncancer risk estimates (Table 3-16). This increase is due to the significantly higher maximum concentration reported for TCE in the 1997/1998 data set. Reference doses for TCE are relatively high and the significantly higher maximum detected concentration reported for 1997/1998 results in an HI of about 0.2 compared to 0.06 using 1995 data. This former value, however, is still significantly lower than the target hazard index of 1, suggesting little potential for adverse health impacts.

Risk and hazards due to exposure to PCE cannot be calculated using the above methods because PCE was not included as a COPC in the original assessment and no modeling of possible future concentrations of PCE in SLWDC-4 was completed. However, chemical and toxicology properties of PCE and TCE are not greatly different. For example, the oral RfDs for PCE and TCE are 0.01 and 0.006 mg/kg/d, and the oral slope factors are 0.052 and 0.011 $(mg/kg/d)^{-1}$, respectively. The maximum concentration of TCE is, however, more than 50 times higher than that for PCE (9,200 versus 170 µg/L). Thus, one expects that any risks or hazards due to exposure to PCE would be substantially less than those associated with exposure to TCE. Since the latter are at or below target risk levels, no significant risks are apparently implied by concentrations of PCE found in one source area.

3.8.5 Uncertainties Associated with the Risk Assessment

There is a degree of uncertainty associated with every step of the risk assessment. For example, there are uncertainties associated with the database, exposure assumptions, and the toxicity assessment have been identified. The following briefly describes the impact of uncertainties in the database, exposure assumptions and toxicity assessment on the final step of the risk assessment, risk characterization.

Uncertainties in the Database

Available data for the Stead Solvent Site are limited. Because it is feasible that actual chemical concentrations at the site are higher in some locations than concentrations already measured, it is possible that site-related risks may have been underestimated. However, this RA evaluates a "hot spot" scenario. By definition, a "hot spot" analysis will overestimate risks. This is likely to compensate significantly for any possible gaps in site data.

Uncertainties in Exposure Assessment

Uncertainties associated with exposure parameters may be significant, but exposures are unlikely to be underestimated. Parameters used by EPA to evaluate reasonable maximum exposure are intended to estimate exposures in the upper range of those possible.

Uncertainties in Toxicity Assessment

A large source of uncertainty is inherent in the derivation of EPA toxicity criteria (i.e., RfDs and cancer slope factors). The main sources of potential error in the derivation of toxicity criteria include extrapolation from animal data to humans and the assumption of linearity in carcinogenic dose response relationships. Safety factors are incorporated into EPA toxicity criteria, however, and they are generally considered more likely to overestimate than underestimate potential cancer and noncancer risk.

Uncertainties in Risk Characterization
For some COPCs, noncarcinogenic effects cannot be evaluated for all exposure pathways, because appropriate toxicological criteria are not available. Future offsite residents could not be evaluated for potential noncarcinogenic risks due to ingestion of and dermal contact with 1,2-DCE and benzene in groundwater, or for potential noncarcinogenic risks due to inhalation of 1,2-DCE, 1,1-DCE, 1,1,2-TCA, 1,2-dibromoethane (EDB), benzene, carbon tetrachloride, and TCE volatized from groundwater used domestically. For future onsite workers a subchronic exposure scenario is evaluated, and subchronic RfDs and RfCs are available for less than half of the chemicals evaluated. However, for some chemicals (1,1,1-TCA, 1,1,2-TCA, and TCE) chronic RfDs or RfCs are available. Screening of the CDIs for these chemicals against the RfCs showed that significant health effects from exposure to these chemicals are not expected. In addition, all of the chemicals that could not be evaluated for noncarcinogenic health effects are probable or known human carcinogens for which oral and inhalation slope factors are available. Carcinogenic effects of these chemicals are likely to outweigh any noncarcinogenic health effects. The uncertainty associated with lack of evaluation of some chemicals for noncarcinogenic effects is therefore considered small.

3.9 Remedial Action Objectives

RAOs are the formal statement of the overall objectives and goals for the site. Establishment of RAOs is the first step in the FS process. Since contaminated groundwater is the only media of concern at the site, the RAOs address only groundwater. RAOs for the Stead Solvent Site are listed below:

- Prevent ingestion and/or inhalation exposure from the use of or exposure to contaminated groundwater in excess of a 10^{-5} cancer risk.
- Prevent the distribution of groundwater for public water supply containing constituent concentrations above MCLs in violation of the Safe Drinking Water Act.
- Prevent the distribution of groundwater for irrigation or watering of livestock containing constituent concentrations in excess of toxic material standards listed in NAC Part 445A.144.

3.10 Remedial Action Goals (RAGs)

RAGs for the Stead Solvent Site were developed for areas with groundwater contamination above MCLs. NAC 445A.22735 indicates that the action level for groundwater must be established based on the Safe Drinking Water Act MCLs, background concentrations, or in the absence of an MCL, an appropriate level of concentration that is based on the protection of public health and safety and the environment. However, as stated previously, it may not be technically feasible or may require prohibitive costs to achieve the required remediation standard. Therefore, numerical goals for groundwater remediation were developed based on the RAOs to protect future onsite construction workers and offsite groundwater users.

3.11 Description of Alternatives

The objective of this section is to provide an explanation of all of the remedial alternatives initially considered for the Stead Solvent Site. The alternatives and major components are shown in Table 3-16. Table 3-17 presents a screening analysis of the initially considered alternatives. Alternatives with the most favorable composite evaluation based on effectiveness, implementability, and cost were retained for further consideration.

The nine alternatives were screened down to the five alternatives listed below.

1. Alternative 1: No Action
2. Alternative 4A: Dual-phase Extraction and Phytoremediation
3. Alternative 4B: SVE, Groundwater Recirculation, and Phytoremediation
4. Alternative 5A: Dual-phase Extraction, Hydraulic Containment to ACL, and Phytoremediation
5. Alternative 5B: SVE, Groundwater recirculation, Hydraulic Contamination to ACL, and Phytoremediation

Alternative 2 was screened because it would not likely meet the RAOs. Alternative 3 was screened for the same reason, since the low permeability and heterogeneous nature of the soils in the source area would not be conducive to air sparging operation for source removal compared to dual-phase extraction or groundwater recirculation. Alternatives 6A and 6B were screened since, compared to Alternatives 5A and 5B, they are more costly but do not provide a significant improvement in the probability of achieving the RAOs nor do they increase protectiveness of human health and the environment.

3.12 Comparative Analysis of Alternatives

The NCP identifies nine evaluation criteria to address technical and policy considerations that have proven to be important for selecting remedial alternatives. These criteria are described briefly below:

1. **Overall Protection of Human Health and the Environment**

   Alternatives are evaluated to determine whether they can adequately protect human health and the environment in both the short- and long-term from unacceptable risks posed by hazardous substances, pollutants or contaminants present at the site. Such protection can be provided by eliminating, reducing or controlling exposure to levels established during development of remedial goals.

2. **Compliance with ARARs**

   Alternatives are evaluated to determine whether they comply with all applicable or relevant and appropriate requirements or, if a waiver is required, how it is justified. Alternatives are analyzed for each phase of implementation, including:

   - Design
   - Construction
   - Start Up
   - Operation
   - Shut Down
   - Completion

3. **Long-Term Effectiveness and Performance**

   Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Also, the adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste are evaluated. Factors that are considered include the magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities.

4. **Reduction of Toxicity, Mobility, and Volume through Treatment**

   This criterion addresses the statutory preference for remedial actions that employ treatment technologies resulting in the permanent and significant elimination of toxicity, irreversible reduction in mobility, or a reduction in total mass or volume of contaminants. The percentage of expected reduction in toxicity, mobility, or volume, and the degree of treatment irreversibility are estimated. The type and quantity of treatment residuals are identified.

5. **Short-Term Effectiveness**

   The short-term impacts of alternatives are evaluated considering the short-term risks that might be posed to the community during implementation; the potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; the time until protection is achieved; the potential impacts on workers during remedial action; and the effectiveness and reliability of protective measures.

6. **Implementability**

   The ease or difficulty of implementing the alternatives are assessed by considering the technical and administrative feasibility of a technology. The technical feasibility includes difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. The administrative factors in this assessment include the availability of services and materials, including: the availability of adequate offsite treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists and provisions to ensure any necessary additional resources; and the availability of prospective technologies are also considered.

7. **Costs**

   A detailed cost analysis is performed that includes direct and indirect capital costs, direct and indirect O&M costs (annual and total), and present worth costs associated with the design and implementation of remedial actions. Estimates are based on standard cost data from various sources, including:

   - EPA
   - Construction Industry
   - Remedial Action Contractors
   - Vendors
   - Pilot Studies

   The accuracy of cost estimates at this stage in the FS, as per EPA guidance, range between -30 to +50 percent of the anticipated actual remediation costs. The present worth analysis evaluates the effects of O&M and periodic costs over the life of the project. Assumptions that are used include a 6.875 percent interest rate and a project life, which varies up to 30 years depending on the alternative and component within the alternative.

8. **Support Agency Acceptance**

   This criterion describes the state's preference of alternatives and will be completed for the most part after the state's FS comment period.

9. **Community Acceptance**

   This criterion reflects the preferences of the community and will be completed after the FS public comment period.

To establish priority among these criteria, they are divided into three groups. Overall Protection of Human Health and the Environment and Compliance with ARARs are threshold criteria and must be satisfied by the remedial action alternatives being considered. Criteria 3 through 7 are secondary, or balancing criteria, and are used to balance and compare alternatives that satisfy the primary criteria. Criteria 8 and 9, which are related to agency and community acceptance, are not evaluated during the FS. Instead, they were evaluated during the state and public comment periods and incorporated into the final alternative selection.

3.12.1 Alternative 1: No Action

Description

The No Action alternative is required by the CERCLA guidelines to serve as a baseline case for comparison with other alternatives. This alternative consists of implementing the existing long-term monitoring plan over a period of 30 years. Since no remedial action will be implemented under this alternative, a 30-year monitoring program is thought to be reasonable. Note that this alternative was designed specifically to require the expenditure of no capital costs. Therefore, no institution controls or SLWDC-4 contingency plan efforts are included in this alternative.

Long-Term Monitoring

The monitoring plan for Alternative 1 is consistent with the long-term monitoring plan that was finalized for the site in December 1998. The plan consists of the following:

- Measuring water levels at 70 monitoring wells on a semiannual basis
- Sampling 10 wells for VOC analysis on a semiannual basis
- Sampling 26 wells for VOC analysis on an annual basis
- Sampling 7 wells for bioparameters on an annual basis

Alternative Evaluation

Criterion 1 - Overall Protection of Human Health and the Environment. As discussed in the Risk Assessment, there are two exposure pathways that may be completed in the future that are of concern at this site — future onsite construction worker and future offsite users of groundwater produced from SLWDC-4. Based on the hazard indices, TCE presents an unacceptable risk to future construction workers above a concentration of 210 µg/L. If the groundwater contaminants contained in the plume areas are allowed to migrate unchecked toward SLWDC-4, concentrations in that well of TCE will exceed MCLs. Since the No Action alternative does not contain provisions to protect future onsite construction workers with source area remediation or institutional controls, or future offsite groundwater user with plume area remediation or institutional controls, this alternative is not considered to be protective of human health and the environment. Note that contaminants contained within the three AOCs are not addressed by the No Action alternative given its lack of proposed site controls and remedial actions.

Criterion 2 - Compliance with ARARs. This alternative does not achieve the chemical ARARs established for the site. Since this is a No Action alternative, there are no action-specific or location-specific ARARs to meet.

Criterion 3 - Long-Term Effectiveness and Permanence. The magnitude of residual risk associated with this alternative will remain high. The control to be implemented includes only monitoring. Implementing the monitoring plan as part of this alternative will allow continued determination of risks to human health and the environment associated with the groundwater contaminants, however, these risks will not be controlled or mitigated.

Criterion 4 - Reduction of Toxicity, Mobility, and Volume through Treatment. No reduction in contaminant toxicity, mobility, or volume is realized under this alternative.

Criterion 5 - Short-Term Effectiveness. Since no remedial actions would be implemented at the site, this alternative can not be considered to possess any short-term effectiveness.

Criterion 6 - Implementability. The implementability criteria, the availability of services and equipment and the ability to construct and operate, apply only to the monitoring activities associated with this alternative. Therefore, this alternative could be readily implemented.

Criterion 7 - Costs. The costs associated with implementation of Alternative 1 consist of groundwater sampling, analysis and reporting over a 30-year period.

Capital Costs	$0
Total Annualized Cost	$690,000
Present Worth Cost (6.875%)	**$690,000**

3.12.2 Alternative 4A

Description
This alternative uses dual-phase extraction to remove contaminants in source areas. Phytoremediation and monitored natural attenuation address contamination within the plume areas; and, institutional controls and long-term monitoring, which includes the SLWDC-4 contingency plan monitoring, manage future onsite and offsite risks. Each of these components are described in detail below.

Dual-Phase Extraction
Three dual-phase extraction systems are proposed, one for each source area. Although the three systems will have a different number of wells, five for Source Area 1, three for Source Area 2, and four for Source Area 3, it has been assumed for costing purposes that the same pumping and treatment system design can be used for each source area. Each system will consist of a pump, knockout tank, and off-gas treatment using vapor-phase carbon. Water from the knockout tanks will be pumped to a centrally located air stripper (with vapor-phase treatment of its off gas), treated and discharged. Note that discharge options for the treated groundwater are discussed in the subsection that follows.

Specifically, each system will use a 15-horsepower (hp) liquid ring pump capable of extracting up to 200 scfm at up to 28 inches of mercury. The pump discharge will be piped to a single 60-gallon knockout tank located next to the pump skid. The knockout tank will be drained by a 3-gpm automatic pump with piping to the air stripper. Extracted vapors from the knockout tank will be piped to two 1,000-pound carbon units piped in series. These units of carbon will be replaced as necessary as adsorption capacity is reached.

Treated Groundwater Discharge
Each of the retained alternatives, except the No Action alternative and Alternative 4B, requires that treated groundwater be discharged through a permitted outfall. Options for disposing treated groundwater include discharge to the sanitary sewer for POTW treatment, discharge to a local surface water feature (NPDES), or discharge, as recharge, to the local shallow aquifer (UIC). Discharge to a local surface water feature would include any alternative including spray irrigation. Under the POTW option, discharge will be to the sanitary sewer in the vicinity of the manhole located at Bravo and Mt. Anderson. A sanitary line takes the water from the manhole to the Truckee Meadows Water Reclamation Facility. This discharge is permitted by the City of Reno. Discharge to a local surface water feature requires a NPDES permit, and discharge to the local aquifer requires an UIC permit. Both the NPDES and UIC permits are administered by NDEP. All proposed discharge options are shown in Figure 3-8.

Costs for each discharge option were used to generate present worth costs for each remedial alternative that requires water discharge. Based on the cost comparison presented in Table 3-18, POTW discharge was selected as the discharge option for treated groundwater from pumping and/or dual-phase extraction wells for all retained alternatives.

Phytoremediation
The areas proposed for phytoremediation under this alternative (as well as Alternatives 4B, 5A, and 5B) have a depth to groundwater that is from 20 to 30 feet bgs (see Figure 3-9). Since this is the maximum depth that trees of the genus *Populus* (including poplars, cottonwoods, and aspens) should be used for contaminant removal from shallow groundwater, the design of the system and selection of the specific tree species used will need to address this condition. A drip irrigation system will be installed at each of the four phytoremediation areas. The trees will be irrigated as needed until such time as is determined that the root systems have reached the water table. Groundwater uptake will remove VOCs from the aquifer and will produce a seasonal inward gradient that will in aid in controlling the migration of remaining VOCs in the plume areas.

Institutional Controls
Institutional controls that currently exist include deed restrictions and zoning ordinances on the airport and for the surrounding properties. Fencing around treatment equipment, where appropriate, would be installed. In addition, Lemmon Valley is certificated for all groundwater use such that the State Engineer would not allow new production of groundwater for potable and non-potable uses. Any modifications to the institutional controls will require acceptance through the post-ROD modification process as defined in EPA guidance.

Table 3-19 summarizes the institutional controls for each of the retained alternatives.

Long-Term Monitoring/Monitored Natural Attenuation
Alternative 4A consists of dual-phase extraction as the remedial action addressing contamination in the source areas, and phytoremediation and monitored natural attenuation (MNA) as the remedial actions addressing the plume areas. To this end, long-term monitoring efforts will include the following:

- Monitoring the effectiveness of remediation in the source areas using dual-phase extraction
- Monitoring the effectiveness of phytoremediation in the plume areas
- Implementing the long-term monitoring program consistent with that currently being performed, as included in the No Action alternative, and supplemented as necessary for purposes of MNA
- Planning and implementing the SLWDC-4 contingency plan

To monitor the effectiveness of dual-phase extraction, it is anticipated that six new monitoring wells will be installed that are completed within the "A" horizon. Two wells will be installed downgradient of each of the three source areas. For the purposes of the monitoring plan, these new wells will be referred to as, "source area wells."

To monitor the effectiveness of the four phytoremediation areas, it is anticipated that three monitoring wells will be installed downgradient from three of the four phytoremediation areas. These wells will also be completed within the "A" horizon. MW-110A will be used to monitor phytoremediation downgradient of the fourth area. These wells will be referred to as, "plume area wells." Implementing the long-term monitoring program consistent with that program currently being performed is discussed in detail under the "no action" alternative. This program will be augmented to support MNA. MNA will require that eight additional wells beyond those that are currently being sampled in the long-term monitoring program be sampled for water levels and water quality parameters. Finally, planning and implementing the SLWDC-4 contingency plan will include capital costs for developing the plan as well as installing six new monitoring wells in three well nests west and northwest of MW-117A. These new monitoring wells will be called the SLWDC-4 "sentinel wells."

Costs associated with long-term monitoring under Alternative 4A were developed using the following assumptions:

- The six sentinel wells will be sampled for VOCs and water levels on a quarterly basis for 30 years.

- The six source area wells will be sampled for VOCs and water levels on a monthly basis for the duration of dual-phase extraction operations, plus 1 year (3 years total). Six monitoring wells in the vicinity of the source areas will be configured with continuous water level data recorders.

- The three plume area wells will be sampled for VOCs and bioparameters on a quarterly basis and for water levels on a monthly basis for 10 years. Three plume area wells will be configured with continuous water level data recorders.

- Long-term monitoring will consist of those components presented previously.

- The eight additional wells to be sampled to support MNA will be sampled semiannually for water levels, VOCs, and bioparameters. These wells will be sampled for 30 years.

- It is assumed that discharge to POTW will be used, therefore the discharge water will be sampled for VOCs on a semiannual basis.

Alternative Evaluation

Criterion 1 - Overall Protection of Human Health and the Environment. A reduction in the potential future risk of groundwater ingestion and dermal contact by offsite groundwater users would be achieved through this alternative since contaminated groundwater would be treated by the dual-phase extraction systems in the source areas and by phytoremediation and natural attenuation in the plume areas. The implementation of institutional controls restricting the use of and exposure to the shallow groundwater would also be protective of future onsite construction workers. However, some of the groundwater contamination within the plume areas would continue to migrate toward SLWDC-4 such that the level of desired protection for future offsite groundwater users is not likely to be achieved under this alternative. In addition, dual-phase extraction would remove contaminants from soils at the LDI-1A AOC.

Criterion 2 - Compliance with ARARs. Under this alternative, not all groundwater with contaminants present above their MCLs will be addressed by remedial action. Therefore, chemical-specific ARARs for the site will not be achieved under this alternative. In addition, this alternative does not comply with allowable waivers to chemical-specific ARARs, where waivers to the chemical-specific ARARs exist (e.g., ACLs). For those actions proposed under this alternative, all action-specific and location-specific ARARs will be met, expect one location-specific ARAR that specifies where "treatment works" may be sited. "Treatment works," as defined by the Bureau of Water Pollution Control would not apply to dual-phase extraction and air stripping systems in this ARAR will be addressed through a waiver with the state.

Criterion 3 - Long-Term Effectiveness and Permanence. The potential for further contaminant migration via groundwater would not be eliminated under this alternative. Long-term public health threats associated with future offsite users of groundwater would be reduced, however, this alternative will not achieve MCLs or ACLs within the source areas and portions of the plume areas due to the following reasons:

- No active groundwater remedial action is proposed to address all relevant portions of the plume areas.
- Continuous desorption of contaminants from dead soil pore spaces may continue to create undesirable dissolved contaminant concentrations in the groundwater.
- Presence of low permeability soil zones retaining or trapping the contaminants that slowly diffuse into groundwater may also continue to create undesirable dissolved contaminant concentrations in the groundwater.

These last two processes result in a tailing (leveling out) of groundwater contaminant concentrations over time within the source and plume areas. The concentrations at which the contaminants level out may exceed MCLs.

Criterion 4 - Reduction of Toxicity, Mobility, and Volume through Treatment. Extraction and onsite treatment of contaminated soil gas and groundwater via dual-phase extraction from the source areas will achieve a moderate reduction in contaminant mobility, toxicity, and volume. Phytoremediation and natural attenuation may also further reduce toxicity and volume, but since all contaminated groundwater is not being extracted or addressed with *in situ* treatment technologies (which are admittedly cost prohibitive), contaminant mobility will not be completely eliminated.

Criterion 5 - Short-Term Effectiveness. Small-scale construction activities during installation of the dual-phase extraction systems and during operation of these systems may result in the minimal release of volatilized contaminants and the installation of wells would produce additional noise during drilling. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in the construction areas and use of personal protection equipment by all personnel within the construction zones. It is assumed that Level D personal protection, with Level C as a contingency, would be used.

Criterion 6 - Implementability. Approximately 8 months would be required for design and contractor selection for the implementation of this alternative. Construction of the components of the alternative would require approximately 6 months. The dual-phase extraction systems would operate for a period of approximately 2 years, phytoremediation would operate for about 10 years, and the long-term monitoring activities are assumed to occur over a 30-year period.

The major engineering considerations required to implement the dual-phase extraction systems of this alternative include:

- Design, installation, and testing of the three skid mounted systems and air stripper
- Design, installation, and testing of the dual-phase extraction wells
- Monitoring requirements
- Clean up verification
- Well abandonment

The major engineering considerations to implement the system to treat groundwater extracted by the dual-phase extraction systems include:

- Design flow
- Siting and design of air stripper
- Siting and design of piping to and from air stripper including to the sewer line used for conveyance to the POTW
- Monitoring the effluent quality for POTW permit
- Design and implement vapor treatment from the air stripper
- Potential for fouling of the air stripper media

The major system components anticipated under this alternative include:

- Three skid-mounted dual-phase systems each including a liquid ring extraction blower, a moisture separator (i.e., knockout tank), activated carbon units, instrumentation, and a remote telemetry control unit
- One air stripper with activated carbon off-gas treatment
- Piping, fittings, and valves for fluids transport
- Electrical conduit and wiring for electric power
- *Populus* species trees for phytoremediation
- Piping for tree irrigation system

The major construction equipment and materials required to implement this alternative include:

- Contractor's temporary facilities and utilities
- Well drilling equipment
- Backhoe for trenching in piping
- Front end loader

Maintenance of the dual-phase extraction systems would be performed in accordance with O&M requirements developed after equipment specifications and procurement are completed. At a minimum, it is expected that regular periodic maintenance would be required on the dual-phase extraction blowers, the valves, and fittings of the piping systems, as well as replacement of vapor-phase activated carbon as required.

Criterion 7 - Costs. Costs associated with Alternative 4A are summarized below.

Capital Costs	$1,071,000
Total Annualized Costs	$1,669,000
Present Worth Cost (6.875%)	**$2,740,000**

3.12.3 Alternative 4B

Description

This alternative is identical to Alternative 4A with the exception that treatment in the three source areas is achieved by groundwater recirculation with SVE, rather than dual-phase extraction. Differences in the components between Alternatives 4A and 4B are discussed below.

Groundwater Recirculation/SVE

The groundwater recirculation systems have been laid out and costed based on the results of the pilot testing and upon PPC's experience with installing and operating DDC systems. Three systems will be used under this alternative, one at each of the source areas. A total of 12 recirculation wells will be installed, as shown in Figure 3-10. The wells at a given source area will be piped to a trailer that houses a blower, carbon canisters for vapor treatment, and a carbon dioxide tank (to prevent iron precipitation). It has been assumed that the groundwater production rate from each of the recirculation wells will be 5 gpm. This was the expected rate used to design the pilot test system, however the actual pilot test rate was approximately 1 gpm. The 5 gpm assumption allows for the possibility that the proposed wells would actually produce a higher flow rate than that observed in the pilot, as may be indicated from the available subsurface characterization data.

Long-Term Monitoring/Monitored Natural Attenuation

Long-term monitoring and MNA will occur much the same way under Alternative 4B as was discussed under Alternative 4A with the following exceptions:

- The source area wells to be installed to monitor the progress of the dual-phase extraction under Alternative 4A will be installed to monitor the performance of the groundwater recirculation remedial action. These wells will be sampled for VOCs and water levels exactly as was scheduled for Alternative 4A except they will be sampled for 5 years instead of 3 years (as was the situation under Alternative 4A).
- SVE pressure monitoring wells will be installed as part of Alternative 4B to be sampled on a biweekly basis over 2 years to monitor SVE system performance.

- No sampling of treated groundwater being discharged will be required because this option does not produce groundwater.

Alternative Evaluation

Criterion 1 - Overall Protection of Human Health and the Environment. A reduction in the potential future risk of groundwater ingestion and dermal contact by offsite groundwater users would be achieved through this alternative since contaminated groundwater would be treated by the dual-phase extraction systems in the source areas and by phytoremediation and natural attenuation in the plume areas. The implementation of institutional controls restricting the use of and exposure to the shallow groundwater would also be protective of future onsite construction workers. However, some of the groundwater contamination within the plume areas would continue to migrate toward SLWDC-4 such that the level of desired protection for future offsite groundwater users is not likely to be achieved under this alternative. In addition, soils containing organic solvent contamination in the LDI-1A AOC would be directly remediated by dual-phase extraction.

Criterion 2 - Compliance with ARARs. Under this alternative not all groundwater with contaminants present above their MCLs will be addressed by remedial action. Therefore, chemical-specific ARARs for the site will not be achieved under this alternative. In addition, this alternative does not comply with allowable waivers to chemical-specific ARARs where waivers to the chemical-specific ARARs exist (e.g., ACLs). For those actions proposed under this alternative, all action-specific and location-specific ARARs will be met, expect one location-specific ARAR (which specifies where treatment works may be sited) that will be addressed through a waiver with the state.

Criterion 3 - Long-Term Effectiveness and Permanence. The potential for further contaminant migration via groundwater would not be eliminated under this alternative. Long-term public health threats associated with future offsite users of groundwater would be reduced, however, this alternative will not achieve MCLs or ACLs within the source areas and portions of the plume areas due to the following reasons:

- No active groundwater remedial action is proposed to address all relevant portions of the plume areas.
- Continuous desorption of contaminants from dead soil pore spaces may continue to create undesirable dissolved contaminant concentrations in the groundwater.
- Presence of low permeability soil zones retaining or trapping the contaminants that slowly diffuse into groundwater may also continue to create undesirable dissolved contaminant concentrations in the groundwater.

These last two processes result in a tailing (leveling out) of groundwater contaminant concentrations over time within the source and plume areas. The concentrations at which the contaminants level out may exceed MCLs.

Criterion 4 - Reduction of Toxicity, Mobility, and Volume through Treatment. Extraction and onsite treatment of contaminated soil gas and groundwater via groundwater recirculation and SVE at the source areas will achieve a moderate reduction in mobility, toxicity, and volume of site contaminants. Phytoremediation and natural attenuation will also further reduce toxicity and volume, but since all contaminated groundwater is not being extracted or addressed with *in situ* treatment technology (which are admittedly cost prohibitive), contaminant mobility will not be completely eliminated.

Criterion 5 - Short-Term Effectiveness. Small-scale construction activities during installation of the groundwater recirculation and SVE systems and during operation of these systems may result in the minimal release of volatilized contaminants and the installation of wells would produce additional noise during drilling. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in the construction areas and use of personal protection equipment by all personnel within the construction zones. It is assumed that Level D personal protection, with Level C as a contingency, would be used.

Criterion 6 - Implementability. Approximately 8 months would be required for design and contractor selection for the implementation of this alternative. Construction of the components of this alternative would require approximately 6 months. The groundwater recirculation systems would operate for a period of approximately 5 years and the long-term monitoring activities are assumed to occur over a 30-year period.

The major engineering considerations to implement the groundwater recirculation and SVE systems of this alternative include:

- Design, installation, and testing of the three trailer-based groundwater recirculation systems
- Design, installation, and testing of the groundwater recirculation wells
- Design and installation of three SVE blower systems
- Monitoring requirements
- Clean up verification
- Well abandonment

The major system components anticipated under this alternative include:

- Three trailer-based groundwater recirculation systems each including an injection blower, an extraction blower, a moisture separator, activated carbon units, carbon dioxide tank (for scale prevention) and piping, and a remote telemetry control unit

- Three skid-mounted SVE blower systems with activated carbon off-gas treatment

- One air stripper with activated carbon off-gas treatment

- Piping, fittings, and valves for fluids transport

- Electrical conduit and wiring for electric power

- *Populus* species trees for phytoremediation

- Piping for tree irrigation system

The major construction equipment and materials required to implement this alternative include:

- Contractor's temporary facilities and utilities
- Well drilling equipment
- Backhoe for trenching in piping
- Front end loader

Maintenance of the groundwater recirculation and SVE systems would be performed in accordance with O&M requirements developed after equipment specifications and procurement are completed. At a minimum, it is expected that regular periodic maintenance would be required on the groundwater recirculation extraction blowers, the valves and fittings of the piping systems, as well as replacement of vapor-phase activated carbon as required.

Criterion 7 - Costs. Costs associated with Alternative 4B are summarized below.

Capital Costs	$1,107,000
Total Annualized Costs	$2,057,000
Present Worth Cost (6.875%)	**$3,164,000**

3.12.4 Alternative 5A

Description
This alternative is identical to Alternative 4A with the addition of a groundwater extraction system to maintain hydraulic containment of groundwater within the plume areas at a TCE ACL. This discussion presented below details those components that are not contained in Alternative 4A but are contained in Alternative 5A.

Groundwater Extraction System
In this alternative, groundwater will be extracted from the plume areas through a configuration of wells designed to contain and treat all groundwater north of Bravo

Avenue above a TCE of 37.5 ppb. The layout of the groundwater extraction system design is presented in Figure 3-11. Details related to other hardware associated with the groundwater extraction system are provided below.

The hardware associated with this alternative includes the requisite equipment to remove the groundwater from the extraction wells, convey they groundwater to the treatment system, treat the groundwater, and discharge the treated groundwater to the POTW. Submersible pumps would be placed in each extraction well, controlled from a single master control panel. All pump discharges will be manifolded and conveyed to the air stripper for treatment. The system will include nine pumping wells rated at about 0.28 gpm each for a total extraction rate of approximately 2.5 gpm.

The shallow tray air stripper will have capacity to treat between 0.5 and 12 gpm to accommodate fluctuations in flow rate from the various systems. A 1½-hp blower with a maximum capacity of 80 scfm will be used to provide an air/water ratio of approximately 40:1. The air stripper treated water under this alternative will be discharged to the POTW. The air stripper system has been located as shown in Figure 3-11 due to the location's proximity to the sanitary sewer discharge point and to centralize it with a dual-phase extraction system for Source Area 3.

Under this alternative, the extracted groundwater will be combined with the groundwater stream from the three dual-phase extraction systems, resulting in a total flow of approximately 8.5 gpm. However, it is estimated that the dual-phase extraction systems will only operate for 2 years, whereas the groundwater extraction system is assumed to operate for 30 years. Therefore, the VOC treatment system must have the ability to treat the expected range of flows over the 30-year design life. Note that based on monitoring results collected during operations, it may be possible to "turn off" the groundwater extraction system prior to the 30-year time horizon identified above. Once the source areas have been remediated in an estimated 2 years, it is possible that concentrations of COPCs in extracted groundwater by the containment system may decline and become asymptotic. Under this scenario, the operational period for the system may be significantly less than 30 years. This possible reduction in time of operation could significantly impact expected remediation costs. Thirty years was used in these analyses to represent the time of operations in lieu of explicit site-specific data.

Long-Term Monitoring/Monitored Natural Attenuation
Long-term monitoring and MNA will occur much the same way under this alternative as was defined for Alternative 4A with the following exceptions:

- Eight existing monitoring wells will be equipped with continuous water level recording devices.

- Eight additional monitoring wells will be sampled monthly for water levels and quarterly for VOCs during the first 3 years of operations, and semiannually thereafter, for up to 30 years.

Alternative Evaluation

Criterion 1 - Overall Protection of Human Health and the Environment. A reduction in the potential future risk of groundwater ingestion and dermal contact would be achieved through this alternative since contaminated groundwater would be treated by the dual-phase extraction systems in the source areas and by phytoremediation and natural attenuation in the plume areas. The implementation of institutional controls restricting the use of and exposure to the shallow groundwater would also be protective of future onsite construction workers. The groundwater extraction system was designed to contain and capture all groundwater containing TCE above the ACL such that future offsite users of groundwater are protected. Therefore, this alternative achieves the appropriate level of protectiveness, consistent with the RAOs. In addition, the hydraulic containment system would remove contaminants from the MW-105 AOC, and dual-phase extraction would remove contaminants from LDI-1A soils.

Criterion 2 - Compliance with ARARs. All chemical-specific ARARs are achieved under this alternative, with the exception of those areas where groundwater containing contaminant concentrations above MCLs are not contained or captured. Under both state and federal regulations, which are relevant and appropriate, a waiver is allowed for use of ACLs, in place of MCLs, if MCLs are not technically feasible and/or are cost-prohibitive to attain, and an ACL can be developed that is adequately protective of human health and the environment. This alternative complies with the requirements of the ACL waiver. For those actions proposed under this alternative, all action-specific and location-specific ARARs will be met, except one location-specific ARAR which specifies where "treatment works" may be sited. "Treatment works," as defined by the Bureau of Water Pollution Control, would not apply to dual-phase extraction and air stripping systems and this ARAR will be addressed through a waiver with the state.

Criterion 3 - Long-Term Effectiveness and Permanence. The potential for further contaminant migration via groundwater would not be completely eliminated under this alternative, however, long-term public health threats associated with groundwater ingestion, inhalation and dermal contact would be reduced to within acceptable levels.

Criterion 4 - Reduction of Toxicity, Mobility, and Volume through Treatment. Extraction and onsite treatment of contaminated soil gas and groundwater via dual-phase extraction at the source areas will achieve a moderate reduction in mobility, toxicity, and volume of contaminants in OU1 and the LDI-1 AOC. Groundwater extraction, phytoremediation, and natural attenuation will also further reduce toxicity and volume, but since all contaminated groundwater is not being extracted, contaminant mobility will not be completely eliminated.

Criterion 5 - Short-Term Effectiveness. Small-scale construction activities during installation of the dual-phase extraction and hydraulic containment systems and during operation of these systems may result in the minimal release of volatilized contaminants and the installation of wells would produce additional noise during drilling. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in the construction areas and use of personal protection equipment by all personnel within the construction zones. It is assumed that Level D personal protection, with Level C as a contingency, would be used.

Criterion 6 - Implementability. Approximately 9 months would be required for design and contractor selection for the implementation of this alternative. Construction of the components of the alternative would require approximately 10 months. The dual-phase extraction systems would operate for a period of approximately 2 years, the hydraulic containment system for 30 years and the long-term monitoring activities are also assumed to occur over a 30-year period.

The major engineering considerations to implement the dual-phase extraction systems of this alternative include:

- Design, installation, and testing of the three skid mounted systems
- Design, installation, and testing of the dual-phase extraction wells
- Monitoring requirements
- Clean up verification
- Well abandonment

The major engineering considerations to implement the groundwater extraction system include:

- Design, installation, and testing of extraction well system
- Potential for well plugging (reduction in flow) over time
- Monitoring requirements
- Containment verification
- Well abandonment

The major engineering considerations to implement the system to treat groundwater extracted by the dual-phase extraction and hydraulic containment systems include:

- Design flow

- Siting and design of air stripper

- Siting and design of piping from air stripper to the sewer line used for conveyance to the POTW

- Monitoring the effluent quality for POTW permit

- Design and implement vapor treatment from the air stripper

- Potential for fouling of the air stripper media

The major system components anticipated under this alternative include:

- Three skid mounted dual-phase systems each including a liquid ring extraction blower, a moisture separator, activated carbon units, instrumentation, and a remote telemetry control unit

- Eight submersible groundwater pumps and controllers

- One air stripper with activated carbon off-gas treatment

- Piping, fittings, and valves for fluids transport

- Electrical conduit and wiring for electric power

- *Populus* species trees for phytoremediation

- Piping for tree irrigation system

The major construction equipment and materials required to implement this alternative include:

- Contractor's temporary facilities and utilities
- Well drilling equipment
- Backhoe for trenching in piping
- Front end loader

Maintenance of the dual-phase extraction systems would be performed in accordance with O&M requirements developed after equipment specifications and procurement are completed. At a minimum, it is expected that regular periodic maintenance would be required on the dual-phase extraction blowers, the valves and fittings of the piping systems, as well as replacement of vapor-phase activated carbon as required.

Criterion 7 - Costs. Costs associated with Alternative 5A are summarized below.

Capital Costs	$1,614,000
Total Annualized Costs	$3,217,000
Present Worth Cost (6.875%)	**$4,831,000**

3.12.5 Alternative 5B

Description

This alternative is identical to Alternative 4B with the addition of a groundwater extraction system to maintain hydraulic containment of groundwater within the plume areas at a TCE ACL exactly as described for Alternative 5A. All components of this alternative have been described for other alternatives. Long-term monitoring/ MNA is described below for completeness. As with Alternative 5A, it was assumed for these detailed analyses that groundwater extraction would continue for 30 years. It is possible, however, based on monitoring results collected during system operation that the extraction system could be turned off prior to a 30-year time horizon. This possible reduction in time of operation could significantly impact expected remediation costs. Thirty years was used in these analyses to represent the time of operations in-lieu of explicit site-specific data.

Long-Term Monitoring/Monitored Natural Attenuation

Long-term monitoring and MNA will occur much the same way under this alternative as was defined for Alternative 4B with the following exceptions:

- Eight existing monitoring wells will be equipped with continuous water level recording devices.
- Eight additional monitoring wells will be sampled monthly for water levels and quarterly for VOCs during the first 3 years of operations, and semiannually thereafter, for up to 30 years.

Alternative Evaluation

Criterion 1 - Overall Protection of Human Health and the Environment. A reduction in the potential risk of groundwater ingestion and dermal contact would be achieved through this alternative since contaminated groundwater would be treated by the dual-phase extraction systems in the source areas and by phytoremediation and natural attenuation in the plume areas. The implementation of institutional controls restricting the use of and exposure to the shallow groundwater would also be protective of future onsite construction workers. The groundwater extraction system was designed to contain and capture all groundwater containing TCE above the ACL such that future offsite users of groundwater are protected. Therefore, this alternative achieves the appropriate level of protectiveness, consistent with the RAOs. In addition, operation of the hydraulic containment system would remove contaminants from the MW-105 AOC, and groundwater recirculation and SVE would remove contaminants from LDI-1A soils.

Criterion 2 - Compliance with ARARs. All chemical-specific ARARs are achieved under this alternative, with the exception of those areas where groundwater containing contaminant concentrations above MCLs are not contained or captured. Under both state and federal regulations, which are relevant and appropriate, a waiver is allowed for use of ACLs, in place of MCLs, if MCLs are not technically feasible and/or are cost-prohibitive to attain, and an ACL can be developed that is adequately protective of human health and the environment. This alternative complies with the requirements of the ACL. For those actions proposed under this alternative, all action-specific and location-specific ARARs will be met, except one location-specific ARAR (which specifies where treatment works may be sited) that will be addressed through a waiver with the state.

Criterion 3 - Long-Term Effectiveness and Permanence. The potential for further contaminant migration via groundwater would not be completely eliminated under this alternative, however, long-term public health threats associated with groundwater ingestion, inhalation and dermal contact would be reduced to within acceptable levels.

Criterion 4 - Reduction of Toxicity, Mobility, and Volume through Treatment. Extraction and onsite treatment of contaminated soil gas and groundwater via groundwater recirculation and SVE at the source areas will achieve a moderate reduction in mobility, toxicity, and volume of contaminants in OU1 and the LDI-1 AOC. Groundwater extraction, phytoremediation, and natural attenuation will also further reduce toxicity and volume, but since all contaminated groundwater is not being extracted, contaminant mobility will not be completely eliminated.

Criterion 5 - Short-Term Effectiveness. Small-scale construction activities during installation of the groundwater recirculation/SVE and hydraulic containment systems and wells and during operation of these systems may result in the minimal release of volatilized contaminants and the installation of wells would produce additional noise during drilling. Therefore, health and safety requirements while implementing this alternative would include periodic monitoring of organic vapors in the construction areas and use of personal protection equipment by all personnel within the construction zones. It is assumed that Level D personal protection, with Level C as a contingency, would be used.

Criterion 6 - Implementability. Approximately 9 months would be required for design and contractor selection for the implementation of this alternative. Construction of the components of the alternative would require approximately 10 months. The groundwater recirculation systems would operate for a period of approximately 5 years while hydraulic containment system operations and the long-term monitoring activities are assumed to occur over a 30-year period.

The major engineering considerations to implement the groundwater recirculation and SVE systems of this alternative include:

- Design, installation, and testing of the three trailer-based groundwater recirculation systems
- Design, installation, and testing of the groundwater recirculation wells

- Design and installation of three SVE blower systems
- Monitoring requirements
- Clean up verification
- Well abandonment

The major engineering considerations to implement the groundwater extraction system include:

- Design, installation, and testing of extraction well system
- Potential for well plugging (reduction in flow) over time
- Monitoring requirements
- Containment verification
- Well abandonment

The major engineering considerations to implement the system to treat groundwater extracted by the groundwater recirculation and SVE systems include:

- Design flow for groundwater recirculation systems
- Design flow and vacuum levels for SVE blower systems
- Siting and design of air stripper
- Siting and design of piping from air stripper to the sewer line used for conveyance to the POTW
- Monitoring the effluent quality for POTW permit
- Design and implement vapor treatment from SVE and air stripper
- Potential for fouling of the air stripper media
- The major system components anticipated under this alternative include:
- Three trailer-based groundwater recirculation systems each including an injection blower, an extraction blower, a moisture separator, activated carbon units, carbon dioxide tank and piping, and a remote telemetry control unit
- Eight submersible groundwater pumps and controllers
- Three skid mounted SVE blower systems with activated carbon off-gas treatment
- One air stripper with activated carbon off-gas treatment

- Piping, fittings, and valves for fluids transport
- Electrical conduit and wiring for electric power
- *Populus* species trees for phytoremediation
- Piping for tree irrigation system

The major construction equipment and materials required to implement this alternative include:

- Contractor's temporary facilities and utilities
- Well drilling equipment
- Backhoe for trenching in piping
- Front end loader

Maintenance of the groundwater recirculation, hydraulic containment, and SVE systems would be performed in accordance with O&M requirements developed after equipment specifications and procurement are completed. At a minimum, it is expected that regular periodic maintenance would be required on the groundwater extraction pumps, wells, dual-phase extraction blowers, the valves and fittings of the piping systems, as well as replacement of vapor-phase activated carbon as required.

Criterion 7 - Costs. Costs associated with Alternative 5B are summarized below.

Capital Costs	$1,750,000
Total Annualized Costs	$3,627,000
Present Worth Cost (6.875%)	**$5,377,000**

A summary of the comparative analysis of alternatives is presented in Table 3-18. This table concisely shows the major differences among the alternatives with regard to the following:

- Long-term effectiveness and permanence
- Reduction of mobility, toxicity, and volume
- Short-term effectiveness
- Implementability
- Capital costs
- Total annualized costs
- Total present worth cost

3.13 Selection of the Remedy

After the careful consideration of all reasonable alternatives as well as all comments provided by interested parties during the public comment period, NDEP has selected alternative 5A for implementation at the Site. Said alternative was selected for OU1 because it best satisfies the requirements of CERCLA and the NCP's nine evaluation criteria. Alternative 5A will additionally remediate the area of concern related to soils in the vicinity of LDI-1A. This area of concern is not part of OU1. Finally, alternative 5A will remediate the AOC related to soils in the vicinity of LD1-1A. This area is not part of OU1, but has been identified as an AOC.

A summary of balancing selection criteria is provided in Table 3-20.

The combined present worth of alternative 5A is $4,831,000, which includes $1,614,000 for capital costs and $3,217,000 for annualized costs (i.e., operations and maintenance).

Alternative 5A was determined to be the most cost-effective alternative for the given level of protection afforded by source control and plume area management. Alternative 5A carries redundancy within its components given that potential exposure to the contaminated groundwater is managed through existing or planned institutional controls. Source control efforts, through the dual phase extraction system, which provides for mass removal from both the saturated and vadose zones, complement the plume control efforts by removing mass in the areas with the highest observed contaminant concentrations. Plume migration will be controlled through hydraulic containment and remediation will occur over time as the mass tributary to the plume area from the source locations is reduced. In addition, mass within the plume area will be removed in conjunction with groundwater extraction wells, through phytoremediation, and by other natural processes. Implementation will be coordinated with Sierra Pacific Power Company's agency-approved aquifer management program.

No exposure pathways are currently complete regarding human or environmental exposures to the groundwater contamination. Current exposure pathways are incomplete due to institutional controls that limit exposure by prohibiting approval of groundwater wells and not allowing residential development due to industrial zoning. Only two potential future scenarios exist – future onsite worker and future offsite groundwater user (which is a user using water obtained from the local public drinking water well (SLWDC-4) – that may result in unacceptable future risks. The elements of Alternative 5A were selected to manage potential future risks at the public water supply well wellhead and within OU1.

Activities to be conducted in the source areas (which are those areas where cancer risks associated with TCE in groundwater for future onsite construction workers ranges from 1×10^{-4} to 1×10^{-5} – one additional cancer in an exposed population of 10,000 to 100,000 people) include dual-phase extraction with treated water discharge to the POTW and air discharge to ambient directly without treatment. The dual-phase extraction will be implemented in areas to be determined based on sampling conducted during the design-planning phase. Dual-phase extraction will be implemented to extract mass from the areas containing the highest concentration of groundwater contaminants. The dual-phase extraction system is planned to operate until the concentration in the source areas reaches either an acceptable risk-based concentration for a future onsite construction worker or asymptotic contaminant levels are achieved in accordance with NAC 445A.22745.

Activities to be conducted in the plume areas (which is that area outside of the source areas where concentrations of TCE in groundwater are greater than the ACL of 37.5 µg/L) will include groundwater extraction, treatment, and discharge, and phytoremediation and monitored natural attenuation. The groundwater extraction system will consist of wells equipped with pumps and will serve the purpose of achieving hydraulic containment for the shallow groundwater contaminated with TCE above 37.5 µg/L. The extracted groundwater will be treated and discharged to the POTW. The groundwater extraction system will operate until either the groundwater action level is achieved or asymptotic contaminant levels are achieved in accordance with NAC 445A.22745. Phytoremediation will be used in selected areas where technically feasible. Implementation will be coordinated with Sierra Pacific Power Company's agency-approved aquifer management program.

Phytoremediation will be implemented in selected areas of the plume where depth to groundwater does not preclude its application and the groundwater contaminant levels exceed the ACL for TCE. Given the experimental nature of phytoremediation within sites in Nevada, the use of this technology without groundwater extraction was not considered to be entirely reliable. If phytoremedation proves to be successful and reliable, the groundwater extraction system performance requirement may be revised accordingly in the future.

Monitoring of the shallow groundwater system is a required component of the remedy. Monitoring will include the regular collection of groundwater levels and groundwater quality samples from an appropriate selection of wells. The monitoring program will have, at a minimum, the following purposes:

- Verify the performance of the groundwater extraction with respect to containment of TCE
- Monitor the mass reduction of TCE and other contaminants within the plume and source areas
- Support the decision to end the various remedial action components
- Protect the public water supply from contaminants in the shallow groundwater

A formal monitoring plan will be developed prior to implementation of any remedial actions for NDEP review and comment. The monitoring plan will be subject to review and revision, in response to observed field conditions and applicable changes in regulatory requirements, on a maximum of a 5-year interval.

Implementation of the selected remedial actions will be performed in accordance with all applicable federal, state, and local permit requirements.

3.14 Declaration of Statutory Determinations

As previously noted, CERCLA mandates that the remedial action must be protective of human health and the environment; attain a level or standard of control of the hazardous substances, pollutants and contaminants, which at least attain the legally applicable or relevant and appropriate requirements (ARARs) under the Federal, State, and local laws; be cost-effective; utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable; and satisfy the statutory preference for remedies that employ treatment to reduce the toxicity, mobility, or volume of the hazardous substances, pollutants or contaminants at the site.

For the reasons discussed herein, NDEP has determined that the selected remedy meets the requirements of CERCLA, including the NCP, and the State of Nevada.

Protection of Human Health and the Environment
The selected remedy is protective of human health and the environment. The health risks associated with the shallow groundwater beneath OU1 are only related to future site conditions since there are currently no completed exposure pathways. The two future scenarios that may produce unacceptable levels of risk if no remedies are implemented include:

- Future construction worker exposed to the shallow groundwater if construction requires excavation into the shallow groundwater.

- Future offsite groundwater user if the contaminant plumes reach SLWDC-4 and the water is distributed for potable use.

The selected remedy manages future risk through the combination of its components. Institutional controls will restrict the use of shallow groundwater and future construction practices that may have implemented deep in-ground construction methods. Further, source area remediation will be performed with the objective of reducing areas of elevated concentrations to below the risk-based concentration allowable for future onsite construction workers. Finally, the plume area groundwater extraction system will be used to restrict the migration of shallow groundwater contamination toward SLWDC-4.

Monitoring the performance of all the components of the remedy will be a critical part of the remedy implementation.

Compliance with ARARs
The selected remedy will be in compliance with all ARARs, with the exception of the chemical-specific ARAR requiring that groundwater containing contaminant concentrations above the maximum contaminant level (MCL) is contained or captured

by active remediation. Under both federal and state regulations, which are relevant and appropriate, a waiver is allowed for use of ACL, in place of MCLs, if the MCL are not technically feasible and/or are cost-prohibitive to attain, and an ACL can be developed that is adequately protective of human health and the environment. The selected remedy complies with the requirements of the ACL waiver. Note that monitored natural attenuation will be implemented throughout the plume area including that portion of the plume where groundwater contaminant concentrations are above MCLs and below ACLs. For the selected remedy, all action-specific and location-specific ARARs will be met.

Cost-Effectiveness
Each alternative underwent a cost analysis to develop costs to the accuracy of +50 to -30 percent. In that analysis capital and O&M costs have been estimated and used to develop present worth costs, or estimates of net present value. For these estimates, annual costs were developed for a 30-year project life using a 6.875 percent discount rate and 1999 costs.

The selected remedy was found to be the most cost-effective alternative for its level of protectiveness.

Utilization of Permanent Solutions and Alternative Treatment Technologies to Maximum Extent Possible
The selected remedy utilizes permanent solutions to the maximum extent practicable. The dual-phase extraction system will permanently remove volatile organic contaminants from both the saturated and vadose zones for above ground disposal. Similarly, groundwater extraction, and to a limited extent phytoremediation, will permanently remove contaminant mass from the saturated zone.

The selected remedy also utilizes alternative treatment technologies to the maximum extent possible. Phytoremedation has been developing broad acceptance both within the regulatory and remediation communities for application to organic solvent remediation. This alternative treatment technology, which will be used to enhance the groundwater extraction system, requires less energy consumption and treatment requirements than does the more traditional "pump-and-treat" approach. Combining groundwater extraction with phytoremediation was determined by the State to provide the best balance to the remedial action.

Preference for Treatment as a Principal Element
The selected remedy satisfies the statutory preference for treatment to reduce the toxicity, mobility, or volume of the contaminants at the Site.

Other Considerations
NDEP recognizes that cleanup of the groundwater within OU1 to state action levels may not be practicable given the low permeability of the native soils and the inherent difficulty in passing water through the contaminated media. The final clean-up standards have not been established at this time but will be determined in accordance

with NAC 445A Sections 445A.226 through 445A.22755 at an appropriate time in the future once remedial actions have been implemented.

CERCLA mandates that the remedial action must be protective of human health and the environment; attain a level or standard of control of the hazardous substances, pollutants and contaminants, which at least attain the legally applicable or relevant and appropriate requirements (ARARs) under the federal, state, and local laws; be cost-effective; utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable; and satisfy the statutory preference for remedies that employ treatment to reduce the toxicity, mobility, or volume of the hazardous substances, pollutants or contaminants at the site.

NDEP has determined that the selected remedy meets the requirements of CERCLA and the State of Nevada.

3.15 Documentation of Significant Changes

There are no significant changes from the selected remedial actions presented in this decision document.

4.0 Plan Forward

ROD approval will serve as the initial step in a series of events that will culminate with the implementation of the selected remedy. The sequence of events leading to selected remedy implementation is as follows:

- Initiate Pre-Construction Monitoring
- Develop and implement Institutional Controls
- Complete Preliminary and Final Design
- Receive Bids for Selected Remedy Construction
- Complete Selected Remedy Construction
- Initiate Post-Closure Monitoring

Each of these events is described in more detail in the following sections.

4.1 Pre-Construction Monitoring

Semi-annual monitoring at the Stead Solvent Site has been ongoing since April 1996. Monitoring includes water levels and groundwater VOC analyses. Semi-annual monitoring will continue throughout all phases of the selected remedy implementation leading to the post-closure monitoring. Additional analyses may be required for design purposes. Such analyses will be identified in the design work plan.

4.2 Institutional Controls

Institutional controls will be developed and implemented for the purposes of protecting human health and the environment. A listing and brief description of institutional controls is provided below.

- **Contingency Plan for SLWDC-4:** It is anticipated that the selected remedy will prevent groundwater contaminants emanating from beneath OU1 to reach SLWDC-4 at concentrations above MCLs. To ensure that this public water supply source is adequately protected above the protection afforded by the groundwater extraction system, phytoremediation and monitored natural attenuation, a monitoring program will be established connecting well head and in-ground sampling efforts to critical actions if target levels of contaminants of concern are detected. A contingency plan detailing the monitoring points and sampling protocols, as well as outlining the potential critical actions, will be prepared as part of the implementation of the selected remedy.

- **Land Use:** Current land use at the Stead Solvent Site is considered light industrial and commercial. An institutional control to ensure similar future land uses is required to prevent future residential land use in the areas above known groundwater contamination within the boundaries of OU1. This institutional control will consist of the extension of the AAWC's current zoning restrictions prohibiting residential land use within the Airport Property into non-Airport property within OU1.

- **Limits on groundwater use:** Groundwater use will be restricted within the OU1 boundary to eliminate potential future use of the shallow groundwater for potable uses. Inasmuch as OU1 is within a certificated water service area, institutional controls currently exist prohibiting the installation of new wells.

- **Limits on construction:** Construction practices within the OU1 boundary will be devised to limit worker exposure to groundwater.

4.3 Preliminary and Final Design

The selected remedy design will be completed as part of a series of milestones. The first milestone is the work plan. The work plan will be completed within 60 days of ROD approval and will describe the design milestone details, provide a design schedule, and describe any additional monitoring that will be required for final design. The other milestones are as follows:

- 30 percent design
- 65 percent design
- 95 percent design with post-closure monitoring
- 100 percent design with bid documents

Each milestone represents an opportunity for State review and comment and is required for the project to proceed to final design, bid, and construction.

4.4 Bid

Following final design, design specifications and drawings will be made available to a list of qualified contractors. The bidding process will conform with the requirements of the Nevada Revised Statutes (NRS).

4.5 Construction

The selected remedy will be constructed according to the state-approved design. A schedule for construction will be provided as part of the bidding process.

4.6 Post-Closure Monitoring

Post-closure monitoring will be required for verification of the selected remedy. Verification will include source area remedial action and monitored natural attenuation effectiveness.

5.0 Nevada Revised Statute 459.500 Jurat

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and to the best of my knowledge comply with all applicable federal, state, and local statutes, regulations, and ordinances.

Tracy C. Bouvette C.E.M. No. 1508 Expiration Date - March 8, 2001	7-21-00 Date

6.0 References

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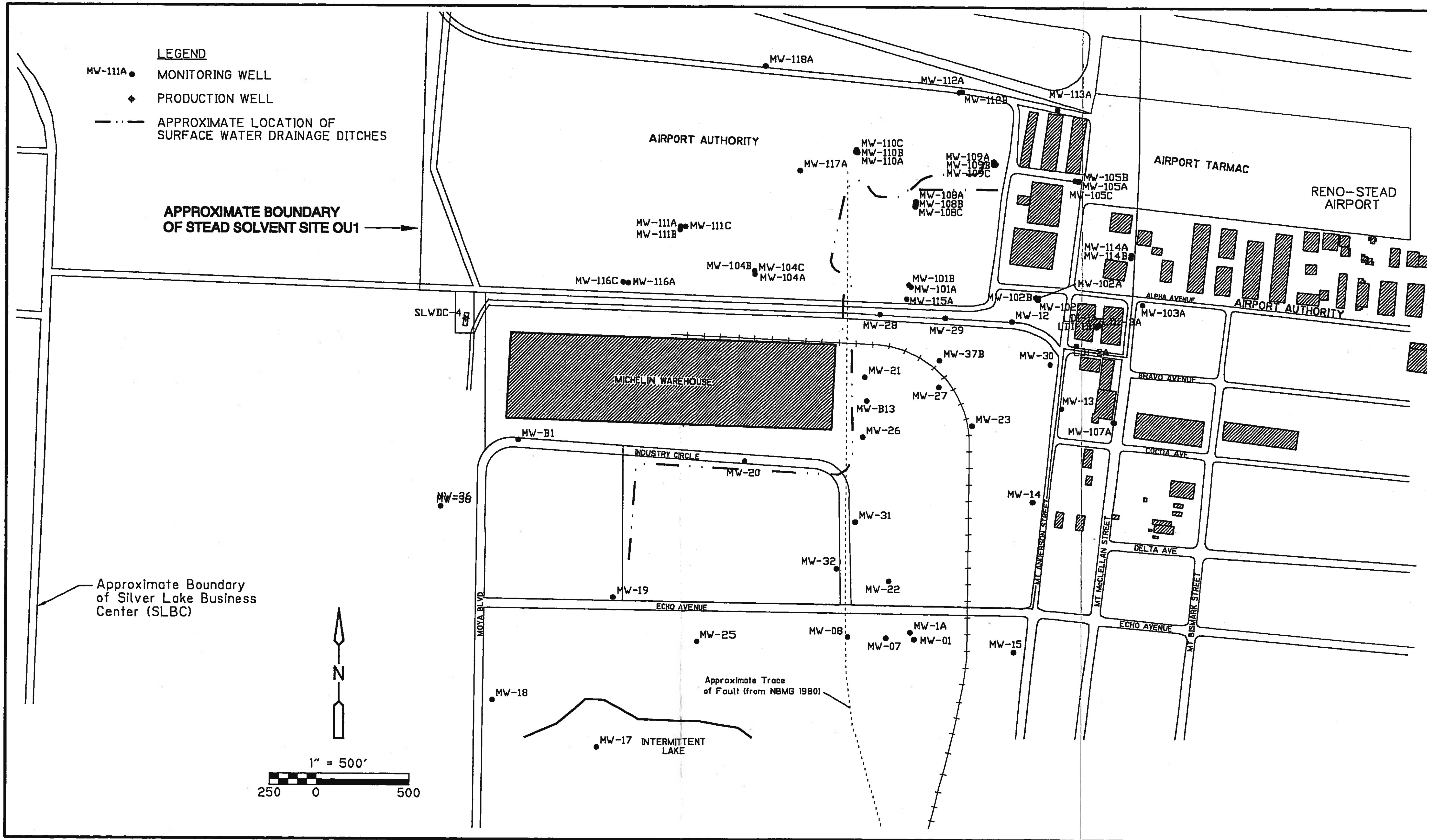

CDM Camp Dresser & McKee

Figure 3
Monitoring Well Location M
Stead Solvent S

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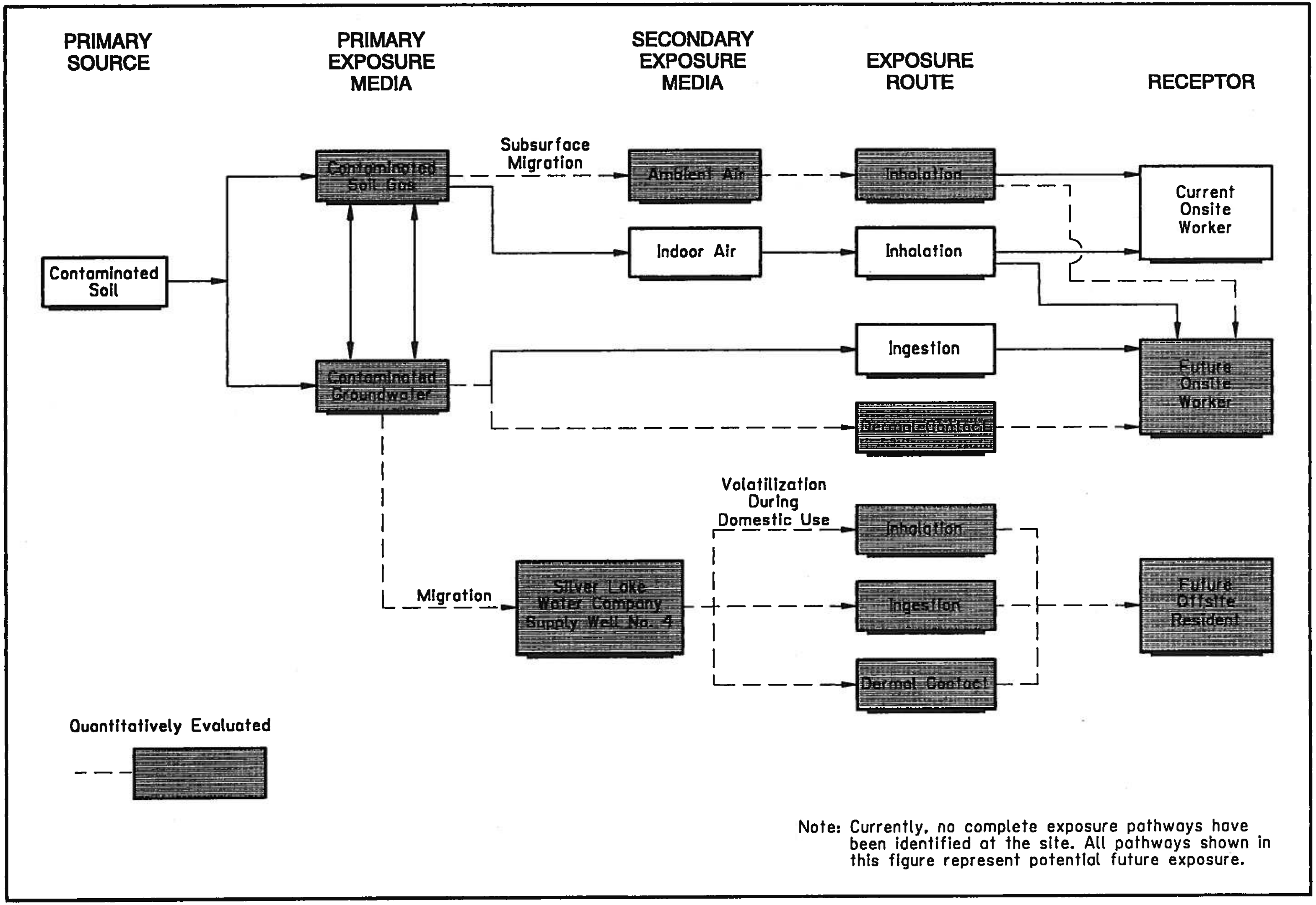
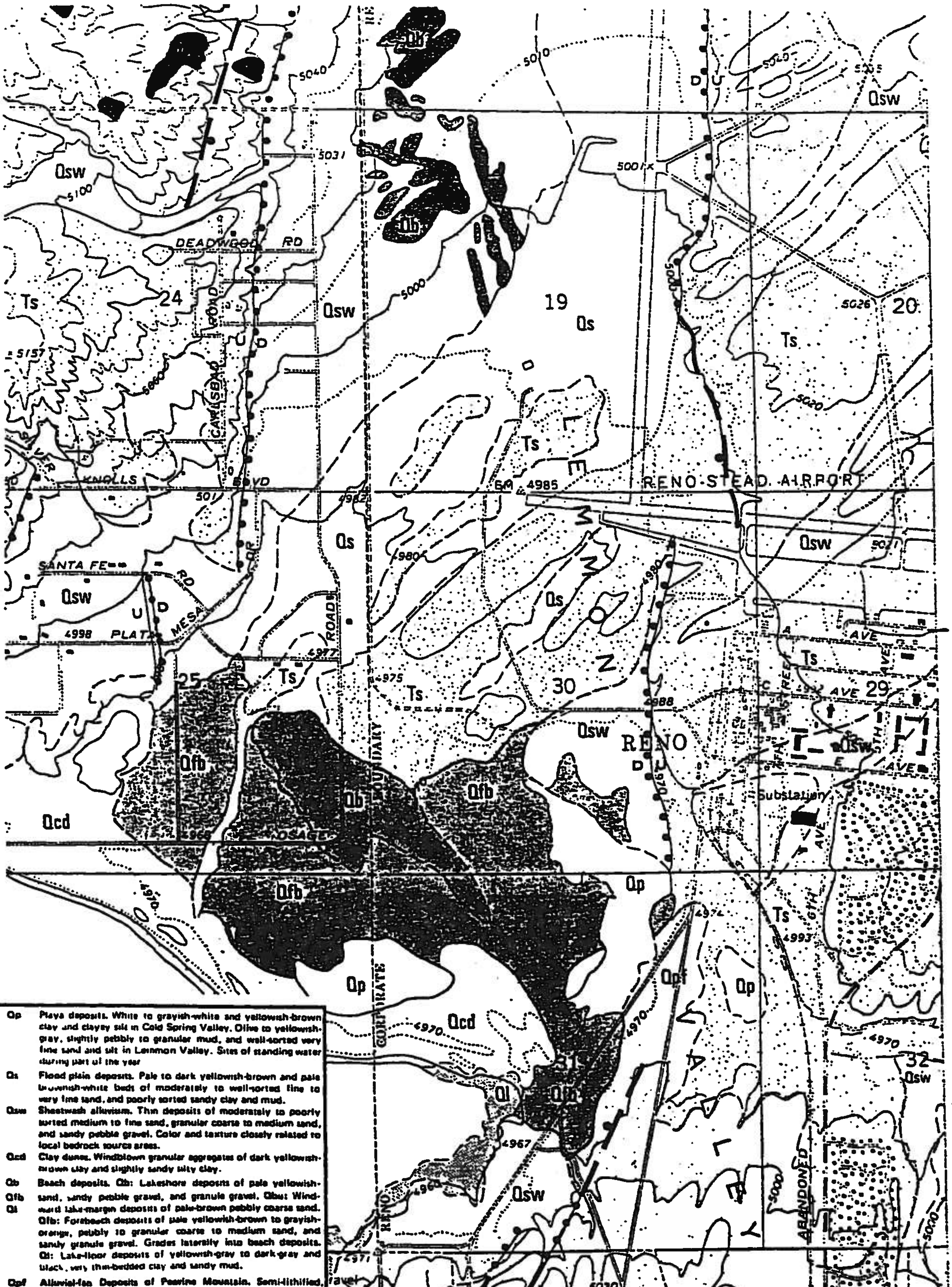


Figure 3-2
Site Conceptual Exposure Model
Stead Solvent Site

CDM Camp Dresser & McKee



Qp	Playa deposits. White to grayish-white and yellowish-brown clay and clayey silt in Cold Spring Valley. Olive to yellowish-gray, slightly pebbly to granular mud, and well-sorted very fine sand and silt in Lemmon Valley. Sites of standing water during part of the year
Qs	Flood plain deposits. Pale to dark yellowish-brown and pale brownish-white beds of moderately to well-sorted fine to very fine sand, and poorly sorted sandy clay and mud.
Qsw	Sheetwash alluvium. Thin deposits of moderately to poorly sorted medium to fine sand, granular coarse to medium sand, and sandy pebble gravel. Color and texture closely related to local bedrock source areas.
Qcd	Clay dunes. Windblown granular aggregates of dark yellowish-brown clay and slightly sandy silty clay.
Qb Qfb Ql	Beach deposits. Qb: Lakeshore deposits of pale yellowish-sand, sandy pebble gravel, and granule gravel. Qbu: Wind-ward lake-margin deposits of pale-brown pebbly coarse sand. Qfb: Forebeach deposits of pale yellowish-brown to grayish-orange, pebbly to granular coarse to medium sand, and sandy granule gravel. Grades laterally into beach deposits. Ql: Lake-floor deposits of yellowish-gray to dark-gray and black, very thin-bedded clay and sandy mud.
Qpf	Alluvial-fan Deposits of Peavine Mountain. Semi-lithified, poorly bedded and poorly sorted reddish-brown and dark yellowish-orange, slightly muddy sandy pebble to cobble gravel. Clasts are composed predominantly of white altered andesite.
Ts	Lacustrine and alluvial sediments. Thick basin-fill deposits of grayish-orange to pale-brown, coarse to medium sand, granular sand, siltstone, silty to pebbly sandstone, and minor sandy pebble conglomerate, very thin-bedded ash and diatomite. Sediments are generally unconsolidated and bedding is usually indistinct. In part includes much younger alluvium near the surface. Probably equivalent in age to the Sandstone of Hunter Creek (Bonham and Bingler, 1973).

Reprinted From: NBMG (1980)

Stead Solvent Site

Site Geologic Map

CDM **Figure 3-3**

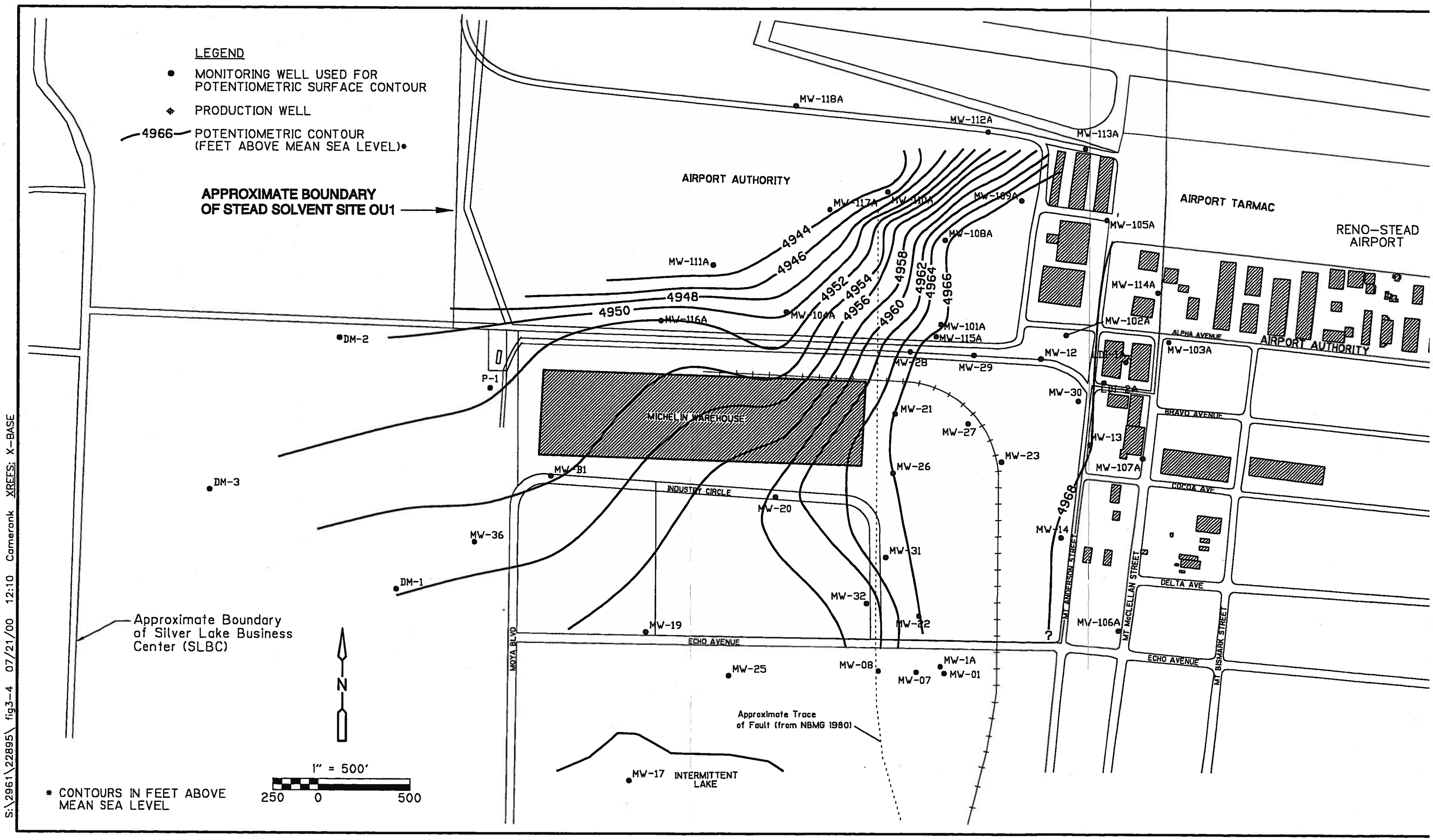


Figure 3

Potentiometric Surface Map in the "A" Horizon, February 19

Stead Solvent Si

CDM Camp Dresser & McKee

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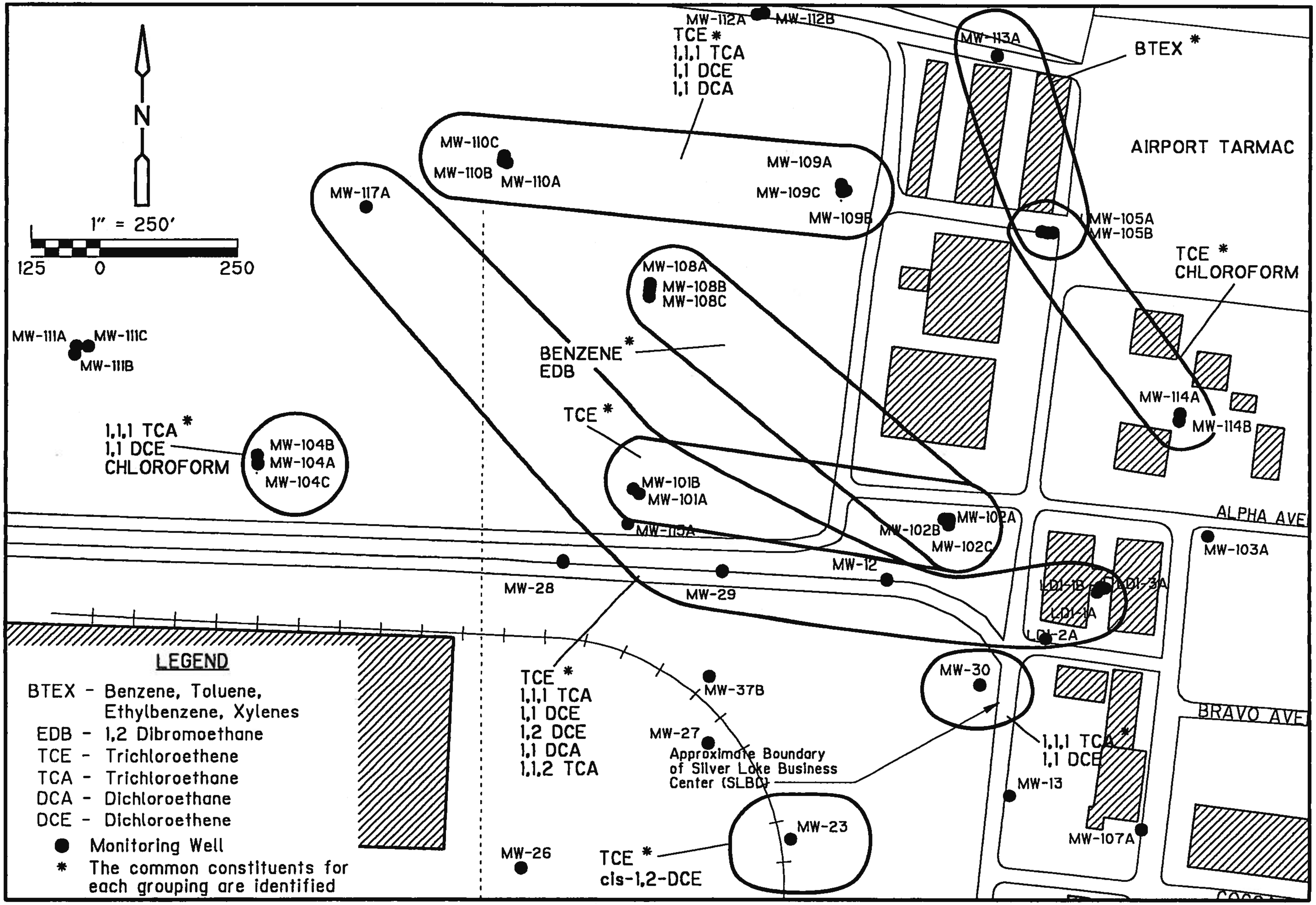
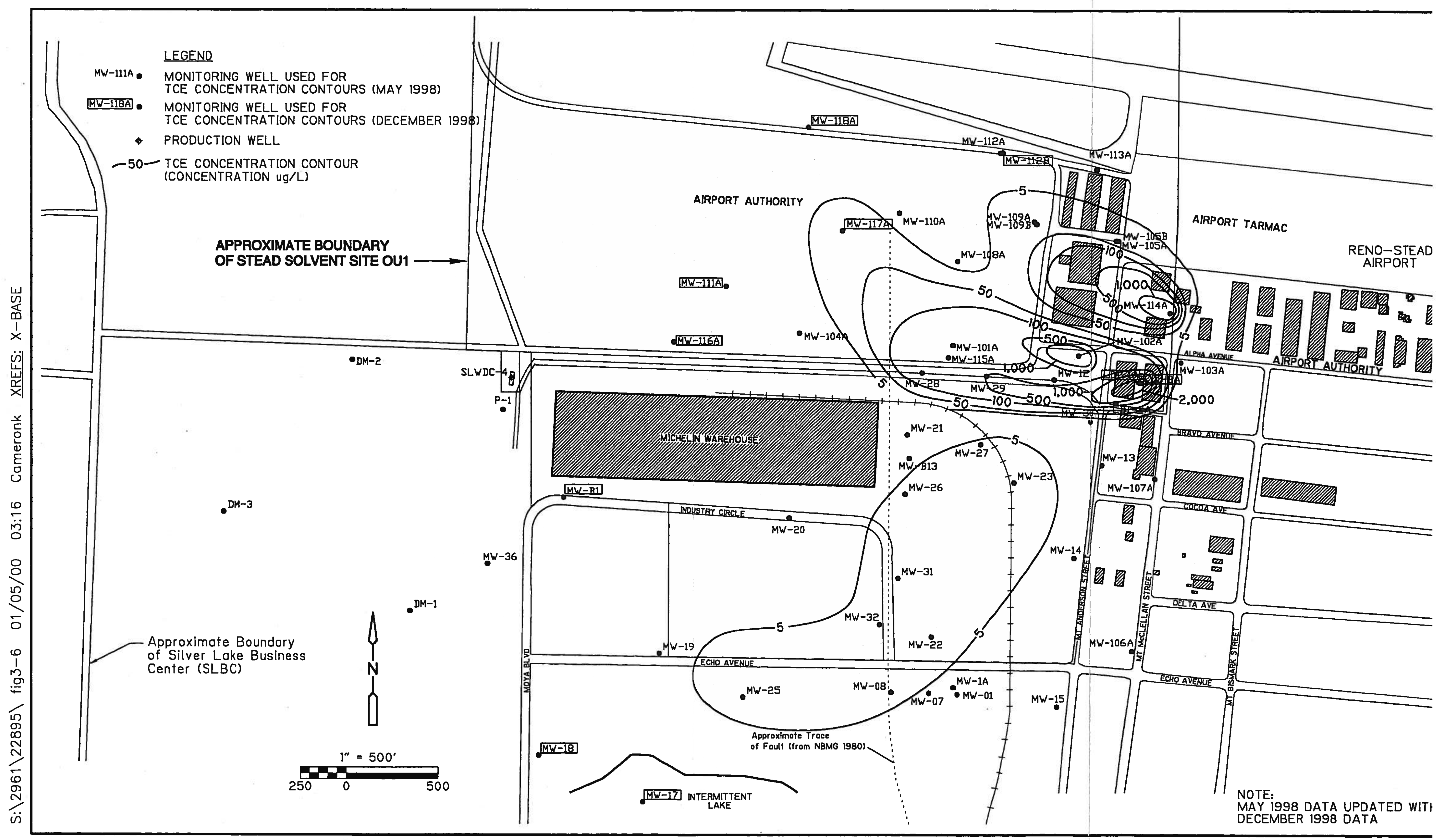


CDM Camp Dresser & McKee

Figure 3-5
Grouping of Like Groundwater Contaminants



Figure

TCE Concentration Contour M

Stead Solvent S

CDM Camp Dresser & McKee

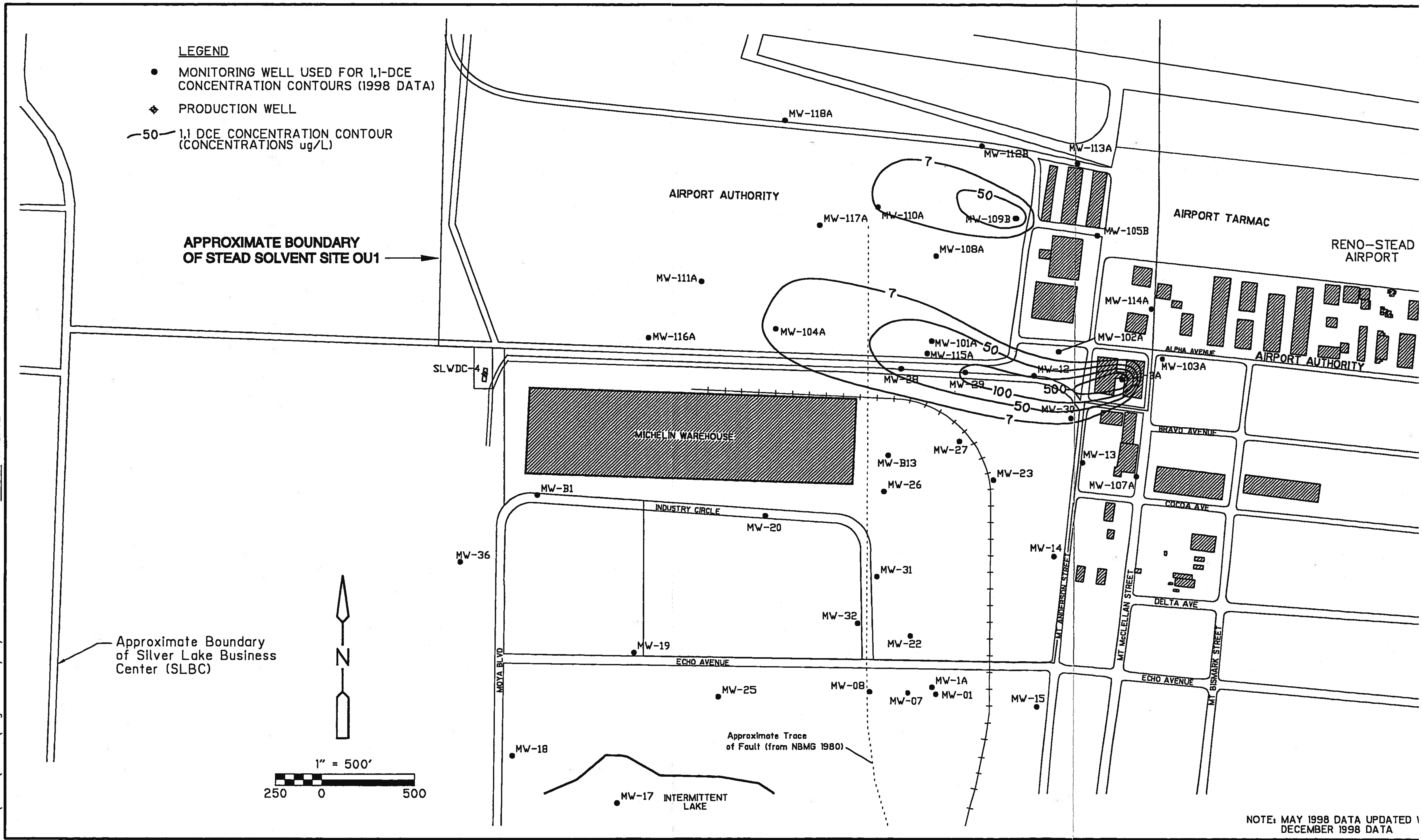


Figure
1,1-DCE Concentration Contour I
Stead Solvent

CDM Camp Dresser & McKee

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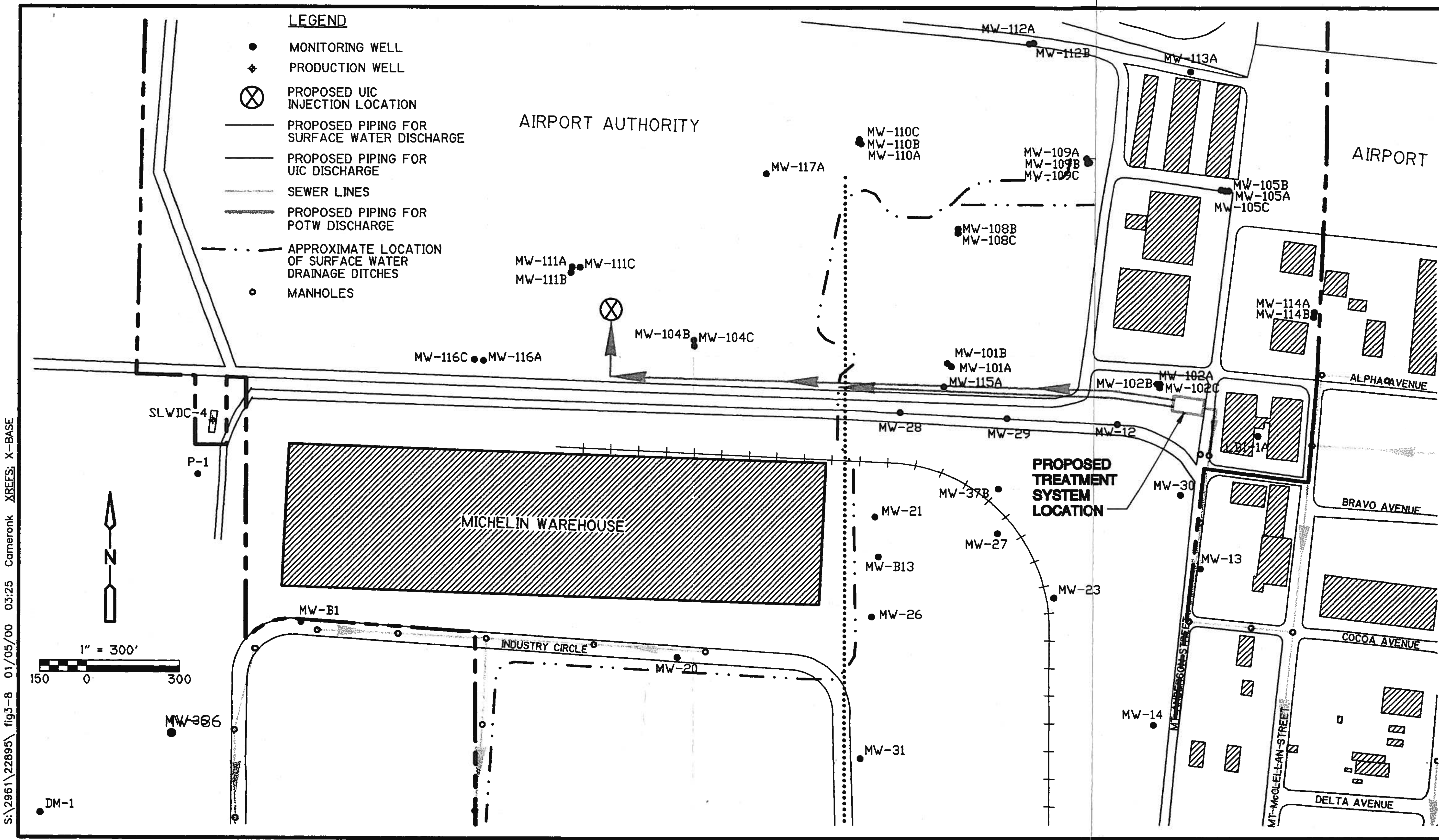

Figure 3
Proposed Discharge Optio
Stead Solvent S

CDM Camp Dresser & McKee

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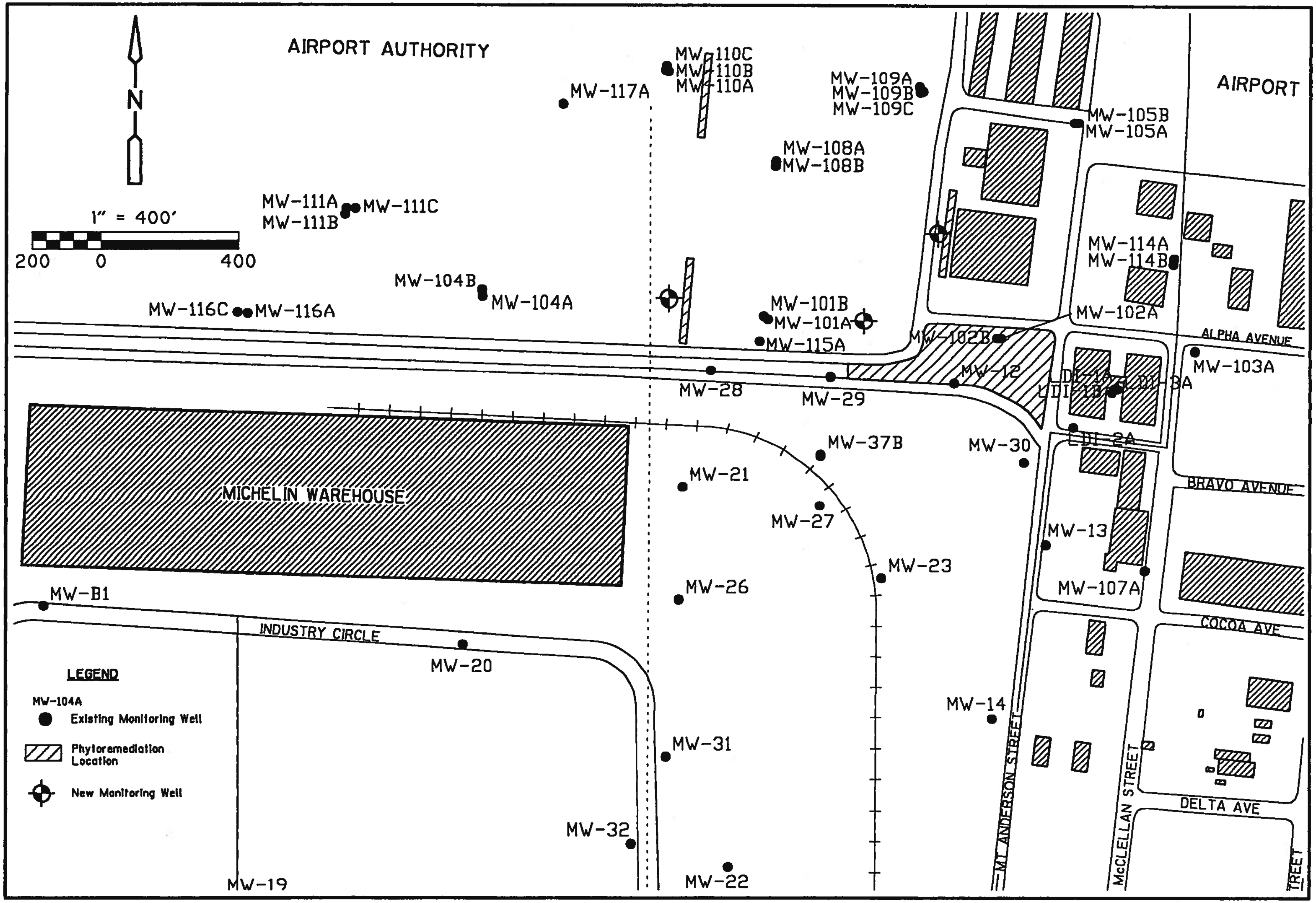

Figure 3-9
Proposed Phytoremediation Locations
Stead Solvent Site

CDM Camp Dresser & McKee

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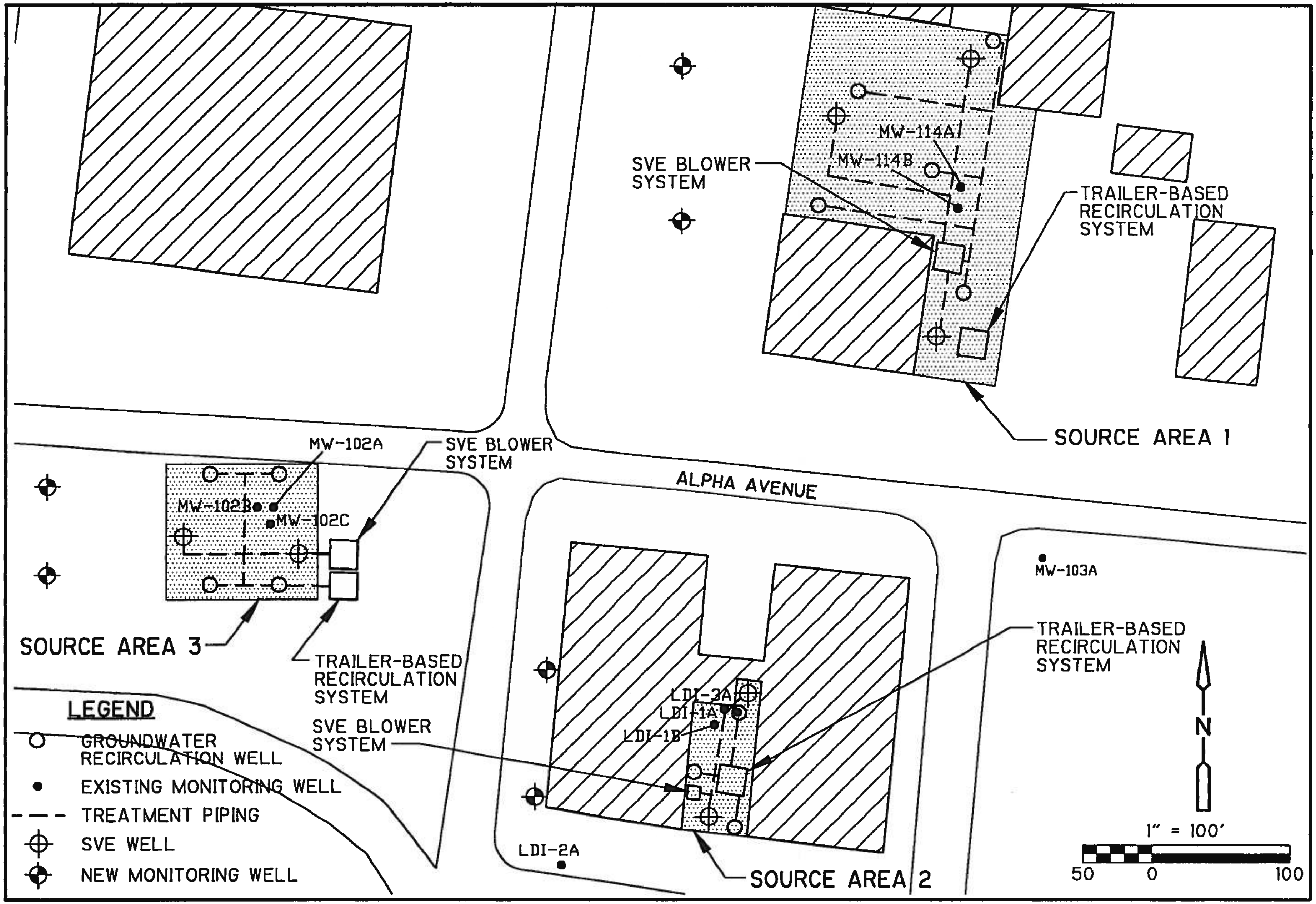

Figure 3-10
Proposed Groundwater Recirculation /SVE Well and System Locations
Stead Solvent Site

CDM Camp Dresser & McKee

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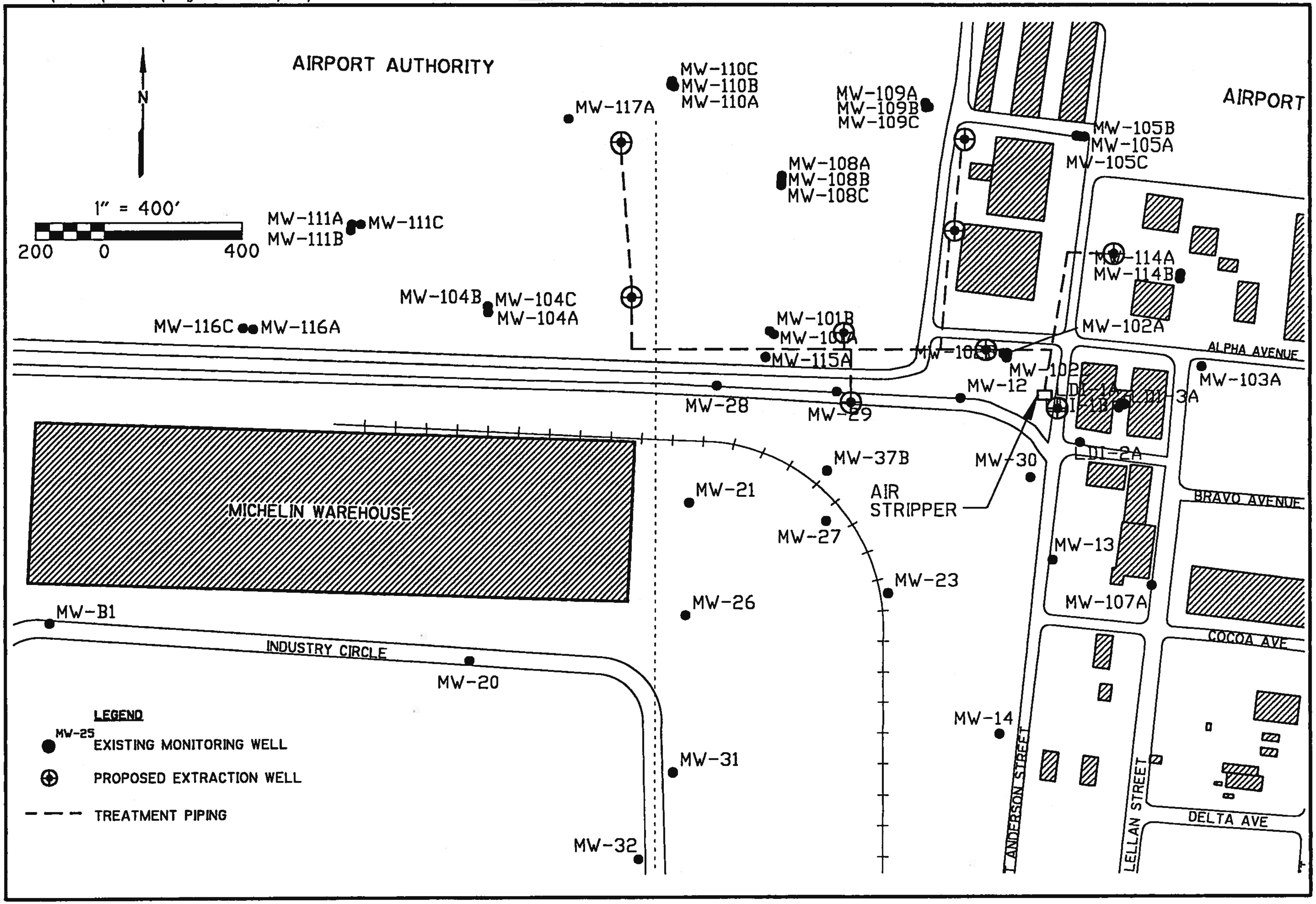

Figure 3-11
Proposed Groundwater Extraction Wells for Capture at the ACL Stead Solvent Site

Table 3-1 Estimated TCE Mass and Volume

Concentration Contour (µg/L)	Area within Contour (Acre)	Groundwater Volume in Contour (L)	Average Concentration (µg/L)	TCE Mass (lb)	TCE Volume (gallons)
5	55.95	552,069,818	28	33.5	2.7
50	10.07	99,404,903	75	16.4	1.4
100	11.65	114,963,395	300	76.0	6.2
500	4.28	42,274,109	750	69.9	5.7
1,000	1.32	13,028,992	1,500	71.8	5.9
2,000	0	2,455,424	2,500	40.6	3.3

Table 3-2 Estimated 1,1-DCE Mass and Volume

Concentration Contour (µg/L)	Area within Contour (Acre)	Groundwater Volume in Contour (L)	Average Concentration (µg/L)	1,1-DCE Mass (lb)	1,1-DCE Volume (gallons)
7	25.07	247,362,134	29	15.5	1.5
50	9.56	94,358,587	75	15.6	1.5
100	2.59	25,558,698	300	16.9	1.7
500	0.47	4,665,735	750	7.7	0.8

Table 3-3 Exposure Point Concentrations for Groundwater (g/L)

Stead Solvent Site (Future Onsite Construction Worker Scenario)[a]				
COPC	Well 101A	Well 102A	Well 105A	Well 108A
1,2-Dichloroethane	53	ND	1.4	ND
1,1-Dichloroethene	180	ND	ND	ND
1,1,1-Trichloroethane	420	ND	ND	ND
1,1,2-Trichloroethane	3.6	5.2	ND	ND
1,2-Dibromoethane	ND	ND	ND	2.1
Benzene	1.1	1.3	110	ND
Carbon Tetrachloride	ND	ND	ND	ND
Trichloroethene	2,300	2,600	ND	1.2

ND = not detected

Silver Lake Company Water Supply Well No. 4(Future Offsite Residential Scenario)[b]	
COPC	Maximum Calculated Groundwater Concentration (µg/L)
1,2-Dichloroethane	0.02
1,1-Dichloroethene	0.27
1,1,1-Trichloroethane	0.47
1,1,2-Trichloroethane	0.0035
1,2-Dibromoethane	0.028
Benzene	0.11
Carbon Tetrachloride	0.001
Trichloroethene	2.75

a Future onsite construction workers are evaluated for potential exposure inside an excavation. The wells with the highest detected concentrations of COPCs are assumed to represent different areas where the excavation may be located.

b Based upon estimated leakage rates during pumping and maximum detected concentrations of chemicals in groundwater

Table 3-4 Exposure Point Concentrations for Ambient Air

COPC[a]	Exposure Point Concentration[b] (mg/m^3)
1,1-Dichloroethene	0.0554
1,1,1-Trichloroethane	0.08699
1,1,2-Trichloroethane	0.0033
Carbon tetrachloride	0.0107
Tetrachloroethene	0.00124
Trichloroethene	0.1957

a Vinyl chloride was not detected within the exposure area identified for the excavation scenario. This COPC was detected only once out of 78 analyses (~ 1 percent) at a concentration of 0.0055 mg/m^3.

b Exposure point concentrations are the maximum detected concentrations of all soil gas data within the specified exposure area.

Table 3-5 Chemicals of Potential Concern (COPCs) in Groundwater for the Stead Solvent Site[a]

Detected Compounds[b]	Frequency of Detection % (Detections/ Analyses)	Maximum Detected Concentration (µg/L)	Site Background Concentration (CDM Wells 106 & 107) (µg/L)	MCL[c] (µg/L)	Risk-Based Concentration[d] (µg/L)	Carcinogen Classification[e]	Rationale[i]
Benzene	35 (23/65)	410	ND	5	0.36	A	MDC>MCL & RBC
Carbon Tetrachloride	9 (6/65)	3.2	ND	5	0.16	B2	MDC>RBC
1,2-Dibromoethane	18 (12/65)*	120	ND	0.05	0.00075	B2	MDC>MCL & RBC
1,2-Dichloroethane	5 (3/65)	53	ND	5	0.12	C	MDC>MCL & RBC
1,1-Dichloroethene	23 (15/65)	180	ND	7	0.044	C	MDC>RBC
1,1,1-Trichloroethane	23 (15/65)	420	ND	200	1,300	D	MDC>MCL
1,1,2-Trichloroethane	12 (8/65)	5.2	ND	5	0.19	C	MDC>MCL & RBC
Trichloroethene	43 (28/65)	2,600	ND	5	1.6	B2[h]	MDC>MCL & RBC

a The screening analysis is based on the groundwater ingestion pathway and does not screen chemicals based on inhalation toxicity. All chemicals that are carcinogens by inhalation are also oral carcinogens, however, and the screening analysis is therefore also protective of potential exposures via inhalation.

b At CDM well.

c MCL = Maximum contaminant level. *Drinking Water Regulations and Health Advisories* (EPA 1995).

d Based on a residential exposure frequency and a tap water ingestion rate of 2 L/day. See text.

e From the Integrated Risk Information System (IRIS) (EPA 1995).

h Under review (EPA 1994).

i MDC = Maximum detected concentration
RBC = Risk-based concentration
FOD = Frequency of Detection

j Risk-based concentrations or MCLs are not available for these compounds. However, they are not likely to cause any adverse health effects at the concentrations present. Some related compounds, for example methyl acetate, ethyl acetate, cyclohexanone and methylcyclohexane, have very high risk-based concentrations (37,000 and 33,000 µg/L, respectively). EPA (1989b) recommends eliminating TICs that are unlikely to significantly contribute to overall health risks.

NA Not available
NC Not classified
ND Not detected
* 1,2-Dibromoethane was also previously twice detected as a TIC, with a maximum estimated concentration of 330 µg/L.

Table 3-6 Exposure Parameters for the Future Onsite Worker Scenario

Exposure Parameter	Value		Source
Body Weight	70 kg		EPA 1989b
Exposure Duration	2 months		Site-specific
Frequency of Exposure	40 days		Site-specific
Exposure Time	8 hrs/day		EPA 1989b
Skin Surface Area	hands & forearms = 1,980 cm^2		EPA 1989c
Inhalation Rate	20 m^3/8 hr day		EPA 1989c
Averaging Time			
Carcinogens	25,550 days		EPA 1989b
Noncarcinogens	61 days		EPA 1989b
Dermal Permeability Constants (RME & Average)	1,1-Dichloroethene	1.6×10^{-2}	EPA 1992d
	1,1,1-Trichloroethane	1.7×10^{-2}	EPA 1992d
	1,1,2-Trichloroethane	8.4×10^{-3}	EPA 1992d
	1,2-Dibromoethane	3.3×10^{-3}	EPA 1992d
	Benzene	1.1×10^{-1}	EPA 1992d
	Carbon Tetrachloride	2.2×10^{-2}	EPA 1992d
	Trichloroethene	2.3×10^{-1}	EPA 1992d
	1,2-Dichloroethane	5.3×10^{-3}	EPA 1992d

Table 3-7 Exposure Parameters for the Future Offsite Residential Scenario

Exposure Parameters	Value	Source
Body Weight		
Adult (TWA)	59 kg	Calculated[a]
Child	15 kg	Calculated[b]
Exposure Frequency		
Adult	350 days/year	EPA 1991a
Child	350 days/year	EPA 1991a
Exposure Duration		
Adult	30 years	EPA 1991a
Child	6 years	Site-specific
Groundwater Ingestion Rate		
Adult	2 L/day TWA (1.9 L/day)	Calculated[a]
Child	1.5 L/day	Calculated[b]
Averaging Time C Noncarcinogens	2,190 days	EPA 1989b
Averaging Time C Carcinogens	25,550 days	EPA 1989b

TWA = time-weighted average
a Based on a 30-year exposure duration, assuming six years as a child and 24 years as an adult
b See Section 4.3.3.1.

Table 3-8 Cancer Slope Factors for Carcinogenic COPCs

COPC	Carcinogen Classification	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$	Source
1,2-Dichloroethane	B2	9.1×10^{-2}	9.1×10^{-2}	EPA 2000[a]
1,1-Dichloroethene	C	6.0×10^{-1}	1.8×10^{-1}	EPA 2000[a]
1,1,2-Trichloroethane	C	5.7×10^{-2}	5.6×10^{-2}	EPA 2000[a]
1,2-Dibromoethane	B2	8.5×10^{1}	7.6×10^{-1}	EPA 2000[a]
Benzene	A	5.5×10^{-2}	2.9×10^{-2}	EPA 2000[a]
Carbon tetrachloride	B2	1.3×10^{-1}	5.3×10^{-2}	EPA 2000[a]
Tetrachloroethene	B2	5.2×10^{-2}	2.0×10^{-3}	EPA 1999[b]
Trichloroethene	B2	1.1×10^{-2}	6.0×10^{-3}	EPA 1999[b]
Vinyl Chloride	A	1.9×10^{0}	3.0×10^{-1}	EPA 1997[c]

[a] Integrated Risk Information System (IRIS).

[b] Carcinogenicity Characterization of Trichloroethylene (CASRN 79-01-6). Tetrachloroethylene (CASRN 127-18-4) and Styrene (CASRN 100-42-5). Office of Research and Development. Environmental Criteria and Assessment Office.

[c] Health Effects Assessment Summary Tables (HEAST).

Table 3-9 Reference Doses for COPCs

COPCs	Subchronic Oral RfD[a] (mg/kg-day)	Chronic Oral RfD[b] (mg/kg-day)	Subchronic Inhalation RfC[a] (mg/kg-day)	Chronic Inhalation RfC (mg/kg-day)
1,2-Dichloroethane	NA	3.0×10^{-2} [e]	NA	1.4×10^{-3} [e]
1,1-Dichloroethene	9.0×10^{-3}	9.0×10^{-3}	NA	NA
1,1,1-Trichloroethane	NA	2.8×10^{-1}	NA	6.3×10^{-1} [c]
1,1,2-Trichloroethane	4×10^{-2}	4×10^{-3}	NA	NA
1,2-Dibromoethane	NA	NA	5.7×10^{-4}	5.7×10^{-5} [a]
Benzene	NA	3.0×10^{-3} [e]	1.7×10^{-2} [e]	1.7×10^{-3} [e]
Carbon tetrachloride	2×10^{-3} [e]	7.0×10^{-4}	1.7×10^{-2} [e]	5.7×10^{-4} [e]
Tetrachloroethene	1×10^{-1}	1.0×10^{-2}	NA	1.4×10^{-1} [e]
Trichloroethene	NA	6.0×10^{-3} [d]	NA	NA
Vinyl Chloride	NA	NA	NA	NA

a EPA (1997). HEAST.
b EPA (2000). IRIS except as noted.
c Withdrawn from IRIS.
d *Risk Assessment Issue Paper for Provisional Oral RfD and Carcinogenicity of Trichloroethylene* (CASRN79-01-06). Environmental Criteria and Assessment Office, Cincinnati, Ohio.
e The RfD/RfC is provisional and was provided to CDM by EPA's Superfund Health Risk Technical Support Center (Tel. (513) 569-7300 in Cincinnati, Ohio).
NA Not available.

Table 3-10 Carcinogenic Risks for the Future Onsite Construction Worker Scenario

Chemical	Well 101	Well 102	Well 105	Well 108
Dermal Contact with Groundwater				
1,2-Dichloroethane	9.06E-09	ND	2.39E-10	ND
1,1-Dichloroethene	6.12E-07	ND	ND	ND
1,1,1-Trichloroethane	NA	ND	ND	ND
1,1,2-Trichloroethane	6.11E-10	8.82E-10	ND	ND
1,2-Dibromoethane	ND	ND	ND	2.09E-07
Benzene	1.98E-09	2.35E-09	1.98E-07	ND
Carbon Tetrachloride	ND	ND	ND	ND
Trichloroethene	2.06E-06	2.33E-06	ND	1.08E-09
Total Pathway Risk	**2.7E-06**	**2.3E-06**	**1.3E-7**	**2.1E-07**
Inhalation of Ambient Air	**Exposure Area for Ambient Air**			
1,1-Dichloroethene	4.46×10^{-6}			
1,1,1-Trichloroethane	NA			
1,1,2-Trichloroethane	8.27×10^{-8}			
Carbon tetrachloride	2.54×10^{-7}			
Tetrachloroethene	1.11×10^{-9}			
Trichloroethene	5.25×10^{-7}			
Vinyl chloride	ND			
Total Pathway Risk	**5.3×10^{-6}**			
Total Carcinogenic Risk for the Future Onsite Worker Scenario	**Well 101**	**Well 102**	**Well 105**	**Well 108**
	8.0×10^{-6}	**7.6×10^{-6}**	**5.4×10^{-6}**	**5.5×10^{-6}**

NA = No carcinogenic criteria available for this chemical
ND = Not detected in "shallow" groundwater at this well

Table 3-11 Carcinogenic Risks for the Future Offsite Residential Scenario

Chemical	RME Risk		
	Groundwater Ingestion	**Dermal Contact with Groundwater**	**Inhalation of Volatile Chemicals during Domestic Use of Groundwater**
1,2-Dichloroethane	2.4E-08	7.2E-09	1.68E-08
1,1-Dichloroethene	2.14E-06	6.41E-07	4.49E-07
1,1,1-Trichloroethane	NA	NA	NA
1,1,2-Trichloroethane	2.63E.09	7.89E-10	1.81E-09
1,2-Dibromoethane	3.14E-05	9.42E-06	1.99E-07
Benzene	6.73E-08	2.02E-08	2.95E-08
Carbon Tetrachloride	1.71E-09	5.14E-10	4.89E-10
Trichloroethene	3.99E-07	1.20E-07	1.52E-07
Total Pathway Risk	**3.4E-05**	**1.0E-05**	**8.5E-07**
Total Carcinogenic Risk for the Future Offsite Residential Scenario			**4.5×10^{-5}**

NA = No carcinogenic criteria available for this chemical
RME = Reasonable maximum exposure

Table 3-12 Hazard Quotients and Hazard Indices for the Future Onsite Worker Scenario

Chemical	Hazard Quotients			
	Well 101	**Well 102**	**Well 105**	**Well 108**
Dermal Contact with Groundwater				
1,1-Dichloroethene	4.75×10^{-2}	ND	ND	ND
1,2-Dibromoethane	NA	NA	NA	NA
1,2-Dichloroethane	NA	NA	NA	NA
1,1,1-Trichloroethane	NA	NA	NA	NA
1,1,2-Trichloroethane	1.12×10^{-4}	1.62×10^{-4}	ND	ND
Benzene	NA	NA	NA	NA
Carbon Tetrachloride	ND	ND	ND	ND
Trichloroethene	NA	NA	NA	NA
Pathway HI	**4.8×10^{-2}**	**1.6×10^{-4}**	**NA**	**NA**
Inhalation of Ambient Air				
1,1-Dichloroethene	NA			
1,1,1-Trichloroethane	NA			
1,1,2-Trichloroethane	NA			
Carbon tetrachloride	1.18×10^{-1}			
Tetrachloroethene	NA			
Trichloroethene	NA			
Vinyl chloride	ND			
Pathway HI	1.2×10^{-1}			
	Well 101	**Well 102**	**Well 105**	**Well 108**
Total HI for the Future Onsite Worker Scenario	**1.7×10^{-1}**	**1.2×10^{-1}**	**1.2×10^{-1}**	**1.2×10^{-1}**

HQ = Hazard Quotient
HI = Hazard Index
NA = Noncarcinogenic toxicity criteria are not available for this chemical
ND = The chemical was not detected in "shallow" groundwater at this well

Table 3-13 Hazard Quotients and Hazard Indices for the Future Offsite Residential Scenario

Chemical	RME HQ		
	Groundwater Ingestion	Dermal Contact with Groundwater	Inhalation of Volatile Chemicals during Domestic Use of Groundwater
1,2-Dichloroethane	NA	NA	2.4×10^{-3}
1,1-Dichloroethene	2.88×10^{-3}	8.63×10^{-4}	NC
1,1,1-Trichloroethane	1.61×10^{-4}	4.82×10^{-6}	5.02×10^{-5}
1,1,2-Trichloroethane	8.39×10^{-5}	2.52×10^{-5}	NC
1,2-Dibromoethane	NC	NC	NC
Benzene	NC	NC	NC
Carbon Tetrachloride	1.37×10^{-4}	4.11×10^{-5}	NC
Trichloroethene	4.39×10^{-2}	1.32×10^{-2}	NC
Pathway HI	**4.8×10^{-2}**	**1.4×10^{-2}**	**2.5×10^{-3}**
Total HI for the Future Offsite Residential Scenario			**6.5×10^{-2}**

HQ = Hazard Quotient
HI = Hazard Index
NC = Not calculated, RfDs or RfCs for these chemicals are not available
RME = Reasonable maximum exposure
NA = Not applicable

Table 3-14 Updated Cancer Risks and Hazard Indices Stead Solvent Site

Detected Compounds	UCL (lognormal)	UCL (arithmetic)	UCL (µg/L)	Maximum (µg/L)	Cancer Risk		Hazard Index	
					UCL	Maximum	UCL	Maximum
1,1,1-Trichloroethane	84	259	259	6,200	NA	NA	0.01	0.17
1,1,2-Trichloroethane	2	9	9	230	3.02e-09	7.90e-08	0.00	0.07
1,1-Dichloroethane	2	3	3	58	NA	NA	NA	NA
1,1-Dichloroethene	35	44	44	890	1.51e-07	3.03e-06	0.01	0.23
1,2-Dibromoethane	1	2	2	23	2.19e-07	2.29e-06	NA	NA
1,2-Dichloroethane	1	2	2	30	2.62e-10	5.13e-09	NA	NA
Benzene	2	5	5	160	9.25e-09	2.90e-07	NA	NA
Carbon Tetrachloride	1	1	1	1	NA	NA	NA	NA
Chloroform	2	2	2	25	NA	NA	NA	NA
cis-1,2-Dichloroethene	2	2	2	18	NA	NA	NA	NA
Ethylbenzene	1	5	5	210	NA	NA	NA	NA
m,p-Xylene	1	13	13	600	NA	NA	NA	NA
Methylene Chloride	1	2	2	1	NA	NA	NA	NA
o-Xylene	1	3	3	130	NA	NA	NA	NA
Tetrachloroethene	2	8	8	170	5.47e-08	1.16e-06	0.04	0.93
Toluene	1	6	6	240	NA	NA	NA	NA
Trichloroethene	959	513	959	9,200	8.59e-07	8.25e-06	5.45	52.33
TOTAL CANCER RISKS/HAZARD INDICES					1.29e-06	1.50e-05	5.52	53.74

COPCs for the site are shown in **bold type**

Table 3-15 Updated Potential Residential Risks from Exposure to Site-Related Contaminants in SLWDC-4 Stead Solvent Site

Chemical	1995 Maximum Detected Concentration (µg/L)	Cancer Risk Ingestion, Dermal, Inhalation[a]	1998/1998 Maximum Detected Concentration (µg/L)	Implied Updated Cancer Risk
1,1,1-Trichloroethane	420	NA	6,200	NA
1,1,2-Trichloroethane	5.2	5.53E-09	230	2.45E-07
1,1-Dichloroethene	180	3.23E-06	890	1.60E-05
1,2-Dibromoethane	120	4.10E-05	23	7.86E-06
1,2-Dichloroethane	6.3	5.00E-08	30	2.38E-07
Benzene	410	8.42E-08	160	3.29E-08
Tetrachloroethene	1.5	NA	170	NA
Trichloroethene	2,600	6.71E-07	9,200	2.37E-06
Total Risk		4.51E-05		2.67E-05

Chemical	1995 Maximum Detected Concentration (µg/L)	Hazard Index Ingestion, Dermal, Inhalation[a]	1998/1998 Maximum Detected Concentration (µg/L)	Implied Updated Hazard Index
1,1,1-Trichloroethane	420	7.60E-04	6200	1.12E-02
1,1,2-Trichloroethane	5.2	1.09E-05	230	4.83E-04
1,1-Dichloroethene	180	3.74E-03	890	1.85E-02
1,2-Dibromoethane	120	2.4E-03	23	4.6E-04
1,2-Dichloroethane	6.3	4.62E-04	30	2.20E-03
Benzene	410	NA	160	NA
Tetrachloroethene	1.5	NA	170	NA
Trichloroethene	2600	5.71E-02	9200	2.02E-01
Total Risk		6.21E-02		2.34E-01

[a] Taken from Table H-10 (cancer risks) or H-12 (Hazard Indices)

Table 3-16 Phase II Remedial Action Alternatives for Screening

Alternative 1: No Action ▪ Long-term monitoring/contingency plan
Alternative 2: Institutional Controls ▪ Long-term monitoring/contingency plan ▪ Institutional controls (including construction practices and limiting groundwater use permits)
Alternative 3: SVE/Air Sparging/Institutional Controls ▪ Soil vapor extraction in source area ▪ Air sparging in source area ▪ Institutional controls (including construction practices and limiting groundwater use permits) ▪ Long-term monitoring/contingency plan
Alternatives 4A and 4B: Dual Phase Extraction or Groundwater Recirculation/Phytoremediation ▪ Dual phase extraction in source area with discharge to POTW (Alternative 4A) ▪ Groundwater recirculation in source area (Alternative 4B) ▪ Phytoremediation in plume area ▪ Monitored natural attenuation in plume area ▪ Institutional controls (including construction practices and limiting groundwater use permits) ▪ Long-term monitoring/contingency plan
Alternatives 5A and 5B: Dual Phase Extraction or Groundwater Recirculation/Phytoremediation/Hydraulic Containment to TCE ACL ▪ Dual phase extraction in source area with nitrogen treatment and NPDES discharge (Alternative 5A) ▪ Groundwater recirculation in source area (Alternative 5B) ▪ Phytoremediation in plume area ▪ Hydraulic containment to TCE ACL in plume area with air stripper and nitrogen treatment and NPDES discharge ▪ Monitored natural attenuation in plume area ▪ Institutional controls (including construction practices and limiting groundwater use permits) ▪ Long-term monitoring/contingency plan
Alternatives 6A and 6B: Dual Phase Extraction or Groundwater Recirculation/Phytoremediation/Hydraulic Containment to MCLs ▪ Dual phase extraction in source area with nitrogen treatment and NPDES discharge (Alternative 6A) ▪ Groundwater recirculation in source area (Alternative 6B) ▪ Hydraulic containment to MCLs in plume area with air stripper and nitrogen treatment and NPDES discharge ▪ Phytoremediation in plume area ▪ Monitored natural attenuation in plume area ▪ Institutional controls (including construction practices and limiting groundwater use permits) ▪ Long-term monitoring/contingency plan

ACL Alternative contaminant level
MCL Maximum contaminant level

Table 3-17 Initial Alternative Screening Table

Alternative	Effectiveness	Implementability	Capital Costs	Total Annualization Costs	Present Worth (6.875%)	Status
1. No Action	1	5	$0	$754,000	$754,000	Retain
2. Institutional Controls	1	5	$59,000	$769,000	$828,000	Combine with all alternatives
3. SVE/Air Sparging/Institutional Controls	1	4	$612,000	$1,574,000	$2,186,000	Screen out
4A. Dual Phase Extraction/Phytoremediation/ Institutional Controls	3	3	$798,000	$1,601,000	$2,399,000	Retain
4B. SVE/Groundwater Recirculation/ Phytoremediation	2	3	$882,000	$1,752,000	$2,634,000	Retain
A. Dual Phase Extraction/Hydraulic Containment to ACL/Phytoremediation	4	2	$1,018,000	$2,458,000	$3,476,000	Retain
5B. SVE/Groundwater Recirculation/Hydraulic Control to ACL/Phytoremediation	3	2	$1,206,000	$2,589,000	$3,796,000	Retain
6A. Dual Phase Extraction/Hydraulic Containment to MCLs/Phytoremediation	5	1	$1,209,000	$2,662,000	$3,871,000	Screen out
6B. SVE/Groundwater Recirculation/Hydraulic Control to MCLs/Phytoremediation	4	1	$1,398,000	$2,891,000	$4,289,000	Screen out

Notes: 5 is the highest score on a scale of 1 to 5
Detailed cost estimates for retained alternatives are summarized in Table 6-2 and detailed in Appendix M

Table 3-18 Present Worth Costs for Discharge Options for Retained Alternatives

Discharge Option	Remedial Alternative		
	Alternative 4A	Alternative 5A	Alternative 5B
POTW	$99,153	$226,582	$149,046
NPDES	$109,614	$356,970	$326,468
UIC	$164,072	$456,615	$468,377

Table 3-19 Summary of Institutional and Land Use Restrictions

Remedial Alternative	Fencing Required *	Deed Restrictions	Land Use Restrictions	Development Restrictions	Groundwater Use Restrictions
1. No Action	No	Yes	Yes	Yes	Yes
4A. Dual Phase Extraction/Phytoremediation/Monitored Natural Attenuation/Institutional Controls	Yes	Yes	Yes	Yes	Yes
4B. Groundwater Recirculation/Phytoremediation/ Monitored Natural Attenuation/Institutional Controls	Yes	Yes	Yes	Yes	Yes
5A. Dual Phase Extraction/Phytoremediation/Monitored Natural Attenuation/Institutional Controls Hydraulic Containment at the TCE ACL	Yes	Yes	Yes	Yes	Yes
5B. Groundwater Recirculation/Phytoremediation/ Monitored Natural Attenuation/Institutional Controls/Hydraulic Containment at the TCE ACL	Yes	Yes	Yes	Yes	Yes

* Fencing requirements around areas with active remediation apply to the period of remediation only.
Yes Restrictions apply.
No No restrictions after remediation assuming that ARARs and cleanup goals are met.

Table 3-20 Detailed Alternative Screening Balancing Criteria

Remedial Action	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity, and Volume (M/T/V)	Short-Term Effectiveness	Implementability	Capital Costs	Total Annualized Costs	Total Present Worth Cost
1. No Action	Does not limit migration of or remove contaminants. Does not reduce exposure pathways.	Slight reduction in M/T/V due to natural attenuation	Level D protective equipment would be required during groundwater sample collection.	High implementability since only long-term monitoring is required.	$0	$690,000	$690,000
4A. Dual Phase Extraction/ Phytoremediation/ Monitored Natural Attenuation/Institutional Controls	Pathway exposure is reduced for onsite, not for offsite. Reduces contamination and potential for further migration.	Reduces contaminant M/T/V. Incomplete but permanent remedy followed by possible attenuation of remaining contaminants.	Level D protective equipment would be required during well drilling and groundwater sample collection. Dual phase extraction operation and drilling activities may result in minimal VOC releases.	POTW discharge required, and operator error or system failure could result in contaminant release to POTW.	$1,071,000	$1,669,000	$2,740,000
4B. Groundwater Recirculation/ Phytoremediation/ Monitored Natural Attenuation/Institutional Controls	Pathway exposure is reduced for onsite, not for offsite. Reduces contamination and potential for further migration.	Reduces contaminant M/T/V. Incomplete but permanent remedy followed by possible attenuation of remaining contaminants.	Level D protective equipment would be required during well drilling and groundwater sample collection. Groundwater recirculation operation and drilling activities may result in minimal VOC releases.	No discharge issues. O&M for recirculation systems likely higher than for dual phase systems and would operate longer.	$1,107,000	$2,057,000	$3,164,000
5A. Dual Phase Extraction/Hydraulic Containment at ACL/ Phytoremediation/ Monitored Natural Attenuation/Institutional Controls	Pathway exposure is significantly reduced. Reduces contamination and potential for further migration both onsite and offsite.	Significantly reduces contaminant M/T/V. Incomplete but permanent remedy followed by possible attenuation of remaining contaminants.	Level D protective equipment would be required during well drilling and groundwater sample collection. Dual phase extraction operation and drilling activities may result in minimal VOC releases.	POTW discharge required, and operator error or system failure could result in contaminant release to POTW. Additional O&M for extraction wells and pumps.	$1,614,000	$3,217,000	$4,831,000
5B. Groundwater Recirculation/Hydraulic Containment at ACL/ Phytoremediation/ Monitored Natural Attenuation/Institutional Controls	Pathway exposure is significantly reduced. Reduces contamination and potential for further migration both onsite and offsite.	Significantly reduces contaminant M/T/V. Incomplete but permanent remedy followed by possible attenuation of remaining contaminants.	Level D protective equipment would be required during well drilling and groundwater sample collection. Groundwater recirculation operation and drilling activities may result in minimal VOC releases.	POTW discharge required, and operator error or system failure could result in contaminant release to POTW. Additional O&M for extraction wells and pumps.	$1,750,000	$3,627,000	$5,377,000