Draft Final
Operable Unit Carbon Tetrachloride Plume Remedial Investigation/Feasibility Study Work Plan Former Fort Ord, California

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ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
ARCH	Air rotary casing hammer
Army	United States Department of the Army
bgs	below ground surface
BLM	Bureau of Land Management
CDFG	California Department of Fish and Game
CDQMP	Chemical Data Quality Management Plan
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CRP	Community Relations Plan
CT	carbon tetrachloride
DHS	Department of Health Services (now Department of Toxic Substances Control, a part of Cal/EPA)
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
F	Fahrenheit
FFA	Federal Facilities Agreement
FORA	Fort Ord Reuse Authority
FO–SVA	Fort Ord–Salinas Valley Aquitard
FS	feasibility study
FSP	Field Sampling Plan
GPR	Ground penetrating radar
Harding ESE	Harding ESE, a MACTEC Company (formerly Harding Lawson Associates)
HASP	Health and Safety Plan
HLA	Harding Lawson Associates (now Harding ESE)
HMP	Habitat Management Plan
IDW	investigation derived waste
LVDC	light vehicle driving course
MCL	Maximum Contaminant Level
MCWD	Marina Coast Water District
MNA	monitored natural attenuation
MSL	mean sea level
ORP	oxidation reduction potential
OU	operable unit
QAPP	Quality Assurance Project Plan
QA	Quality Assurance
QC	Quality Control

RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SAR	sodium adsorption ratio
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
SUMP	Site Use Management Plan
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Department of the Interior, Fish and Wildlife Service
VOC	volatile organic compound

1.0 INTRODUCTION

This Remedial Investigation/Feasibility Study (RI/FS) Work Plan describes the tasks associated with conducting an RI/FS for the carbon tetrachloride study area, referred to as the Operable Unit Carbon Tetrachloride Plume (OU CTP) site, at the former Fort Ord (Fort Ord), California (Plate 1). Based on previous investigations previous investigations conducted by Harding ESE, Inc. (Harding ESE) on behalf of the U.S. Army (Army) and Army Corps of Engineers (USACE), carbon tetrachloride (CT) has been detected in soil gas and groundwater at the site, and is present in groundwater at concentrations exceeding the state maximum contaminant level (MCL). These previous investigations were conducted as part of a Federal Facilities Agreement (FFA) signed by Fort Ord for the Army with the U.S. Environmental Protection Agency, Region IX (EPA); the former California Department of Health Services (DHS), now known as the Department of Toxic Substances control (DTSC), a part of the California Environmental Protection Agency (Cal/EPA); and the California Regional Water Quality Control Board, Central Coast Region (RWQCB) in July 1990.

Several planning documents related to investigation and cleanup activities at Fort Ord have been prepared under the direction of the USACE including:

- Health and Safety Plan (HASP; *Harding ESE, 2002g*)
- Site Safety and Health Plan (SSHP; *HLA, 1995*)
- Sampling and Analysis Plan (SAP; *Harding ESE, 2002f*)
- Chemical Data Quality Management Plan (CDQMP; *HLA, 2002h*)
- Community Relations Plan (CRP; *HLA, 1991)*

1.1 Work Plan Purpose and Objectives

The purpose of this Work Plan is to describe the tasks involved in conducting an RI/FS for the OU CTP area at Fort Ord. The objectives of this Work Plan include: 1) further delineating the extent of CT in groundwater in the A-Aquifer, the Upper and Lower 180-Foot Aquifers, and the 400-Foot Aquifer; 2) further characterizing the hydraulic properties of these aquifers; 3) evaluating the potential for natural attenuation processes to occur within the aquifer and degrade CT; and 4) constructing a groundwater flow and mass transport model to simulate the current extent of contamination, and provide additional data for the evaluation of remedial alternatives in the FS to address the presence of CT in groundwater.

1.2 Work Plan Organization

Harding ESE has prepared this Work Plan in accordance with EPA's *Guidance of Conducting Remedial Investigations/Feasibility Studies Under CERCLA (EPA, 1988*) and the Work Plan outline included in the FFA.

2.0 SITE HISTORY AND SETTING

The following sections summarize the location, general history, and physical setting of Fort Ord, as well as a general description of geologic and hydrogeologic features at OU CTP.

2.1 Location

Fort Ord is adjacent to Monterey Bay in northwestern Monterey County, California, approximately 80 miles south of San Francisco (Plate 1). The base consists of approximately 28,000 acres adjacent to the cities of Seaside, Sand City, Monterey, and Del Rey Oaks to the south and Marina to the north. Highway 1 passes through the western part of the Fort Ord, separating the beachfront portions from the rest of the base. The south and southeast portions of the Fort Ord are bordered by unincorporated portions of Monterey County, and include several communities as well as the Laguna Seca Recreation Area and Toro Regional Park. Land use immediately east of the Fort Ord is primarily agricultural.

OU CTP is located in the northern portion of Fort Ord, generally east of the city of Marina and west of Blanco Road (Plate 2). This area encompasses the lateral extent of CT detected in three different aquifers up to 550 feet below ground surface (bgs) (Section 3.2).

2.2 General History

Beginning with its founding in 1917, Fort Ord served primarily as a training and staging facility for infantry troops. From 1947 to 1974, Fort Ord was a basic training center. After 1974, the 7th Infantry Division occupied Fort Ord. Fort Ord was selected in 1991 for decommissioning, but troop reallocation was not completed until 1993. Although Army personnel still operate the base, no active Army division is stationed at Fort Ord.

2.3 Land Use

The area south of Reservation road within the Fort Ord boundary included in OU CTP was primarily used as a light vehicle driving course (LVDC) and a wireman training course. The area north of Reservation Road was used for general training exercises. The eastern portion of Marina was primarily used for agriculture and livestock until the 1960s when the area was converted to residential use.

In the late 1980s, the Preston Park housing area was established and a significant portion of the former training area and LVDC was developed as residential housing. Since the closure of Fort Ord in 1994, the Fort Ord Reuse Authority (FORA) has been charged with the conversion of the base for commercial, residential, educational, and industrial land uses. Within the OU CTP area, the area north of Reservation Road was transferred in 1995 to the University of California to form a biological reserve. Further development is planned north of Reservation Road, including the expansion of the Monterey Bay Education Science and Technology Center of the University of California, Santa Cruz; land in this area will be used by a variety of light industry, commercial, and educational tenants. Further north the Fritzsche Army Airfield (FAAF) property was transferred to the city of Marina; this facility is now an operational commercial airport called the Marina Airport, which serves light fixed-wing aircraft and helicopters.

The future land uses presented in this section are primarily based upon the FORA March 1997 Fort Ord Base Reuse Plan (*FORA, 1997*) and the July 1995 U.S. Army Corps of Engineers (USACE) and Bureau of Land Management (BLM) Site Use Management Plan (SUMP) (*USACE, 1995*). Other sources of future land use information were provided in public benefit conveyance, negotiated sale requests, and transfer documents, and in the Installation-Wide Multispecies Habitat Management Plan (HMP) (*HLA, 1997*). The Reuse Plan identified approximately 20 land use categories at Fort Ord (*FORA, 1997*) including habitat management, open space/recreation, institutional/public facilities, commercial, industrial/business park, residential, tourism, mixed use, and others.

The HMP (*HLA, 1997*) presents the revised boundaries of the habitat reserve areas and describes special land-use controls and habitat monitoring requirements for target species within the HMP reserve and development areas. The HMP confirms locations of low-intensity uses such as the HMP reserve areas; it also specifies an allowance for development within the reserve areas for public access support facilities in as much as 2 percent of the area.

2.4 Infrastructure

Infrastructure components within the study area boundaries include the current and historical water supply system, the storm drain system, and the sanitary sewer system. The active water supply and sanitary sewer systems at Fort Ord have recently been transferred to the Marina Coast Water District (MCWD). All three infrastructure components are described below.

2.4.1 Water Supply System

Two water supply systems are located within the study area boundaries (Plate 2) - the Fort Ord system, and the MCWD system. The Fort Ord water supply system historically included conveyance from drinking water wells Nos. 26, 27, and 28, located within the OU CTP. These wells were deactivated in the late 1980's due to seawater intrusion, but No. 27 had also been placed on standby status prior to its deactivation due to detection of CT. These wells were destroyed in 1999 and the connection to the water system has been disconnected. The common water line still exists in the area, but has been isolated from the remaining water system. There are currently no drinking water wells within the study area boundary on Fort Ord property.

The MCWD drinking water system within the study area boundary historically included Well Nos. 5, 8, and 8a and, since 1986, No. 11. Of these, Well Nos. 5 and 8 have been destroyed, 8a is inactive and is currently being converted by the Army to a monitoring well, and No. 11 is active. Of the four aquifers identified at Fort Ord described in Section 4.9 (the A-Aquifer, the Upper and Lower 180-Foot Aquifers, 400-Foot Aquifer, and the Deep Aquifer), Well No. 11 is the only well that is screened in the Deep Aquifer. No volatile organic compounds (VOCs) have been detected in Well No. 11 to date; however, CT had been detected at MCWD-8a at low concentrations concurrently with the Fort Ord Well Nos. 26, 27, and 28 in the late 1980's and early 1990's.

One irrigation well also exists within the study area boundaries and is located at a storage facility called Marina Mini-Storage; the well is hence referred to as the mini-storage well. This well extracts water from the upper portion of the Lower 180-Foot Aquifer and irrigates a small landscaped portion of the property. The frequency of operation and maximum capacity of the pump are not known. Recently the well head and pressure tanks have been moved to a subsurface vault by the property owner, presumably as part of business expansion. The property is supplied with drinking water from the city municipal system.

2.4.2 Storm Drainage and Sanitary Sewer Systems

As of this past year, Marina Coast Water District is responsible for the storm drainage and sanitary sewer systems throughout Fort Ord. Within the OU CTP area, these systems are in place throughout the Preston Park Housing area and within the eastern portion of the city of Marina.

2.5 Climate

The area's climate is characterized by warm, dry summers and cool, rainy winters. The Pacific Ocean is the principal influence on the climate at Fort Ord, and the source of fog and onshore winds that moderate temperature extremes. Daily ambient air temperatures typically range from 40 to 70 degrees Fahrenheit (F), but temperatures in the low 100s have occurred. Thick fog is common in the morning throughout the year. Winds are generally from the west.

The average annual rainfall of 14 inches occurs almost entirely between November and April. Because the predominant soil is permeable sand, runoff is limited and streamflow occurs only intermittently and within the very steep canyons in the eastern portion of Fort Ord.

2.6 Ecological Setting

Fort Ord is located on California's central coast, a biologically diverse and unique region. The range and combination of climatic, topographic, and soil conditions at Fort Ord support many biological communities. Field surveys were conducted from 1991 through 1994 to provide detailed site-specific, as well as basewide, information regarding plant communities, botanical resources, observed and expected wildlife, and biological resources of concern. Plant communities were mapped for the whole base as described in the *Draft Basewide Biological Inventory, Fort Ord, California* (*HLA, 1992*).

The OU CTP area is typically described as including the following plant communities: central maritime chaparral; Coast live oak woodland; grassland; and developed/landscaped areas. Central maritime chaparral is the most extensive natural community at Fort Ord, occupying approximately 12,500 acres in the south-central portion of the base. Grasslands, located primarily in the southeastern and northern portions of the base, occupy approximately 4,500 acres. The remaining approximately 4,000 acres of the base are considered fully developed and not defined as ecological communities.

Special-status biological resources are those resources, including plant and wildlife taxa and native biological communities, that receive various levels of protection under local, state, or federal laws, regulations, or policies. The closure and disposal of Fort Ord is considered a major federal action that could affect several species of concern and other rare species listed by the California Department of Fish and Game and/or the California Native Plant Society, or listed as threatened or endangered under the federal Endangered Species Act (ESA). The U.S. Department of the Interior, Fish and Wildlife Service's (USFWS's) final Biological Opinion for the Disposal and Reuse of Fort Ord (*USFWS, 1993*) required that a habitat management plan be developed and implemented to reduce the incidental take of listed species and loss of habitat that supports these species. The HMP for Fort Ord complies with the USFWS Biological Opinion and establishes the guidelines for the conservation and management of wildlife and plant species and habitats that largely depend on Fort Ord land for survival (*HLA, 1997*). Of the 12 plant communities identified at Fort Ord, two are considered rare or declining and of highest inventory priority by the California Department of Fish and Game (*CDFG, 1997*): central maritime chaparral and valley needlegrass grassland. Special-status taxa that occur or potentially occur in the plant communities at Fort Ord include 22 vascular plants, 1 invertebrate, 4 reptiles, 1 amphibian, 9 birds, and 2 mammals.

Within the area of OU CTP, specific resources of concern include Monterey spineflower (Chorizanthe p. pungens), sand gilia (Gilia tenuiflora arenaria), sandmat manzanita (Arctostaphylos pumila), toro manzanita (Arctostaphylos montereyensis), coast wallflower (Erysimum ammophilum), Monterey ceanothus (Ceanothus cuneatus rigidus), Eastwood's goldenbush (Ericameria fasciculata), and the black legless lizard (Anniella pulchra nigra). Coast live oak (Quercus agrifolia) woodland is considered to be potential habitat for the Monterey ornate shrew (Sorex ornatus salarius) and the Monterey dusky-footed woodrat (Neotoma fuscipes luciana).

2.7 Topography and Surface Waters

Elevations at Fort Ord range from approximately 900 feet above mean sea level (MSL) near Wildcat Ridge, on the east side of the base, to sea level at the beach. Topographic elevations within the OU CTP area range from about 40 to 180 feet MSL (Plate 3). The predominant topography of the area reflects morphology typical of the dune sand deposits that underlie the western and northern portions of the base, including the area currently under investigation for CT contamination. In these areas, the ground surface slopes gently west and northwest, draining toward Monterey Bay. Runoff is minimal because of the high rate of surface-water infiltration into the permeable dune sand; consequently, well-developed natural drainages are absent throughout much of this area. Closed drainage depressions typical of dune topography are common.

2.8 Geology

Fort Ord is within the Coast Ranges Geomorphic Province. The region consists of northwest-trending mountain ranges, broad basins, and elongated valleys generally paralleling the major geologic structures. In the Coast Ranges, older, consolidated rocks are characteristically exposed in the mountains but are buried beneath younger, unconsolidated alluvial fan and fluvial sediments in the valleys and lowlands. In the coastal lowlands, these younger sediments commonly interfinger with marine deposits.

Fort Ord is at the transition between the mountains of the Santa Lucia Range and the Sierra de la Salinas to the south and southeast, respectively, and the lowlands of the Salinas River Valley to the north. The geology of Fort Ord generally reflects this transitional condition; older, consolidated rock is exposed at the ground surface near the southern base boundary and becomes buried under a northward-thickening sequence of poorly consolidated deposits to the north. Fort Ord and the adjacent areas are underlain, from depth to ground surface, by one or more of the following older, consolidated units:

- Mesozoic granitic and metamorphic rocks
- Miocene marine sedimentary rocks of the Monterey Formation
- Upper Miocene to lower Pliocene marine sandstone of the Santa Margarita Formation (and possibly the Pancho Rico and/or Purisima Formations).

Locally, these units are overlain and obscured by geologically younger sediments, including:

- Plio-Pleistocene alluvial fan, lake, and fluvial deposits of the Paso Robles Formation
- Pleistocene eolian and fluvial sands of the Aromas Sand
- Pleistocene to Holocene valley fill deposits consisting of poorly consolidated gravel, sand, silt, and clay
- Pleistocene and Holocene dune sands
- Recent beach sand
- Recent alluvium.

The geology of Fort Ord is described in detail in Volume II of the Basewide RI, Basewide Hydrogeologic Characterization (*HLA, 1994*).

2.9 Hydrogeology

Hydrostratigraphic units of interest within OU CTP include aquifers within the dune sands, valley fill deposits, and the Aromas Sand/Paso Robles Formation. The A-Aquifer is located within the recent dune sands and is perched above a regional aquitard called the Fort Ord-Salinas Valley Aquitard (FO-SVA). The valley fill deposits contain both the Upper and Lower 180-Foot Aquifers, and portions of the 400-Foot Aquifer locally. The Aromas Sand and Paso Robles Formation contain the 400-Foot Aquifer and the Deep Aquifer. The following sections describe the present groundwater monitoring well locations relevant to OU CT, and the characteristics of the four affected aquifers.

2.9.1 Present Groundwater Monitoring Well Locations

Plates 4, 5, and 6 illustrate existing monitoring well locations used to monitor groundwater quality and elevations in the vicinity of each CT plume in the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot/400-Foot Aquifers, respectively. Additionally, previously used municipal wells (including those now destroyed and one inactive well), an active drinking water well, and a private irrigation well are also illustrated on Plate 6. Cross-section locations are illustrated on Plates 7 and 10.

2.9.2 A-Aquifer

The A-Aquifer is generally located within recent dune sands overlying a gently dipping marine clay unit (FO-SVA) that generally controls the direction of groundwater flow in this aquifer. However, in the downgradient area of the CT plume (west of MW-BW-44-A), the upper portion of the FO-SVA appears to have been removed and replaced with a clean beach sand and gravel unit. Dune sand was observed overlaying this beach sand and gravel unit. The sand and gravel unit appears to have been deposited in a marine environment as indicated by traces of shell fragments in drilling cuttings. Coarse material included polished chert pebbles and well-rounded granite gravel up to 1.5 inches in diameter, as observed at MW-BW-44-A. The abrupt transition of the upper surface of the FO-SVA between wells MW-BW-43-A and MW-BW-44-A (about 100 yards) combined with the lithologic contents is suggestive of a wave-cut terrace. The coarse material was probably transported by littoral currents although the ultimate origin has not yet been determined. A cross-sectional view of the A-Aquifer along the axis of the CT plume is illustrated on Plate 7.

The recent dune sands are primarily well-graded fine- to medium-grain or fine- to coarse-grain sand, usually with a minor silt component. The saturated portion of the dune sands, the A-Aquifer, is composed of fine- to coarse-grain, well-graded sand east of the terrace. Typically, at least one foot of gray-blue clay was penetrated at each A-Aquifer borehole to confirm the presence of the FO-SVA prior to constructing the well; the augers were also inspected for clay upon their removal from the borehole to confirm that the FO-SVA had been encountered.

Elevations of the top of the FO-SVA ranges from 19 feet below MSL at MW-BW-47-A to 58 feet above MSL at MW-BW-54-A. Data indicate the top of the FO-SVA uniformly dips to the west beneath the CT plume area until reaching the terrace where elevations abruptly drop about 30 feet further west. The water table in the A-Aquifer mimics and is controlled by the FO-SVA top surface.

The absence of the upper portion of the FO-SVA in the downgradient area of the CT plume does not appear to change the aquitard status of this clay unit. Regionally, the FO-SVA appears to extend 2,000 to 4,000 feet farther west of MW-B-11-A, based on lithologic logs from MCWD wells. The lower clay units of the FO-SVA appear to be laterally continuous throughout the CT investigation area.

As in previous investigations of the CT plume, neither lithologic nor geophysical data indicate the presence of channels in the surface of the FO-SVA as has been observed to the north in the OU 1 investigation area. However, the facies change from dune sand to clean beach sand and gravel in the downgradient area of the CT plume may be of particular significance with respect to its potential for continued migration. Although no channels have been observed, groundwater velocities are expected to be much higher in the sand and gravel unit relative to the dune sand unit.

Groundwater flows through the A-Aquifer northwest from the suspected source area to about MW-BW-27-A from which groundwater flows more westward (Plate 8). West of MW-BW-45-A, groundwater flow appears to subtly shift toward the south. This subtle change in flow direction is apparently related to the facies change discussed above. Groundwater gradients in the A-Aquifer across the site vary from 0.005 feet/foot near the suspected source area to 0.008 feet/foot farther downgradient. West of the facies change, the gradient is considerably less (about 0.0014 feet/foot) which reflects the higher hydraulic conductivity of the beach sand and gravel unit relative to the dune sand.

Hydrographs from representative A-Aquifer monitoring wells are illustrated on Plate 9 and indicate that groundwater elevations are relatively stable yearlong, despite significant irrigation to the east from the Salinas Valley. A notable exception was observed during the 1997/98 winter when unusually large amounts of rainfall occurred as part of an El Niño event. As a result of this event the water table locally rose over 5 feet.

The A-Aquifer thickness varies from about 12 feet at MW-BW-42-A to about 32 feet at MW-BW-35-A based on groundwater elevations measured in January 2001. The aquifer generally thins in the downgradient direction from about 30 feet near the suspected source area to less than 20 feet near MW-BW-42-A.

The additional data from MW-BW-51-A and MW-BW-54-A further refines the location of the A-Aquifer groundwater divide east of the CT plume. The location of the divide appears to be generally controlled by the surface of the FO-SVA. The groundwater divide appears to have prevented the CT plume from migrating east of the suspected source area; although the detection of CT at MW-BW-16-A (east of the groundwater divide) at low concentrations warrants further assessment.

2.9.3 Upper 180-Foot Aquifer

The Upper 180-Foot Aquifer has been characterized to a lesser degree within OU CTP than the A-Aquifer due to the greater depth and cost associated with installing each monitoring well. Data from the nine monitoring wells installed within the OU CTP area indicate that the Upper 180-Foot Aquifer is about 60 feet thick and is characterized by fine to coarse sand which grades to a sand and gravel layer near the base of the aquifer (Plate 10). Although the hydraulic conductivity of this aquifer in this area has not been quantified, it is assumed that its value would be considerably higher than that of the A-Aquifer based on aquifer test data previously collected 3,000 feet south of the study area. Groundwater in the Upper 180-Foot Aquifer throughout the Main Garrison area of Fort Ord generally flows eastward toward Salinas Valley; however, gradients within the OU CTP area reflect a local southeastern flow direction (Plate 12). This local discrepancy seems to reflect a discharge area to the Lower 180-Foot Aquifer southeast of OU CTP. Groundwater elevations across the site vary with a small gradient of about 0.001 feet/foot; however, seasonal stresses are significant and result in groundwater elevation fluctuations of about eight feet.

Hydrographs of Upper 180-Foot Aquifer wells in the study area indicate that groundwater in the Upper 180-Foot Aquifer reflects a seasonal pattern previously observed during basewide monitoring that matches the schedule of groundwater pumping from Salinas Valley (Plate 11). South and east of the study area, seasonal fluctuations in Upper 180-Foot Aquifer groundwater elevations drop groundwater elevations slightly below the bottom of the FO-SVA, creating unconfined conditions. Within the study area, however, groundwater elevations remain above the bottom of the FO-SVA thus maintaining confined conditions yearlong.

2.9.4 Lower 180-Foot and 400-Foot Aquifers

The Lower 180-Foot Aquifer is separated from the overlying Upper 180-Foot Aquifer by a zone of clay and clayey sand units called the Intermediate 180-Foot Aquitard (Plate 10). Two clay zones are observed to comprise this aquitard to the west, but appear to merge into one to the east. Both have been observed further east and south of the study area and groundwater elevations in the sand units between the two (where distinct) are similar to elevations within the Lower 180-Foot Aquifer. For this reason, it was concluded that the upper clayey zone be referred to as the Intermediate 180-Foot Aquitard, and that the lower zone may lie within the Lower 180-Foot Aquifer itself (*Harding ESE, 2001a*). Data from the current investigation suggests that, lithologically, the clay zones are part of the same aquitard and will be collectively referred to as the Intermediate 180-Foot Aquitard. Yellowish brown clays were observed throughout this aquitard, although the lower portion also contains greenish gray silt and an olive-colored fat clay, possibly indicating a marine origin. The sand observed within the Intermediate 180-Foot Aquitard is not clearly defined as belonging to either the Upper 180-Foot Aquifer or to the Lower 180-Foot Aquifer.

Sand and/or gravel of the Lower 180-Foot Aquifer was typically observed in drilling cuttings to 100 feet below the Intermediate 180-Foot Aquitard, although geophysical logs also indicate several thin clay or silt units that appear to be somewhat laterally continuous throughout the study area. Although the predominant lithology of the Lower 180-Foot is sand and gravel, resistivity values measured in six recently installed boreholes are atypically low (less than 20 ohm-meters^2) through this depth range, especially to the west of the study area. The now-destroyed drinking water wells that had been installed into the Lower 180-Foot Aquifer in the area had been abandoned during the 1980's due to seawater intrusion and the low resistivity data indicate that the Lower 180-Foot Aquifer is still contaminated with high chloride concentrations despite the cessation of groundwater production in the area from this aquifer. The lowest resistivity values were observed in boreholes MW-BW-30-180 and MW-BW-31-180, closest to the previous drinking water wells and to Monterey Bay.

The 400-Foot Aquifer, the deepest aquifer included in the study area, underlies the Valley Fill Deposits and probably consists of Aromas Sand or Paso Robles Formation sediments. A significant aquitard was not observed to separate the Lower 180-Foot Aquifer from the underlying 400-Foot Aquifer within the OU CTP; however, the natural gamma log consistently indicates (except at MW-BW-35-180) lower values in the 400-Foot Aquifer than in the Lower 180-Foot Aquifer. Resistivity data indicating seawater intrusion appears to terminate slightly deeper than the gamma shift. A fine-grained unit was not observed in drilling cuttings or in samples from the continuous core at MW-BW-32-180 near the location of the gamma shift. An aquitard between these two aquifers is apparent in the well logs of the active Fort Ord drinking water wells about a mile east of the OU CTP area.

The lithologic contact between these two aquifers appears to be indicated by natural gamma data, rather than resistivity data, as it appears that a mineralogic/lithologic change may distinguish the two aquifers. The deeper resistivity shift indicates that seawater has partially intruded the uppermost portion of the 400-Foot Aquifer, probably due to seasonal downward gradients or dispersion (*Harding ESE, 2002d*).

Gamma values increase primarily in response to the presence of potassium, which is usually found in concentrated amounts in clay units, but also in granitic rocks (feldspar). The differing amounts of potassium in the Lower 180-Foot and 400-Foot Aquifers may reflect different depositional environments.

As granite weathers, feldspar is quickly removed leaving behind silica grains that ultimately become sand. At least a portion of the sediments within the 400-Foot Aquifer were deposited in an eolian environment (*Dupre, 1975 and 1990*) which may have removed much of the original potassium via physical weathering. Sediments within the Lower 180-Foot Aquifer were primarily deposited in a fluvial environment with relatively less weathering, possibly resulting in larger residual potassium concentrations relative to the 400-Foot Aquifer.

The hydraulic contact between the Lower 180-Foot and 400-Foot Aquifers, then, appears to be one of contrast in the hydraulic conductivity of two permeable units deposited under different depositional environments. It can be inferred that the conductivity of the Lower 180-Foot Aquifer is the higher of the two because elevated chloride concentrations associated with seawater intrusion are primarily found within this aquifer and not in the 400-Foot Aquifer. Seawater, as well as any contaminant, will migrate along the pathway of least resistance (highest hydraulic conductivity).

Two clay units were observed within the 400-Foot Aquifer, the first of which was used to define the placement of the bottom two screens in each monitoring well (one above and one below). The second clay is a distinctive reddish-brown unit and was observed in the continuous core sample (MW-BW-32-180) and in cuttings from each borehole except MW-BW-35-180. In contrast, the shallower clay observed within the 400-Foot Aquifer is yellow-brown or olive gray/green. The reddish-brown clay observed at these boreholes is about 200 feet deeper than the red clay marker referenced in the 1975 Kaiser report that defined the 180-Foot Aquifer from the 400-Foot Aquifer and appears to be unrelated (*Kaiser, 1975*).

Groundwater generally flows to the east or southeast within both the Lower 180-Foot and 400-Foot Aquifers, however, there also appears to be more complex vertical flow patterns that may reflect heterogeneities within each aquifer (Plate 13). Based on data collected in December 2001 and March 2002, a vertical potential exists from the 400-Foot to the Lower 180-Foot Aquifer in the western portion of OU CTP, but this appears to be reversed somewhat in the eastern portion of OU CTP where groundwater pressures are locally lower in the 400-Foot Aquifer than in the Lower 180-Foot Aquifer. Seasonal patterns of flow within these two aquifers cannot yet be determined from wells within OU CTP.

Hydrographs of Lower 180-Foot Aquifer wells at Fort Ord indicate that groundwater elevations reflect a seasonal pattern previously observed during basewide monitoring that matches the schedule of groundwater pumping from Salinas Valley (Plate 14). Groundwater elevations appear to remain above the bottom of the Intermediate 180-Foot Aquitard, thus maintaining confined conditions yearlong.

2.9.5 Deep Aquifer

Although the Deep Aquifer will not specifically be investigated as part of this program MCWD owns and operates three drinking water wells completed in this aquifer, one of which (MCWD Well No. 11) is located within the study boundary of the current investigation. This aquifer is therefore considered a potential target for contamination from the overlying 180 and 400-Foot Aquifers and little is known about hydraulic interaction between these aquifer systems. The Deep Aquifer refers to the aquifer(s) contained in the middle or lower portions (the “B” and “C” members) of the Paso Robles Formation and include what have been called the 800-foot, 900-foot, 1,000-foot, and 1,500-Foot Aquifers (*Thorup, 1976 and 1985; Geoconsultants, 1993*). The drinking water well MCWD-11 is located within the study boundary but is completed to a depth of 1,650 with perforated intervals beginning 970 feet bgs, considerably deeper than where CT has been detected to date.

Due the greater depth and higher cost of installation, most production wells (municipal or agricultural) have not penetrated the Deep Aquifer. However, wells have been installed progressively deeper to avoid saline contaminated water; therefore, future production from the Deep Aquifer may increase. Generally, water from this aquifer contains higher natural concentrations of salt and has high sodium adsorption ratios (SAR). For this reason, growers in the Salinas Valley have found the Deep Aquifer to be less desirable as a source of irrigation water. Seawater intrusion has not been documented at the few wells that penetrate this aquifer and water quality in the Deep Aquifer; however, chloride concentrations typically range from 100 to 130 mg/L at MCWD Well No. 12 and are typically about 60 mg/L at MCWD Well No. 10 and in Well No. 11 (*MCWD, 2001*).

3.0 INITIAL EVALUATION

3.1 Summary of Previous Investigations

Previous investigations at Fort Ord have reviewed chemical use, storage, and disposal, although most of these reviews were not specific to the OU CTP site. The following sections summarize the results of previous investigations relevant to the OU CTP site; present the conceptual site model; provide a general discussion of data gaps and project data quality objectives; describe the site investigation approach; and identify potential Applicable or Relevant and Appropriate Requirements (ARARs) for the OU CTP site.

3.1.1 Reviews and Investigations of Chemical Use, Storage, and Disposal

The most comprehensive review of chemical use, storage, and disposal was conducted in the Basewide RI/FS in 1994, which evaluated the entire Fort Ord facility (*HLA, 1994*). When the basewide RI/FS was conducted, however, the extent of CT in groundwater at the OU CTP site was not known. Nonetheless, the review of basewide activities related to chemical use, storage, and disposal included the use of CT as a cleaning solvent, and indicated whether or not it had been stored and ultimately disposed at Fort Ord. The basewide review did not result in the discovery of any use of CT within the OU CTP area that would explain its presence in soil gas or groundwater.

3.1.2 Site Investigations

Several site investigations have been conducted by Harding ESE in the OU CTP area to delineate the extent of CT in groundwater within the A-Aquifer, the Upper 180-Foot Aquifer, and, most recently, the Lower 180-Foot and 400-Foot Aquifers. The site investigations conducted specific to the OU CTP area are as follows:

- HLA, 1999. *Draft Final Carbon Tetrachloride Investigation Report, Fort Ord, California.* Prepared for the U.S. Army Corps of Engineers, Sacramento District. November 10.

  This report summarizes lithologic and analytical data from historic sampling of the nearby Fort Ord and MCWD municipal drinking water wells and from the two original monitoring wells that had been installed in 1974. It also described the field program of installing four A-Aquifer monitoring wells (MW-BW-15-A through MW-BW-18-A), four Upper 180-Foot Aquifer monitoring wells (MW-BW-19-180 through MW-BW-22-180), and the collection of several Hydropunch samples.

- Harding ESE, 2001b. *Draft Final Carbon Tetrachloride Study Area, Drilling Letter Report, Former Fort Ord, California.* Prepared for the U.S. Army Corps of Engineers, Sacramento District. July 16.

  This report summarizes the drilling field program when six A-Aquifer monitoring wells (MW-BW-23-A through MW-BW-28-A) and three Upper 180-Foot Aquifer wells (MW-BW-25-180, MW-BW-26-180, and MW-BW-29-180) were installed.

- Harding ESE, 2002a. *Draft Final Natural Attenuation Summary Report, Carbon Tetrachloride Investigation, Former Fort Ord, California.* Prepared for the U.S. Army Corps of Engineers, Sacramento District. November 29.

This report summarizes analytical data collected from March 2000 through December 2000 specifically to assess the potential for natural attenuation in the A-Aquifer and Upper 180-Foot Aquifer. At the time, only the upper half of the A-Aquifer plume had been delineated. Analytical data include dissolved oxygen, oxygen reduction potential (ORP) values, dissolved gases, major cations and anions, and VOCs.

- Harding ESE, 2002b. *Draft Final Carbon Tetrachloride Study Area, Drilling Letter Report – Wells MW-BW-30-A through MW-BW-42-A*. Prepared for the U.S. Army Corps of Engineers, Sacramento District. January 31.

  This report summarizes the installation of 13 A-Aquifer monitoring wells MW-BW-30-A through MW-BW-42-A.

- Harding ESE, 2002c. *Draft Final Carbon Tetrachloride Study Area, Drilling Letter Report – Wells MW-BW-43-A through MW-BW-54-A*. Prepared for the U.S. Army Corps of Engineers, Sacramento District. February 6.

  This report summarizes the installation of 12 A-Aquifer monitoring wells MW-BW-43-A through MW-BW-54-A.

- Harding ESE, 2002d. *Preliminary Draft Carbon Tetrachloride Study Area, Drilling Letter Report – Westbay Wells*. Prepared for the U.S. Army Corps of Engineers, Sacramento District. February 15.

  This report summarizes the installation of six multiple screen monitoring wells (manufactured by Westbay Instruments, Inc.). A total of 35 monitoring ports were installed at six locations to monitor groundwater data (elevation and quality) within the Lower 180-Foot and 400-Foot Aquifers, in addition to further characterizing the lithology to depths of about 600 feet bgs.

Collectively, these site investigations provide data that can be used to the extent of CT and several CT daughter products in the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer. Recent data suggests that the 400-Foot Aquifer has not been contaminated by CT. Results from samples collected at wells within the Upper 180-Foot and Lower 180-Foot Aquifers appear to confirm that at least one previously used drinking water well had acted as a vertical conduit from the A-Aquifer. Groundwater directions have been observed for each aquifer, although the degree of seasonal changes within the Lower 180-Foot Aquifer has not yet been determined.

3.2 Conceptual Site Model

Information from previous investigations was reviewed during the scoping process and was used to create a conceptual model of contamination and receptors at Fort Ord. The model considered: known and suspected routes of migration, and known or potential human and environmental receptors (*EPA, 1988*). An overview of the conceptual site model is present in this section; additional specific information is included in Sections 4.0 and 5.0 of this Work Plan. The conceptual site model is based on information gathered in previous investigations, and will be modified on the basis of additional information gathered during the RI. The information needed to complete the conceptual site model is defined in general terms in Section 3.3 and more specifically in Sections 4.0 and 5.0.

The A-Aquifer plume area extends from the Preston Park housing area to the north where the plume diverts to the northwest and migrates parallel to Reservation Road, apparently terminating east of the Fort Ord boundary north of Reservation Road (Plate 15). The Upper 180-Foot Aquifer area essentially overlaps with the southeastern portion of the A-Aquifer plume, but also extends further east beyond Imjin

Road along Old County Road (Plate 16). The Lower 180-Foot Aquifer study area extends from the eastern portion of the city of Marina eastward to at least Imjin Road north of Reservation Road; however, the downgradient and northern extent of this plume is not yet defined (Plate 17). The conceptual migration route connecting the plumes in each of these aquifers is described in Section 3.2.2.

3.2.1 Chemical Sources

Analytical results from soil gas samples collected in 1987 and from recent groundwater samples suggest the source of CT lies in the vicinity of what is now the Preston Park housing area, just west of Imjin Road. Although a positive response of CT was noted in the 1987 soil gas samples, the concentrations reported are considered unrealistically low (detection limit was reported at 0.0005 ppb) and thus these data are considered to be qualitative only, not quantitative. This area was further investigated in 1988 using geophysical techniques (Electro-magnetic survey) and there was no indication of buried material or disturbed ground.

Historical land use of this area prior to the construction of the housing area, which occurred in 1988 and 1989, included use of a driver training course for light military vehicles (e.g., jeeps) and a wireman training area. Neither land use is normally associated with solvent usage and disposal; however, CT is a solvent known to have been used for cleaning electronic components, including radios. It is not known whether CT or any other solvent was used by the Army to clean radio components in the field as part of the wireman training activities.

3.2.2 Migration Routes

While the CT concentrations in soil gas likely correspond with the source area of CT in groundwater in the A-Aquifer, the sources of CT in the Upper and Lower 180-Foot Aquifers are more complex. The source and quantity of CT disposed and the time it was disposed is unknown. It appears that once CT migrated downward through the vadose zone to intercept the A-Aquifer water table, the resulting plume migrated northwest about ¾ of a mile where it intercepted at least one vertical conduit surrounding a previously used municipal well constructed with an inadequate sanitary seal. Suspected wells that may have acted as vertical conduits include MCWD-8, FO-26, FO-27, and FO-28 (Plate 2). Other wells in the area, including MCWD-8a, MCWD-11, and the Mini-Storage well, are not suspected to be or have been vertical conduits. It is likely that at least one of the wells suspected to have acted as a vertical conduit allowed groundwater from the A-Aquifer to migrate downward through the well annulus until it reached the Upper and Lower 180-Foot Aquifers. The A-Aquifer plume continued to migrate to the northwest/west of the suspected source area, to its current extent of approximately 1 ½ miles.

CT emerging from the well annulus in the Upper 180-Foot Aquifer appeared to continued to migrate laterally to the southeast toward a suspected pinch-out in the underlying confining unit where the CT plume appears to migrate downward and enter the Lower 180-Foot Aquifer (about 1 mile downgradient of the suspected vertical conduit). The Lower 180-Foot Aquifer plume emanating from the well annulus appears to have migrated laterally to the east for at least 1 mile. Therefore it appears that two distinct CT plumes exist within the Lower 180-Foot Aquifer, although neither the Upper 180-Foot Aquifer nor Lower 180-Foot Aquifer plumes have yet been fully delineated. The Lower 180-Foot Aquifer is thicker, has a higher hydraulic conductivity, and a lower hydraulic pressure than the Upper 180-Foot Aquifer; therefore, it is likely that the Lower 180-Foot Aquifer was and continues to be the ultimate target for CT migrating downward through the suspected vertical conduit(s). Concentrations in the Lower 180-Foot Aquifer, however, appear lower than those in the Upper 180-Foot Aquifer and possibly reflect a higher degree of dilution.

3.2.2.1 Fate

Fate processes are those associated with a change in the structure and concentration of a compound. For organic compounds in groundwater, a biodegradation process typically occurs over time to change the structure and concentration of these compounds. This process is collectively referred to as natural attenuation. Chlorinated solvents, such as CT, typically attenuate or biodegrade slowly, although they may degrade and become dechlorinated under anaerobic conditions through co-metabolic processes or by direct use of a microbial community as an electron acceptor. As previously discussed in the *Draft Final, Natural Attenuation Summary Report*, the microbial degradation of CT appears to be minimal compared to the apparent physical attenuation near the toe of the plume. Groundwater conditions do not appear to be degrading CT beyond its first daughter product (chloroform) in the source area; however, the toe of the plume had not been fully characterized during the field work reported in the *Draft Final, Natural Attenuation Summary Report* (*Harding ESE, 2002a*).

As described in Section 1.1, one of the objectives of this Work Plan is to construct a groundwater flow and mass transport model to simulate the current extent of contamination and provide additional data for the evaluation of remedial alternatives in the FS to address the presence of CT in groundwater. Based on current data regarding concentrations of CT in groundwater at the site and their property for natural attenuation, one of the remedial alternatives that should be considered in the FS is natural attenuation. Natural attenuation is defined as "*...naturally occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in those media. These in-situ processes include biodegradation, dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization or destruction of contaminants*" (*EPA, 1999*). These processes can be further simplified into chemical, physical, and biological categories, of which physical and biological processes are discussed in this report.

In most instances, chlorinated solvents biodegrade via reductive dechlorination in the presence of electron donors (e.g., non-chlorinated fuel hydrocarbons, landfill leachate, or natural organic carbon). If electron donors are depleted from the contamination site before the chlorinated compound is degraded, then biologically driven dechlorination may cease and allow the continued downgradient migration of the contaminant.

Potential degradation pathways of CT to its daughter products are illustrated below in Figure 1:

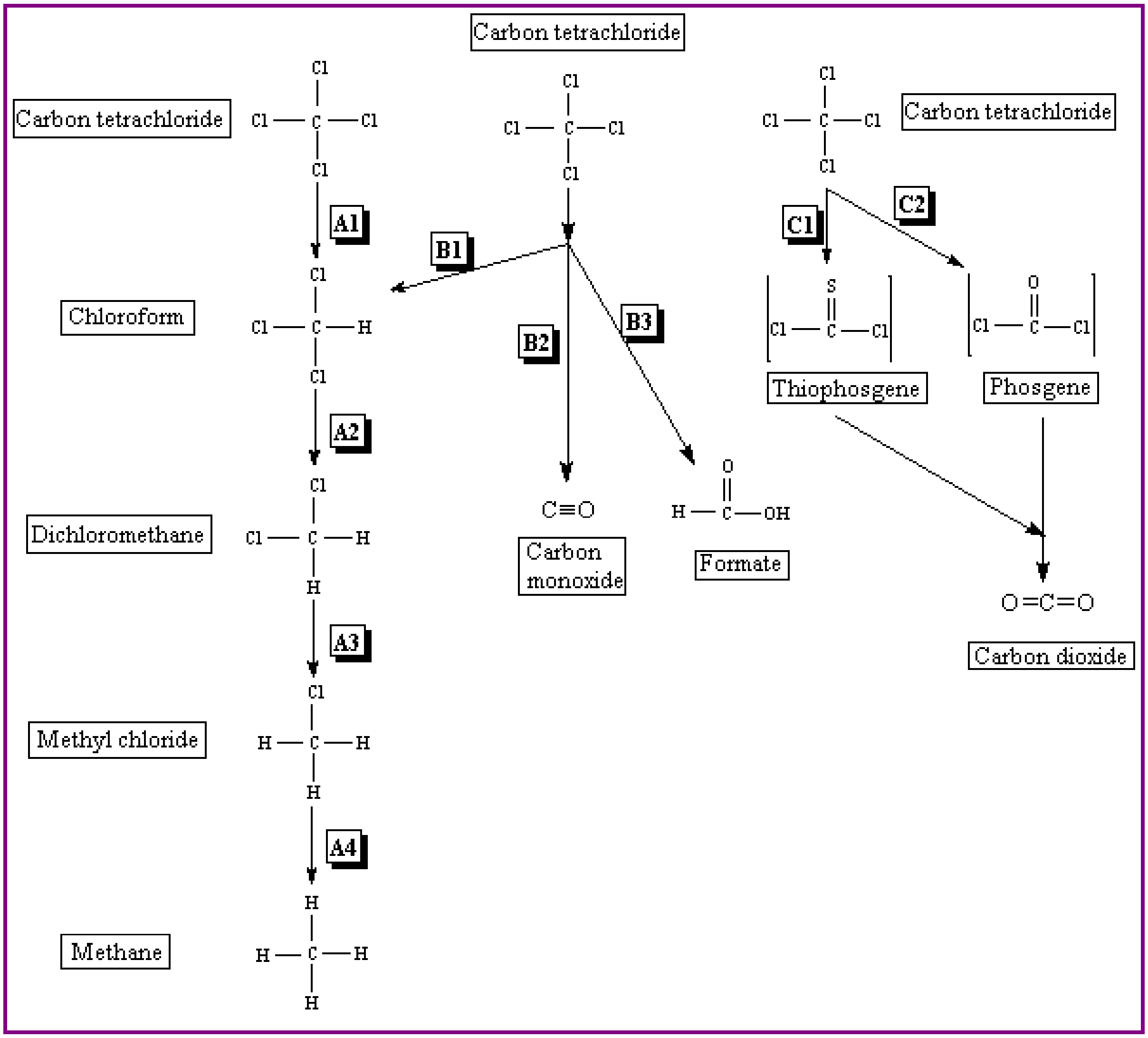


Figure 1. Carbon Tetrachloride Degradation Pathways (Timothy J. Tripp and Jiangbi Liu, University of Minnesota)

The left-most pathway in Figure 1 (the "A" pathway) is a sequential two-electron reduction process and is the model used in this report to describe anticipated daughter products. CT is degraded to chloroform, dichloromethane, chloromethane and ultimately methane by reductive dechlorination (Timothy J. Tripp and Jiangbi Liu, University of Minnesota). The "B" and "C" degradation pathways on Figure 1 also follow reductive processes, but degrade CT to carbon monoxide and carbon dioxide, respectively, without the generation of chloroform.

In addition to reductive dechlorination from microbial processes, dilution, dispersion, and adsorption are also important physical processes that account for the natural attenuation of chemical compounds. In the CT plume area, dilution is considered the most dominant process due to the very low percentage of fine grain material that would normally result in more significant sorption or dispersion effects.

A monitored natural attenuation (MNA) program is one that assesses the contaminated environment and establishes its condition relative to natural attenuation processes. A MNA program also monitors these conditions over time to evaluate the progressive natural degradation and/or removal of a contaminant or contaminants from the groundwater environment. Support for a MNA program as a remedial alternative at this site is indicated by the following three observations:

- Reductions in organic contaminant concentrations in groundwater along the flow path downgradient from the suspected source of contamination have been occurring over time
- The presence of inorganic compounds indicate a reducing environment coincident with the highest contaminant concentrations, and
- The presence of observed daughter products indicate the occurrence of biodegradation.

Section 4.0 of this Work Plan discusses the rationale for evaluating existing data and collecting additional analytical data to ascertain the potential for natural attenuation processes in each aquifer with respect to CT degradation.

3.2.2.2 Transport

Transport properties describe the partitioning of a chemical in various environmental media (e.g., soil, gas, and water) and the migration of a chemical between the media. Partitioning is described by mass transfer coefficients (e.g., Henry's Law, the organic carbon partitioning coefficient), but the partitioning coefficient can be approximated using the water solubility and vapor pressure of the chemical.

The distribution of CT and its daughter products in soil, soil gas, and groundwater requires further delineation. Unfortunately, little is known about the source of CT, including when it was released to the environment, how many release events occurred, and what amount of CT is present, and under what conditions CT was released. As discussed in Section 3.1.2, there is sufficient data to provide an overall understanding of the distribution of CT in groundwater; however, it is anticipated that results from a soil gas survey will provide additional information useful to further delineating the amount of residual source, if any, in the vadose zone.

Daughter products, most notably chloroform, have been detected throughout the CT plume in the A-Aquifer, indicating some amount of reductive dechlorination is occurring. As reported in the Draft Final Natural Attenuation Summary Report (*Harding ESE, 2002a*), the A-Aquifer plume appears to be undergoing physical attenuation at the toe of the plume where a significant change in hydrogeologic conditions occurs. Daughter products have also been detected in wells screened in the Upper and Lower 180-Foot Aquifer plumes; however, neither of these plumes have been fully delineated, and the extent to which natural attenuation processes are occurring in groundwater at these depths is not yet known.

3.2.2.3 Environmental Characteristics

A number of environmental characteristics, such as soil type, affect migration of organic compounds in groundwater. The predominant soil type at this site is sand, which has a high effective porosity; thus allowing chemicals to move quickly downward, with limited radial distribution (dispersion) compared to silty or clayey soils. Within the soil matrix, the migration of organic compounds is also affected by the presence of organic matter, measured in terms of carbon content. Sandy soils generally have low levels of organic carbon, as has been substantiated in other parts of Fort Ord. Measurement of total organic carbon is planned for soil samples from proposed monitoring wells in the A-Aquifer and the Upper and Lower 180-Foot Aquifers.

3.2.3 Chemical Migration Pathways

Chemical migration pathways include volatilization to ambient air, surface runoff, soil contamination, and leaching of chemicals into groundwater.

3.2.4 Potential Receptors

The risks associated with hazardous waste sites are functions of the chemicals at the site and the activities and locations of individuals that might be receptors of those chemicals. At Fort Ord, four groups of receptors were identified and are described below.

3.2.4.1 Groundwater Users

The Lower 180-Foot Aquifer is still the primary source of water to water users located on Fort Ord facility. Four municipal wells (active Well Nos. 29, 30, and 31 and inactive Well No. 32) are located about two miles east-southeast of the OU CTP area, and at least one of the two apparent CT plumes in the Lower 180-Foot Aquifer has migrated toward the westernmost well. CT has not yet been detected in any of these four drinking water wells. Although these wells were installed and operated by the Army, the entire water distribution system, including the wells, has recently been transferred to the MCWD.

The neighboring community of Marina is also dependent on groundwater for its drinking water source and until the mid-1980s also relied on the Lower 180-Foot Aquifer as its primary water source. Three Deep Aquifer wells were installed between 1986 and 1989; the city of Marina is no longer dependent upon water from the Lower 180-Foot Aquifer, except for the portion of Marina now located on the former Fort Ord property and served by the former Fort Ord supply wells (Well Nos. 29 through 32). One of the Deep Aquifer wells, MCWD Well No. 11, is located within the footprint of the CT plume although this well is screened from about 970 to 1,650 feet bgs. No VOCs, including CT or its daughter products, have been detected in routine samples. However, due to its proximity to the CT plume, additional hydrogeologic data will be collected to further quantify the potential for CT to migrate from the Lower 180-Foot Aquifer to the Deep Aquifer.

3.2.4.2 Residential Occupants

In addition to exposure to CT from groundwater, residents in the Preston Park housing area may also be exposed to CT in the form of soil gas escaping form the vadose zone to the atmosphere. The likelihood of this scenario cannot be determined and for that reason a soil gas study will be conducted in the vicinity of the original soil gas sampling area established in 1987. At that time the area had not been developed for residential use, but soil gas concentrations were considered spurious and inconsequentially low. With the delineation of the A-Aquifer groundwater plume indicating this area as the potential source area, it is appropriate to reevaluate the possibility of residual source CT within the vadose zone. It is also important to note that the primary goal of the soil gas survey is to delineate the extent of any potential residual CT that may be acting as a persistent source to groundwater. If CT is detected in shallow soil gas samples at elevated concentrations, it is likely that additional sample collection will be recommended to further evaluate the potential risk to residents.

3.2.4.3 Ecological Receptors

The basewide RI (*HLA, 1994*) identified at least 13 species of animals and plants occurring at Fort Ord are listed or considered candidates for listing as threatened or endangered species; however, most of these are found in the undeveloped eastern portion of Fort Ord or in the vicinity of the Beach Trainfire Ranges. Additionally, although the existing storm drainage system at Fort Ord was shown to represent a pathway for migration of contaminants into the surface waters of the Salinas River and Monterey Bay, there is no indication that CT from the OU CTP area could enter the storm drain system and reach Monterey Bay or the Salinas River. Therefore, it is concluded that ecological receptors are essentially absent from the OU CTP area.

3.3 Data Gaps and Project Data Quality Objectives

This section present a general discussion of data gaps identified in existing characterization data for the site, as well as project data quality objectives (DQOs). Section 4.0 of this Work Plan includes a more detailed analysis of existing data and data gaps throughout the OU CTP site. Also included are the specific objectives of the site investigations at OU CTP. The Basewide Sampling and Analysis Plan (SAP; *Harding ESE, 2002f*) includes procedures required to be followed to fill the data gaps and achieving the DQOs.

3.3.1 General Data Gaps

Relevant data for the OU CTP site were reviewed to identify significant data gaps in the chemical, hydrogeological, and ecological databases. The primary data gaps that were identified are associated with chemical contamination and hydrogeologic conditions; these gaps are discussed in general below. Specific data gaps are further discussed in Section 4.0.

The nature and extent of CT in the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer has not been fully delineated. The extent of CT in the A-Aquifer is best understood, although data gaps still exist near the source area, near the groundwater divide, and near the toe of the plume. The extent of CT in the Upper and Lower 180-Foot Aquifers is not yet known. A significant area of potential CT contamination within the Upper 180-Foot Aquifer has yet to be characterized, both horizontally and vertically. Similarly, the vertical and horizontal extent of CT contamination within the Lower 180-Foot Aquifer has yet to be determined.

The nature and extent of CT in the soil gas near the suspected source area (Preston Park housing area) is unknown. Results from samples collected in 1987 at depths of six feet indicate low concentrations with the likelihood of insignificant exposure risks to residents; however, the potential for a residual source at greater depths cannot be determined with existing data and additional sample collection and analysis is needed. The installation of additional soil gas sampling points has been included in the Draft Work Plan Addendum dated May 6, 2002 (*Harding ESE*); however, the analysis and results will be reported as part of the RI.

Aquifer hydraulic characteristics (e.g., hydraulic conductivity and transmissivity) have not been quantified in the aquifers within the OU CTP area. The domain of the existing groundwater flow model includes the OU CTP area; however, the grid density is not sufficient to evaluate CT distribution or hydraulic communication between aquifers.

Analytical data indicative of natural attenuation processes have been collected from a limited number of monitoring wells screened in the A-Aquifer near the source of the plume. However, sufficient data have not been collected throughout the multiple CT plumes to fully assess the degree to which natural attenuation is occurring site-wide. Natural attenuation indicators such as elevated concentrations of speciated metals, dissolved oxygen, oxidation-reduction potential, major cation and anions, and dissolved gases are important to understand the potential for the natural attenuation of CT in each aquifer. Alternatively, this information can be used to assist in the design of an enhanced natural attenuation remedial alternative.

3.3.2 Project Data Quality Objectives

Data Quality Objectives (DQO) were applied to optimize and describe the data collection objectives for the project (*EPA, 1994*). The seven steps of the DQO process as prescribed by the U.S. Environmental Protection Agency (EPA) are:

- State the problem
- Identify the decisions
- Identify inputs to the decisions
- Define study boundaries
- Develop decision rules
- Specify limits on decision errors
- Optimize study design.

3.3.2.1 Statement of the Problem

CT has been detected in groundwater samples from the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer at concentrations exceeding the state MCL. Groundwater flow directions and the extent of CT in these aquifers surrounding the study area are not adequately defined with the current monitoring well network, although these conditions are relatively well understood in the A-Aquifer. Data gaps along the entire suspected migration route of the CT plume include: (1) the source area and possible residual source(s) within the vadose zone, (2) the location of the vertical conduit between the A-Aquifer and the Upper and Lower 180-Foot Aquifers, (3) the horizontal and vertical extent of CT in the Upper and Lower 180-Foot Aquifers, and (4) hydraulic properties of the A-Aquifer, Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer. Additionally, conditions for natural attenuation processes to sufficiently occur to remediate the CT plumes have not yet been fully evaluated.

3.3.2.2 Identification of Decisions

The following decision statements will be addressed with the installation of the proposed monitoring wells and subsequent monitoring:

1. Determine whether or not the source of CT is coincident with the area defined in 1987 with detected CT in soil gas and whether a residual source of CT still exists within the vadose zone.

2. Confirm the source of the Upper 180-Foot Aquifer plume and that it is migrating to the southeast toward a pinch-out in the underlying aquitard where it then migrates downward and enters the Lower 180-Foot Aquifer.

3. Assess the extent of CT in the aquifers beneath and surrounding the site and continue the groundwater investigation to delineate the extent of CT. This is of particular importance in the Lower 180-Foot Aquifer plumes because of the potential impact to active drinking water wells screened in this aquifer (FO-29, FO-30, and FO-31).

4. Determine whether former supply wells (FO-26, FO-27, FO-28, and MCWD Well Nos. 5, 8, and 8a) or MW-B-13-180 acted as vertical conduits through the FO-SVA or whether CT was able to migrate directly through the FO-SVA to contaminate the Upper and Lower 180-foot aquifers and use this information to properly develop appropriate a remedial system(s) if needed.

5. Assess whether CT in groundwater could potentially impact drinking water quality produced from the MCWD Well No. 11 and evaluate appropriate measures to prevent drinking water quality degradation.

6. Determine whether additional monitoring wells are needed, based primarily on groundwater flow directions and the observation of concentrations exceeding the MCL, and recommend the proper locations for their installation.

3.3.2.3 Identify Inputs to Decisions

The collection of additional lithologic data, groundwater elevations and gradients, and groundwater quality data is necessary to address the decision statements stated above. Lithologic data will be collected during the installation of each monitoring well (observing cuttings, driller's notes, etc.) as well as from geophysical logs (e.g., conductivity and natural gamma logs). This information will be used to define aquifers and aquitards located throughout the study area, which will in turn be used to evaluate potential contaminant migration pathways (Objectives 3 and 4).

Groundwater elevations will be measured with an electric sounder following the surveying of a reference point at each monitoring well, providing horizontal and vertical coordinates and elevation. In the case of monitoring Westbay monitoring wells, proprietary tools will be used to measure groundwater elevations. Groundwater quality data will be determined, first with any samples collected following the development process, and thereafter with samples collected during quarterly sampling events. Data from these monitoring activities will be used to confirm potential migration pathways, further delineate the extent of CT, and project its downgradient extent in each aquifer (Decision Statements 1 through 5). This evaluation will thus determine whether additional monitoring wells are necessary (Decision Statement 6).

Should groundwater elevation data not aid in identifying accurate groundwater flow directions, or similarly, if subsequent quarterly groundwater sample results indicate the presence of CT at concentrations above the state MCL (0.50 μg/L), additional monitoring wells may be considered. The state MCL for CT (or other VOCs detected) will be used as the action level (concerning groundwater quality decisions) until aquifer cleanup levels are determined following a risk assessment and acceptance of the record of decision (ROD). The state MCL for CT (0.50 μg/L) is being used currently because it is more stringent than the federal MCL (5.0 μg/L). The final aquifer cleanup goal may change based upon risk assessment calculations. One goal of this investigation is to construct a ROD for the OU CTP area. Tables 2 through 10 describe the appropriate analytical measurement methods to provide the necessary water quality data.

3.3.2.4 Definition of Study Boundaries

Study boundaries are limited by the amount of data supporting groundwater flow direction interpretations, which differ in each aquifer.

A-Aquifer

Groundwater flows from the southeast to the northwest in the A-Aquifer and groundwater quality data from this aquifer suggest that the overall extent of CT is understood and is limited by MW-BW-50-A (source area) to MW-BW-43-A (downgradient). Thus the study boundaries are generally defined by these upgradient and downgradient monitoring wells. The groundwater divide may have adequately prohibited the CT plume from migrating toward the east, however, at least one monitoring well (MW-BW-16-A) indicates low concentrations of CT. Therefore, the study boundary in the A-Aquifer will include the area northeast of the overall plume in the vicinity of MW-BW-16-A.

Upper 180-Foot Aquifer

The study boundary in the Upper 180-Foot Aquifer begins at two suspected areas of entry to this aquifer from the overlying A-Aquifer and extends southeast toward a suspected pinch-out in the underlying aquitard, where it apparently then enters the Lower 180-Foot Aquifer. The source areas include at least one of several previously used municipal drinking water wells (FO-27, FO-28, MWCD-8, and MCWD-8a) and potentially a monitoring well installed in 1974 (MW-B-13-180), any or all of which may have acted or continue to act as a vertical conduit through the FO-SVA. Additional wells will therefore be installed southeast of MW-BW-19-180 and MW-BW-25-180 (downgradient), northwest of MW-BW-26-180 (upgradient), and in the vicinity of MW-OU2-30-180 (the well that currently controls the downgradient extent of CT in the Upper 180-Foot Aquifer).

In addition to the suspected vertical conduits at one or more of the previously used municipal wells, it is possible that the FO-SVA has been breached beneath the wave-cut terrace near the toe of the A-Aquifer plume. However, clay has been noted beneath this geologic feature and further west of its location (Plate 7). In addition, groundwater gradients within the overlying A-Aquifer indicate continuous flow to the west. If a conduit exists through the FO-SVA at this location, clay should not have been observed and groundwater flow should reverse in direction, indicating significant recharge to the Upper 180-Foot Aquifer. Proposed Westbay monitoring wells MP-BW-36 and MP-BW-37 will be designed to include ports within the Upper 180-Foot Aquifer (top and bottom) to determine whether groundwater in this aquifer is contaminated upgradient of the suspected vertical conduits of the previously used municipal wells. Should CT be detected in this upgradient location, additional upgradient data may be required to fully delineate the plume and locate other potential source areas (such as near the wave-cut terrace).

A tracer test will also be conducted at MW-B-13-180 to determine whether a vertical conduit exists at this location and whether this well should be destroyed and/or replaced. These proposed wells and tracer test will address Decision Statements 2, 3, and 4.

Lower 180-Foot Aquifer

The study boundary in the Lower 180-Foot Aquifer is similarly controlled by the suspected entry location(s) represented by the previously used municipal drinking water wells but includes the additional entry point east of the suspected pinch-out of the overlying aquitard. The downgradient extent of CT contamination in either plume has not yet been determined; however, the overall direction of groundwater flow has at least partially been determined. It is not yet known what seasonal changes occur with respect to groundwater flow direction. The downgradient boundary in this aquifer is thus arbitrarily set at the former Fort Ord boundary to the north and east. The southern boundary is somewhat better controlled by wells installed to monitor the OU 2 plume, and hence will be coincident with Intergarrison Road.

Table 1 summarizes the proposed well construction details and anticipated depths to best meet all objectives stated above. There is little risk in cross-aquifer migration with the construction of A-Aquifer monitoring wells because this aquifer is unconfined and groundwater is isolated from the Upper 180-Foot Aquifer by the FO-SVA. Because of the large vertical gradient (downward) between the A-Aquifer and underlying aquifers (Upper and Lower 180-Foot Aquifers), Upper and Lower 180-Foot Aquifer monitoring well seals through the FO-SVA and other minor aquitards must be properly designed and installed to prevent the downward migration of A-Aquifer groundwater. Thus, the sanitary seal of each well will continue from ground surface entirely through the FO-SVA until reaching the top of the sandpack, and consists of a bentonite-cement mixture.

All well drilling activities must be conducted during a time of the year when sensitive flora species are not in bloom (primarily during late winter months through springtime). A Harding ESE biologist will approve the beginning of these activities and will survey sensitive species populations before and after the installation of the proposed monitoring wells. Groundwater samples will be collected from each monitoring well on a quarterly schedule following the wells' installation and development.

3.3.2.5 Development of Decision Rules

The assessment of direction of groundwater flow directions and quality of groundwater (parameters of interest) depends on field measurements and analytical sample results. Whether the decision statements above have been addressed then also depend on this data. Action levels describe measurable limits that, when reached, require that a decision be made. Two decision rules are therefore presented below.

The action level for groundwater elevation data is interpretive and depends on whether groundwater elevation data is sufficient to calculate accurate groundwater flow directions (a parameter of interest). This is not anticipated to be problematic in the A-Aquifer, where existing groundwater flow data does not indicate a complex flow pattern. Groundwater flow in the Upper or Lower 180-Foot Aquifer, however, may be more complex than that in the A-Aquifer and thus it is not known if the proposed monitoring wells in these aquifers will sufficiently identify the directions of groundwater flow. **Decision Rule #1: If groundwater directions of flow cannot be adequately determined in either aquifer, additional monitoring wells or piezometers may be required**.

The delineation of CT (a parameter of interest) is dependent on the practical quantitation level (PQL) of the analytical test method and the MCL (Table 2). Because a record of decision (ROD) has not been written to include this study area, aquifer cleanup levels (ACLs) have not yet been established and state MCLs will be used as regulatory compliance criteria because they are more stringent than federal MCLs. Until a ROD is signed, the state MCL will be used as the action level that will determine whether the extent of CT is adequately delineated or not, and whether additional monitoring wells area required. **Decision Rule #2: If CT is detected in samples from 'perimeter wells' at concentrations exceeding the state MCL, additional monitoring wells may be required**. A perimeter well is defined as a well that represents the furthest lateral extent of CT in groundwater. The detection of CT at concentrations below the state MCL (0.50 μg/L) may also be useful, however, to corroborate groundwater flow patterns.

Because the MCL (0.50 μg/L) rivals the standard PQL for CT by EPA Test Method 8260 (0.50 μg/L), the laboratory will use a PQL of 0.30 μg/L ,which is approximately 3.3 times the method detection limit (MDL). CT concentrations detected between two times the MDL (0.18 μg/L) and 0.30 μg/L will also be reported, but will be qualified as estimated concentrations.

3.3.2.6 Specification of Limits of Decision Errors

The decision error involved with data resulting from the installation of these wells comprises sampling design error and measurement error. To date, consistent analytical data from existing wells, including groundwater elevations and quality, suggest that measurement error has been relatively small, if not negligible. The insufficient number of monitoring wells in the study area indicates a sampling design error that warrants correction. Measurement error will be considered tolerable if quality assurance/quality control (QA/QC) procedures and acceptance criteria specified in this Work Plan are followed.

Despite the importance of controlling decision error, the consequences of decision errors for the placement of the proposed monitoring wells differ between the A-Aquifer and the Upper and Lower 180-Foot Aquifers. Groundwater flow in the A-Aquifer is considered simple and will presumably be confirmed with the recommended placement of monitoring wells in this aquifer. Because groundwater flow in the Upper and Lower 180-Foot Aquifers appears to be potentially more complex, the potential decision error in well placement is more significant.

The presence of an organic compound upgradient or downgradient of the study area as indicated by groundwater sample results from the proposed monitoring wells is the null hypothesis. The alternate hypothesis is that CT will not be detected in groundwater samples, which would indicate that the current interpretation of the plume extent is correct. This interpretation is integral with the determination of groundwater flow directions in each aquifer. A false positive decision error would then be described as one that stated that CT is not present beyond the study area when it actually is present. Conversely, a false negative decision error would be one that stated CT is present at some extent beyond the study area when it actually is not. The importance of describing the possible decision errors is identifying the consequences of each. In the case of stating the extent or absence of CT beyond the study area, it is not likely that a false positive or negative decision error will be made if the sampling design and measurement errors are minimized.

A false positive decision error could lead to the incorrect conclusion that the extent of CT is limited to the study area (existing monitoring wells) and result in the upgradient or downgradient areas not being recognized as contaminated and therefore not incorporated into future remedial design, if needed.

The possibility of a false positive decision error (not recognizing the extent of CT) is equally dependent on measurement error is as the possibility of a false negative decision error. Because samples will be collected on a regular basis, it is unlikely that measurement error shall persist over time and lead to significant decision error. Therefore, the consequences of decision error in locating the proposed monitoring wells, either by sampling design error or by measurement error, are anticipated to be minor.

3.3.2.7 Optimization of Investigation Design for Obtaining Data

The most resource-effective data collection design concerning analytical data from samples collected from the proposed monitoring wells is to sample them at the same frequency as the existing wells and compare concentrations of detected compounds respective of distance from existing wells in the study area. Samples from the proposed wells will be analyzed by the same method as samples from existing wells (as in the groundwater monitoring program) to be consistent.

3.4 Site Investigation Approach

The investigation of the OU CTP area will focus on the extent of CT in groundwater. The investigation approach will be to prioritize the installation of wells in the Lower 180-Foot Aquifer because these wells will be located in an area with restricted access due to sensitive habitats for endangered plants within the biological reserve. Drilling activities have been precluded during the seasonal wet season, which typically begins in November. Following the installation of the Lower 180-Foot Aquifer wells, the Upper 180-Foot Aquifer wells will be installed during the wet season, as these wells will be located outside of the biological reserve area. The initiation of the tracer test is independent of the seasonal rain cycle as groundwater flow directions in the A-Aquifer remain consistent yearlong; however, it will be scheduled to occur prior to the onset of the wet season to avoid complications. Proposed aquifer tests are categorized as either static or active. The static testing will depend on observing stresses to the Lower 180-Foot Aquifer from nearby pumping wells, such as the mini-storage well or MCWD-11. Active pumping tests may be conducted in any of the three aquifers being investigated, and will be determined once the proposed wells have been installed and water quality data evaluated.

Once data from the aquifer tests have been evaluated, the groundwater model will be constructed to simulate groundwater flow conditions. Advective groundwater flow will be simulated using the MODFLOW code (*McDonald and Harbaugh, 1983*); a grid will be constructed to include the entire extent of contamination in all three aquifers with additional coverage to avoid boundary condition interference(s). The orientation of the grid typically is controlled by groundwater flow direction, but because of the multiple flow directions presented in each aquifer, a compromise grid orientation will have to be decided upon. Multiple layers will represent each aquifer so that three-dimensional flow patterns may be presented in the model output.

Following the calibration of the advective flow model, a mass transport model (either MT3D or RT3D) will be built to simulate the movement and potential degradation of the CT plume. The CT plumes will either be represented by: (1) introducing assumed source conditions (e.g., initial concentration/mass and time of release) to simulate the development of the entire plume, or by (2) starting with the delineated extent of CT once the RI is complete to project the potential for future migration. The latter is a simpler approach but does not benefit from fully integrating the advective flow model with historical conditions. However, the former approach is typically limited by the many assumptions that are made to account for historical data that is not available (e.g., source conditions, historical groundwater flow direction changes, and pumping patterns).

The groundwater flow and mass transport models will be used to evaluate various remedial alternatives. Lithologic data and well completion details will be provided in an update to the groundwater well management plan.

3.5 Applicable or Relevant and Appropriate Requirements

The RI/FS will contain a discussion of potential ARARs for the OU CTP site. Promulgated standards such as MCLs in groundwater that apply to the presence of CT in groundwater at the site will be identified. Section 121 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requires that site cleanups comply with federal and state laws that are "applicable or relevant and appropriate requirements" (ARARs). Under CERCLA Section 121(d)(2), the federal ARARs for a remedial action could include requirements under any of the federal environmental laws. State ARARs include promulgated requirements under state environmental or facility citing laws that are more stringent than federal ARARs, and that have been identified in a timely manner, pursuant to 40 Code of Federal Regulations (CFR) Part 300.400(g)(4). A requirement may be either "applicable" or "relevant and appropriate," as described below.

3.5.1 Definition of ARARs

Applicable requirements are defined as those cleanup or control standards, or other substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state laws. Applicable requirements are identified on a site-specific basis by determination of whether the jurisdictional prerequisite of a requirement fully addresses the circumstances at the site or the proposed remedial activity. All pertinent jurisdictional prerequisites must be met for the requirement to be applicable. These jurisdictional prerequisites are as follows:

- The party must be subject to the law
- The substances or activities must fall under the authority of the law

- The law must be in effect at the time the activities occur
- The statute or regulation requires, limits, or protects the types of activities.

A requirement is applicable if the specific terms (or jurisdictional prerequisites) of the statute or regulation directly addresses the circumstances at the site.

"Relevant and appropriate" refers to those cleanup standards, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, that while not necessarily applicable, address problems or situations sufficiently similar to those encountered at the CERLCA site, and whose use is well suited to the particular site (*EPA, 1993*). The relevance and appropriateness of a requirement can be judged by comparing a number of factors including the characteristics of the remedial action, the items in question, or the physical circumstances of the site, with those addressed in the requirement. If there is sufficient similarity between the requirements and the circumstances at the site, determination of the requirement as relevant and appropriate may be made.

Determining whether a requirement is both relevant and appropriate is a two-step process. First, to determine relevance, a comparison is made between the response action, location, or chemicals covered by the requirement and related conditions at the site, release, or potential remedy. A requirement is relevant if it generally pertains to these conditions. Second, to determine whether the requirement is appropriate, the comparison is further refined by focusing on the nature of the items, the characteristics of the site, the circumstances of the release, and the proposed response action. The requirement is appropriate if, based on such comparison, its use is well suited to the particular site. The facility must comply with the substantive elements of requirements that are determined to be both relevant and appropriate.

There are certain circumstances under which ARARs may be waived. CERCLA Section 121(d) allows the selection of alternatives that will not attain ARAR status if any of six conditions for a waiver of ARARs exists. However, the selected alternative must be protective even if an ARAR is waived. Only five of the conditions for a waiver may apply to a DOD site. The conditions for a waiver are as follows:

- The action selected is only part of a total response action that will attain the required level or standard of control when completed
- Compliance with the designated requirement at that site will result in greater risk to human health and the environment (e.g., worker safety) than alternative options
- Compliance with the designated requirement is technically impracticable from an engineering perspective
- The action selected will result in a standard of performance that is equivalent to an applicable requirement through the use of another method or approach
- A state requirement has not been equitably applied in similar circumstances on other clearance actions within the state
- A fund-financed clearance action does not provide a balance between available monies and the need for protection of human health and the environment at sites where the need is more immediate (not applicable to DOD sites).

To Be Considered Requirements (TBCs), the final class of requirements considered by EPA during the development of ARARs, are non-promulgated advisories or guidance documents issued by federal or state governments. They do not have the status of ARARs, and are not legally binding, but may be considered in determining the necessary cleanup levels or actions to protect human health and the environment.

4.0 WORK PLAN RATIONALE

This section presents the Work Plan rationale and describes the tasks proposed for implementation during the RI for the site, including: additional monitoring well installation and well conversion; natural attenuation sampling; tracer and aquifer testing; geophysical and soil gas surveys; groundwater modeling; and development of a well management program for the site.

4.1 Well Installation and Development

Shallow and deep ground water monitoring wells will be installed to further delineate the extent of CT contamination in the A-Aquifer and the Upper and Lower 180-Foot Aquifers. Available information suggests that the 400-Foot Aquifer is not contaminated. A-Aquifer wells will be constructed of five-inch diameter Schedule 80 PVC casing and screen and will be installed with hollow-stem auger drilling tools. Most of the proposed Upper 180-Foot Aquifer wells will be constructed similarly, but may be installed using either an air rotary casing hammer drilling (ARCH) rig, mud rotary rig, or a sonic rig. Westbay monitoring wells will be installed to monitor groundwater elevation and quality in the Lower 180-Foot Aquifer and at select locations within the Upper 180-Foot Aquifer. These wells will be installed using either mud rotary or sonic drilling rig equipment. The use of a sonic drilling rig will require the use of telescoped drive casing of diameters ranging from 6 to 8 inches. Each well will be developed appropriately, using either air-lifting equipment, bailers, or pumps, or a combination thereof. Westbay wells installed using sonic drilling techniques will be passively developed, relying on the natural groundwater gradient, because no drilling fluids will be used and cross-contamination will be minimal. Investigation-derived waste (IDW) generated under this task will be managed in accordance with the SAP (*Harding ESE, 2002f*).

4.1.1 A-Aquifer

Five A-Aquifer wells were proposed in the previous Work Plan Addendum (*Harding ESE, 2002e*) and were located to (1) further define the suspected source area, (2) characterize the extent of CT near the groundwater divide in the vicinity of MW-BW-16-A, and (3) delineate the extent of CT near the toe of the plume. Groundwater quality and elevation data from these wells will be evaluated as part of the RI/FS report to further characterize the A-Aquifer CT plume and migration pathways.

4.1.2 Upper 180-Foot Aquifer

Eleven monitoring wells are proposed in this Work Plan to further delineate the CT within the Upper 180-Foot Aquifer as illustrated on Plate 18. Existing data suggest that CT is present only within the upper portion of this aquifer; however, data only exists near the suspected entry area to this aquifer and data from the OU 2 TCE plume suggest that contamination progressively migrates downward as the plume approaches what appears to be a natural hydraulic connection between the Upper 180-Foot Aquifer and the underlying Lower 180-Foot Aquifer along Old County Road. The CT plume also appears to behave similarly as several monitoring wells along Old County Road indicate the presence of CT within the Lower 180-Foot Aquifer and its absence within the Upper 180-Foot Aquifer. Thus it appears that CT within the Upper 180-Foot Aquifer eventually reaches the suspected natural hydraulic conduit and enters the Lower 180-Foot Aquifer (Plates 16 and 17) and it is possible the depth of the plume varies with distance.

The Upper 180-Foot Aquifer CT plume currently appears to have derived from at least one vertical conduit located at the previously used drinking water wells in the area (FO-26, FO-27, FO-28, or

MCWD-8) and has subsequently migrated to the southeast toward the suspected natural hydraulic conduit connecting the Upper and Lower 180-Foot Aquifers. To strengthen this conceptual model of the Upper 180-Foot Aquifer CT plume wells MW-BW-43-180 through MW-BW-53-180 will be located between the suspected vertical conduits and the current downgradient control of the plume (MW-OU2-30-180). Two of these wells will flank MW-OU2-30-180 to monitor for the presence of CT north and south of this existing monitoring well. Monitoring groundwater elevation and collecting samples upgradient of the suspected vertical conduits (northwest of MCWD-8 and FO-27) will be accomplished by Westbay monitoring systems (MP-BW-36 and MP-BW-37) that will include ports in the Upper and Lower 180-Foot Aquifers. Additionally, Westbay monitoring systems (MP-BW-41 and MP-BW-42) will be used to monitor groundwater quality in the Upper 180-Foot and Lower 180-Foot Aquifers downgradient of MW-OU2-30-180 (Plate 18). Groundwater samples may also be collected from the A-Aquifer from the boreholes of several of the proposed Upper 180-Foot Aquifer well locations to further delineate the A-Aquifer plume.

4.1.3 Lower 180-Foot Aquifer

Seven monitoring well systems are proposed to further delineate the extent of CT in the Lower 180-Foot Aquifer (Plate 19). Results from existing monitoring wells and Westbay monitoring ports in both the Lower 180-Foot and 400-Foot Aquifers indicate that CT is not present in the 400-Foot Aquifer. Furthermore, it does not appear likely that CT will reach the 400-Foot Aquifer in the future because of a slight upward gradient from the 400-Foot Aquifer to the Lower 180-Foot Aquifer. However, because the study area is being extended to the north of the previously delineated area, several of the proposed Westbay monitoring wells will include one port installed within the 400-Foot Aquifer to achieve vertical control on groundwater pressure and quality.

The seven proposed monitoring wells will be constructed using Westbay components, consistent with the monitoring wells installed in this aquifer in November 2001. Monitoring ports will be installed at specific depths identified from the lithologic log to contain coarse materials conducive to contaminant migration. The objective of these monitoring wells/ports is to further delineate the extent of CT in the Lower 180-Foot Aquifer. The source area to this aquifer is suspected to be in the vicinity of the currently active private irrigation well (mini-storage well) and the formerly used drinking water wells MCWD-5 and MCWD-8. Downgradient wells will be installed in the vicinity of the Marina Airport in response to the observation of higher CT concentrations in the northern portion of the study area and the apparent seasonal northward shift in groundwater flow resulting from irrigation patterns within the Salinas Valley.

In addition to delineating the extent of CT emanating from the vertical conduit(s) suspected to be located at the previously used drinking water wells, the proposed wells will also further delineate the extent of CT emanating from an apparently natural vertical conduit near the toe of the Upper 180-Foot Aquifer (Plate 17). It appears that the Upper 180-Foot Aquifer has reached this conduit and is actively migrating downward into the Lower 180-Foot Aquifer. This migration route will also be partially addressed by the proposed Upper 180-Foot Aquifer monitoring wells.

Investigation-derived waste (IDW) anticipated to be generated under this Work Plan includes drilling cuttings, drilling fluids, and development purge water. The installation of the recommended Lower 180-Foot Aquifer wells (which may require drilling with a mud fluid) requires specific attention because of the additional IDW generated. If the Lower 180-Foot Aquifer monitoring wells are installed using an alternative drilling method (e.g., sonic), significantly less IDW may be anticipated.

4.2 Natural Attenuation Sampling

Although a preliminary survey of water quality parameters indicative of natural attenuation processes (e.g., biologically driven reductive dechlorination) did not indicate a significant degree of activity, the survey did not include the full extent of the CT plume in any of the three impacted aquifers.

Therefore, it is recommended that representative wells be selected for additional monitoring of analytes useful for assessing natural attenuation processes during a single monitoring event. Analytes will include, but are not limited to: major cations and anions; dissolved gases; speciated iron, manganese, sulfur, and nitrogen; oxidation reduction potential (ORP), total organic carbon (TOC), and dissolved oxygen (DO). The U.S. EPA Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17 will be used as a guidance document prior to developing the FS to evaluate potential remedial options relying on a monitored natural attenuation program (*EPA, 1999*).

Only the A-Aquifer plume has been delineated to date and thus the representative wells for the Upper and Lower 180-Foot Aquifer cannot be identified at this time. Although representative wells for additional monitoring from the A-Aquifer could be listed in this Work Plan, Harding ESE proposes to present a complete list of representative wells for each aquifer once the proposed wells for the Upper and Lower 180-Foot Aquifers have been installed and water quality assessed. At that time, a list of representative wells will be presented to the regulatory agencies for approval. The collection of groundwater samples to evaluate potential natural attenuation processes will not preclude the evaluation of other potential remedial alternatives in the FS.

4.3 Tracer Test

A portion of the CT plume in the Upper 180-Foot Aquifer appears to be emanating from MW-B-13-180, rather than from a vertical conduit(s) at one of the previously used drinking water wells. This monitoring well was installed in 1974 for an investigation unrelated to the current CERCLA investigation and may have been inadvertently installed as a vertical conduit between the A-Aquifer and the Upper 180-Foot Aquifer.

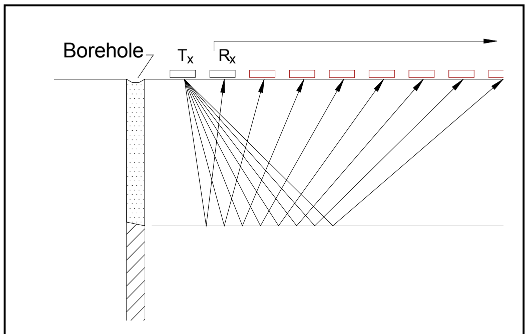
Harding ESE proposes to dose the A-Aquifer with a conservative tracer compound (e.g., chloride or bromide salt or a fluorescent dye) via a source well adjacent to and upgradient of MW-B-13-180 (Plate 20). The tracer test will commence when a large amount of tracer compound is introduced into the source well. If a salt is used as the tracer compound, groundwater from MW-B-13-180 (the target well) will be monitored at hourly intervals for up to six months using a datalogger attached to an ion-specific probe. The probe will be installed in the upper portion of the saturated screen section of MW-B-13-180. Background concentrations will be determined prior to the test both with probe readings and one groundwater sample sent to a USACE-approved analytical laboratory. Additionally, grab samples will be collected from MW-B-13-180 at three month intervals during the test to substantiate data collected by the bromide probe.

Should bromide concentrations increase within MW-B-13-180 it could indicate that a vertical conduit exists; this monitoring well may then be recommended for destruction and replaced with a well of appropriate construction and sanitary seal. Alternatively, a natural conduit could coincidentally exist in this area, however unlikely.

4.4 Geophysical Survey

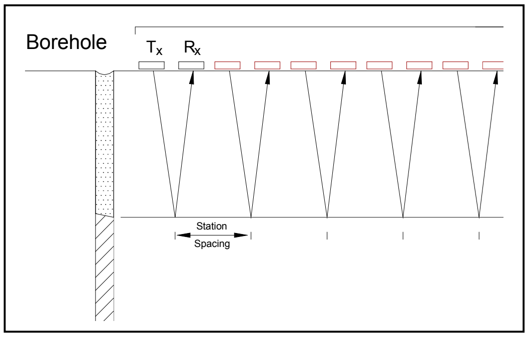
As described in the *Draft Final Natural Attenuation Summary Report* (*Harding ESE, 2002a)*, the toe of the A-Aquifer plume appears to be controlled and maintained by a geologic facies change that includes a significant increase in hydraulic conductivity within the A-Aquifer. This facies change is suspected to represent a wave-cut terrace within the FO-SVA where marine clay was replaced with coarse sand and gravel in a high-energy beach environment. The CT plume has been observed immediately upgradient of this feature but not downgradient of it, alluding to a physical attenuation process and possibly a chemical attenuation process that destroys the CT plume or at least limits its continued migration. It appears that the CT plume is simply diluted to below detection levels as it crosses this feature.

To further verify this process, Harding ESE proposes to conduct a specialized signal-enhanced ground penetrating radar (GPR) survey to help delineate the facies change near the toe of the CT plume (Plate 21). Three signal enhancing techniques will be used to maximize GPR survey resolution and investigation depth: walk-away testing, bi-static data acquisition, and stacking. These techniques are expected to succeed due to the unusually shallow depth of the FO-SVA (less than 30 feet).

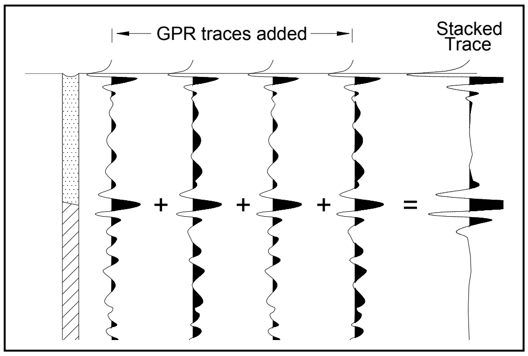


Walk-away Test Schematic

Walk-away tests are performed before a production survey to optimize the distance between the transmitting (T_X) and receiving (R_X) antennas and GPR station spacing. The technique is also used to assess GPR signal velocity to facilitate depth calculations. A walk-away test entails taking discreet radar measurements as the distance between T_X and R_X is gradually increased. The test can be repeated using GPR antennas with different frequencies. GPR data for each type of antenna are displayed on a single panel that allows the interpreter to assess data quality and compare the performance of various antennas. Ideally, ground truth is available (e.g., logs from a nearby well or boring) so that reflections can be correlated to known geologic boundaries, enabling GPR signal penetration depth and resolution capabilities to be determined.



Bi-static data acquisition refers to the use of physically separate transmitting and receiving antennas. GPR locating surveys for underground utilities and substructures location typically use a single antenna (acting as both a transmitter and receiver) to simplify field logistics. However, deeper GPR investigations with geologic targets can benefit from bi-static operation because noise from the near-surface is greatly reduced and the two antennas can be focussed more effectively on the target of interest.



Stacking is a means of enhancing GPR reflections by obtaining several discrete measurements at each station. The measurements are combined (added) to increase the amplitude of the repeat reflections associated with geologic features. The increased amplitude helps these reflections stand out against background noise, making them easier to identify on a GPR profile. Because random noise does not repeat the associated “reflections” are not enhanced by the addition of successive measurements. In fact, such noise is often suppressed by stacking.

4.5 Aquifer Tests

Understanding the potential for groundwater flow and velocities is important to evaluating the potential for further contamination and estimating the effort required for remediation. Typical aquifer tests include stressing the aquifer in some way (pumping or displacing water within a well) and monitoring the response to this stress in nearby wells or, in the case of slug tests, within the same well. Where discharge water is required to be contained due to contamination, pumping tests are only feasible for aquifers with low or moderate hydraulic conductivities or where observation wells are located relatively close to the extraction well. Aquifer tests on aquifers with extremely high hydraulic conductivities would require observation wells be located very close to the extraction well because these aquifers will yield a great deal of discharge water that presents a containment challenge. For this reason, pumping tests would be easiest to implement in wells screened in the A-Aquifer or the Upper 180-Foot Aquifer, although testing the Lower 180-Foot Aquifer would be relatively straight-forward if sufficient capacity exists with the sanitary sewer or storm drain system and necessary permits are approved. Slug tests may be more appropriate for testing the Lower 180-Foot Aquifer, but only at Westbay ports which allow for a large displacement of water. Aquifers with high hydraulic conductivities will recover from a slug test very quickly and a larger displacement of water compensates for this and allows usable data to be collected. At a minimum, slug tests will be performed upon the Lower 180-Foot and 400-Foot Aquifers at a representative number of Westbay pumping ports.

Hydraulic characteristics of the A-Aquifer have been collected at the OU 1 and OU 2 areas and have largely indicated that the A-Aquifer has relatively consistent hydraulic parameters. The most significant exception was noted in the downgradient portion of the OU 1 plume where an apparent buried channel was tested with significantly higher hydraulic conductivity values (300 feet/day versus 10 to 50 feet/day as measured elsewhere. The downgradient area of the geologic facies change does appear to represent a significant increase in hydraulic conductivity which may require further characterization.

Aquifer tests have also been conducted on the Upper 180-Foot Aquifer in the OU 2 and Sites 2 and 12 area with varying values of hydraulic conductivity. Generally, values have ranged from 200 to 10,000 feet/day, which are consistent with a fine to coarse sand unit with intermittent amounts of gravel. It is suspected that aquifer properties do not differ significantly in the OU CTP area; however, the additional proposed monitoring wells may indicate otherwise. Therefore, once the proposed Upper 180-Foot Aquifer monitoring wells have been installed and water quality data has been reviewed, the necessity and location of an aquifer test will be discussed with the regulatory agencies.

The Lower 180-Foot Aquifer has not been tested using monitoring wells because this aquifer is considerably more productive than the overlying aquifers and wastewater generation would be significant. Additionally, the higher hydraulic conductivity of this aquifer would necessitate that any observation wells be located very close to the pumping well. Due to the low density of monitoring wells in this aquifer, previous investigations have not lead to a sufficiently dense network that would lend itself to aquifer testing. The general lack of detectable VOCs in this aquifer also did not warrant that such tests be conducted.

Existing hydraulic conductivity values for the Lower 180-Foot and 400-Foot Aquifers have derived largely from specific capacity tests conducted on individual municipal wells. These results are sufficient to indicate the general character of an aquifer and confirm that the Lower 180-Foot Aquifer is considerably more permeable than the A-Aquifer or the Upper 180-Foot Aquifer.

However, CT contamination within the Lower 180-Foot Aquifer now requires that aquifer parameters be estimated within the study area. Because of the complexities and expense of performing aquifer tests on such a deep aquifer, Harding ESE proposes to observe groundwater elevation fluctuations continuously for one week at the MP-BW-30 and MP-BW-31 Westbay wells. These two well locations (with a combined total of 12 monitoring ports) are located closest to the private irrigation well (screened in the Lower 180-Foot Aquifer) and MCWD-11 (the active drinking water well screened in the Deep Aquifer).

Passively monitoring fluctuations, while knowing when these two pumping wells are operating, may be used to estimate aquifer parameters (in the case of the mini-storage well) and the degree of hydraulic communication between the Deep Aquifer and the overlying Lower 180-Foot and 400-Foot Aquifers (in the case of MCWD-11). Estimating hydraulic parameters from the Lower 180-Foot Aquifer will be dependent upon the well owner's permission, since we would need to obtain extraction rate data from the mini-storage well. Thus, although only qualitative data may be obtained from these tests, this information is anticipated to contribute to the overall understanding of how the mini-storage well and MCWD-11 may be influencing the distribution of CT in the Lower 180-Foot Aquifer, if at all.

Results of the aquifer tests will be used to construct the groundwater flow model and may be altered within a reasonable range as part of the calibration process. The final calibrated model may therefore result in hydraulic characteristics that slightly vary from field data, but that may nonetheless offer a representative simulation of aquifer characteristics.

4.6 Groundwater Model

Following the collection of groundwater elevation and quality data from the proposed monitoring wells in each aquifer, a groundwater flow model (MODFLOW) will be constructed to simulate groundwater flow movement; a mass transport model (MT3D or RT3D) will be constructed upon the advective solution to simulate the movement of the CT plume and its potential degradation. Objectives include, but should not be limited to: (1) demonstrating the understanding of the conceptual model of CT contamination and transport, (2) simulating CT degradation to assess natural attenuation processes, and (3) simulating various remediation alternatives.

Due to the complexities involved with historical data, Harding ESE proposes to construct a transient groundwater flow model that will simulate seasonal gradient variations and historical groundwater extraction from previously used municipal wells. The advection model will primarily be calibrated to present-day conditions but also to sparse historical data. The advection model will serve as the foundation to the mass transport model, which will simulate a surface discharge of CT in the suspected source area, its migration through the A-Aquifer to the suspected vertical conduits, and subsequent contamination of the Upper and Lower 180-Foot Aquifer.

Because it is not known when the release occurred or how much CT was released, several assumptions will be necessary to simulate the generation of the plumes from a hypothetical surface source and verification of historical groundwater quality conditions will not be possible. Should this approach prove unworkable, the initial starting conditions for the mass transport model may need to be based on the extent of CT contamination as understood at the end of the RI program. Ultimately the groundwater advection and mass transport model will be used as a tool to evaluate various remedial alternatives and, as such, the models will necessarily have to allow for appropriate output for each alternative evaluated in the FS. The focus of the mass transport model will be on the simulation of current conditions and the simulation of reasonable alternate future conditions.

4.7 Groundwater Well Management Plan

The groundwater well management plan (*HLA, 1998*) will be updated to incorporate the proposed monitoring wells and will be provided in a GIS-format. Critical information, such as but not limited to well installation dates, coordinates/elevations, construction details, and aquifer associations, will be included in this plan. Monitoring wells installed since the previous edition will be provided in hardcopy format in a separate binder as an addendum to the original hardcopy lithologic logs and well completion forms.

4.8 Soil Gas Survey

A soil gas survey was scheduled as part of the previous Work Plan Addendum (*Harding ESE, 2002e*) to be conducted near the suspected source area of the CT plume in the A-Aquifer (near the Preston Park housing area). Three soil gas samples will be collected throughout the vadose zone at up to 25 locations. Results will be evaluated as part of the RI to further delineate the source area of the CT plume in the A-Aquifer. Specifically, if CT concentrations are elevated in this area a source removal task may be established to control the continued persistence of the CT plume in the A-Aquifer. Should CT or daughter products not be detected it will be concluded that a source no longer exists within the vadose zone in this vicinity.

4.9 MCWD-8a Conversion

The previously used drinking water well MCWD-8a was scheduled as part of the previous Work Plan Addendum (*Harding ESE, 2002e*) to be converted to a monitoring well to assess groundwater elevations and quality from the Lower 180-Foot Aquifer. Subsequent water quality data collected from this converted well will be evaluated as part of the RI to further delineate the extent of CT in the Lower 180-Foot Aquifer and identify the vertical conduit(s) responsible for migration from the A-Aquifer.

5.0 RI/FS TASKS

This section describes the standard RI/FS tasks that have been defined to provide consistent reporting and effective monitoring of this project. The RI/FS tasks presented below are consistent with those provided in EPA's RI/FS guidance document (*EPA, 1988*). For each RI/FS task, a general definition of the task is provided, followed by a more detailed description of how the task applies to this project.

5.1 Task 1 – Project Planning

This task includes efforts related to initiating the project and scoping project activities. The majority of project planning occurs during the scoping phase of the RI/FS and includes both site planning and project planning. However, because of the iterative nature of the RI/FS, the planning process continues throughout the project.

5.2 Task 2 – Field Investigation

This task incorporates efforts related to fieldwork in implementing the RI/FS. Section 3.4 of this Work Plan presents the investigation approach for the RI and Section 5.0 presents the rationale for the proposed fieldwork. The Field Sampling Plan (FSP) presents the specific work scopes for the fieldwork and the Quality Assurance Project Plan (QAPP) details the procedures to be followed when carrying out the field activities.

5.3 Task 3 – Data Management

This task includes efforts relating to the analysis, validation, and data entry of analytical samples collected during the field investigation, including soil samples, soil gas samples, and groundwater samples. Sample analysis and validation is described fully in the QAPP.

5.4 Task 4 – Data Evaluation

This task includes the evaluation of data once is has been verified. Typical data evaluation activities include data reduction, data tabulation, plotting/contouring, constructing cross-sections, and modeling groundwater flow and environmental fate and transport processes.

5.5 Task 5 – Risk Assessment

This task includes efforts related to assessing risks to human health and the environment. A baseline risk assessment will be initiated after data are collected during the RI field investigation phase. In general, the objectives of a baseline risk assessment may be attained by identifying and characterizing the following:

- Toxicity levels and levels of hazardous substances present in relevant media
- Environmental fate and transport mechanisms within specific media
- Potential human and environmental receptors
- Potential exposure routes and extent of actual or expected exposure
- Extent and likelihood of expected impact or threat

- Level of uncertainty associate with above items.

Results of the risk assessment will be used to determine the OU CTP risk-based aquifer cleanup levels (ACLs) for chemicals of concern. The ACLs may differ from the state MCLs, which will be used to delineate the plume until the ROD is signed.

5.6 Task 6 – Treatability Studies

This task includes efforts to prepare and conduct pilot, bench, or other treatability studies. Treatability studies are conducted primarily to achieve the following:

- Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and to support the remedial design of a selected alternative

- Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected.

The necessity for treatability studies for the OU CTP RI/FS has not yet been established, but will be identified as early in the RI/FS process as possible. If treatability studies are warranted, a Work Plan detailing the studies will be prepared. Results of such study will be described in the FS.

5.7 Tasks 7, 8, and 9 – Feasibility Study

Tasks 7, 8, and 9, described below, comprise the Feasibility Study activities. The Feasibility Study will be conducted in accordance with the EPA's RI/FS guidance document (*EPA, 1988*) and will be consistent with the Feasibility Study outline provided in the FFA.

5.7.1 Task 7 – Remedial Alternatives Screening

This task includes efforts to select and initially screen the remedial technologies and alternative that will be subjected to a detailed evaluation. This FS task is initiated during the data evaluation task when sufficient data are available to begin the screening process. Selected remedial alternatives will be screened on the basis of the effectiveness, implementability, and order-of-magnitude cost. On the basis of the results of the screening process, selected alternatives will be retained for detailed analysis.

5.7.2 Task 8 – Remedial Alternatives Evaluation

This task comprises the detailed analysis of remedial alternatives. Alternatives remaining after the screening process will undergo further analysis using the nine evaluation criteria specified by the EPA (EPA, 1988) for the RI/FS program:

1. Overall protection of human health and the environment

2. Compliance with Applicable or Relevant and Appropriate Requirements

3. Long-term effectiveness and permanence

4. Reduction of toxicity, mobility, or volume through treatment

5. Short-term effectiveness

6. Implementability

7. Cost

8. State acceptance

9. Community acceptance.

The results of the detailed analysis of remedial alternatives will used to select a preferred alternative for implementation at OU CTP, which will be identified in the FS.

5.7.3 Task 9 – Feasibility Study Reports

This task consists of efforts relating to preparation of FS deliverables and includes all draft and draft final reports. Specific reporting requirements are presented in the following section.

6.0 SCHEDULE AND REPORTING

A preliminary schedule for conducting the RI/FS is presented in Appendix A. The schedule begins with preparation of the project planning documents and continues through preparation of the RI/FS report. The schedule is more defined for the initial stages of the RI/FS and is generalized for later stages. Revised schedules will be prepared as the RI/FS progresses.

Deliverables for the RI/FS, defined in the FFA, include both Preliminary Submittals and Secondary Submittals. The deliverables are included on the schedule (Appendix A) and are described below. Additional submittals will be described in conjunction with updated schedules, as appropriate.

Deliverables included in the scoping and plan development stage of the RI/FS include the following:

- Draft and Draft Final Work Plan (Primary Submittal)
- Draft and Draft Final RI/FS Report
- Draft, Draft Final, and Final Proposed Plan
- Draft, Draft Final, and Final Record of Decision (ROD)

Progress reports will be prepared throughout the RI/FS process. Additional deliverables and an updated schedule will be described in future Work Plans, as appropriate.

7.0 REFERENCES

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TABLES

Table 1. Proposed Monitoring Well Construction Details and Anticipated Lithology
OU CTP RI/FS Work Plan
Former Fort Ord, California

		Anticipated Depths (feet bgs)					Anticipated Depths of Westbay Ports (feet bgs)						
							Upper 180-Foot		Lower 180-Foot				400-Foot
Well Name	Approximate ground surface elevation (feet MSL)	Upper 180-Foot Aquifer Top	Upper 180-Foot Aquifer Bottom	Lower 180-Foot Aquifer Top	Lower 180-Foot Aquifer Bottom	Total Depth	MP-1	MP-2	MP-1	MP-2	MP-3	MP-4	MP-1
MP-BW-36	120	176	226	276	426	426	180	225	280	300	350	420	
MP-BW-37	130	183	233	283	433	483	190	230	290	310	360	430	480
MP-BW-38	145	179	229	279	429	479			290	310	360	430	470
MP-BW-39	145	212	262	312	462	462			320	340	390	460	
MP-BW-40	130	177	227	277	427	477			285	305	355	425	470
MP-BW-41	155	180	230	280	430	480	190	230	290	310	360	430	470
MP-BW-42	160	191	241	291	441	491	200	240	295	315	365	435	490
MW-BW-43-180	125	150	210	N/A	N/A	220	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-44-180	145	170	230	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-45-180	145	165	225	N/A	N/A	235	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-46-180	145	160	220	N/A	N/A	230	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-47-180	155	172	232	N/A	N/A	242	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-48-180	165	177	237	N/A	N/A	247	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-49-180	170	173	233	N/A	N/A	243	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-50-180	155	158	218	N/A	N/A	228	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-51-180	155	162	222	N/A	N/A	232	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-52-180	155	165	225	N/A	N/A	235	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MW-BW-53-180	170	181	241	N/A	N/A	251	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
MSL = mean sea level
bgs = below ground surface
MP- # = Westbay monitoring port number

Table 2. Chemicals of Concern and Regulatory Compliance Criteria
OU CTP RI/FS Work Plan
Former Fort Ord, California

Chemical of Concern (COC)	Federal Maximum Contaminant Levels (MCL) (mg/L)	State Maximum Contaminant Levels (MCL) (mg/L)
Benzene	5	1
Carbon Tetrachloride	5	0.5
Chloroform	NA	100
1,1-Dichoroethane	NA	5
1,2-Dichoroethane	5	0.5
1,1-Dichoroethene	7	6
cis-1,2-Dichloroethene	70	6
Total 1,2-Dichloroethene	NA	6
1,2-Dichloropropane	5	5
Total 1,3-Dichloropropene	NA	0.5
Dichloromethane (methylene chlorid	5	5
Tetrachloroethene (perchloroethene	5	5
1,1,1- Trichloroethane	200	200
Trichloroethene	5	5
Vinyl Chloride	2	0.5

Note:
1) These VOCs have been detected at former Fort Ord and not all have been detected in the OU CT area.
2) The most stringent criteria will be used at OU CTP in lieu of a signed ROD, but the final aquifer cleanup levels may change based on the results of the risk assessment.

Table 3. Analytical Methods, Parameters for Analysis, and Practical Quantitation Limits
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method and Parameters	Practical Quantitation Limit Water (µg/L)	Practical Quantitation Limit Soil (µg/kg)
EPA Method 8260		
Volatile Organic Compounds		
Bromodichloromethane	0.5	5.0
Bromoform	0.5	5.0
Carbon tetrachloride	0.3	5.0
Chlorobenzene	0.5	5.0
Chloroethane	0.5	5.0
Chloroform	0.5	5.0
Dibromochloromethane	0.5	5.0
1,2-Dichlorobenzene	0.5	5.0
1,4-Dichlorobenzene	0.5	5.0
1,1-Dichloroethane	0.5	5.0
1,2-Dichloroethane	0.5	5.0
1,1-Dichloroethene	0.5	5.0
cis-1,2-Dichloroethene	0.5	5.0
trans-1,2-Dichloroethene	0.5	5.0
1,2-Dichloroethene (total)	0.5	5.0
1,2-Dichloropropane	0.5	5.0
Methylene chloride	5.0	10
Tetrachloroethene	0.5	5.0
1,1,1-Trichloroethane	0.5	5.0
1,1,2-Trichloro-1,2,2-trifluoroe	1.0	5.0
Trichloroethene	0.5	5.0
Vinyl chloride	0.5	5.0
Benzene	0.5	5.0
Ethylbenzene	0.5	5.0
Toluene	0.5	5.0
Xylenes	0.5	5.0

Table 4. Summary of External (Field) Quality Control Samples
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method Number	Parameters	Trip Blanks	Equipment Blanks	Field Water Blanks	QA Samples	Field Duplicates
8260	Volatile Organic Compounds	1 per container	1 per event	1 per lot of water	1 per 10 samples	1 per 10 samples

1 per container indicates one trip blank per shipping container per laboratory.
1 per event indicates one equipment blank per day for groundwater sampling activities if reusable bailers are used. The frequency of equipment blanks for soil sampling activities (if required) will be specified in the SAP.
1 per lot of water indicates one field water blank per discrete lot of water used for rinsing reusable sampling equipment. Field water blanks are not required for soil sampling events or when disposable bailers are used for groundwater sampling.
QA samples are Quality Assurance samples submitted to the COE South Pacific Division Laboratory.
NA Not applicable.

Table 5. Sample Preservation and Storage Requirements
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method Number	Parameters	Matrix	Holding Time (from sample date)	Containers	Preservative	Minimum Sample Size
8260	Volatile Organic Compounds	water	analysis - 14 days	40 mL VOA vials with Teflon septa	Hydrochloric acid to pH < 2 Store at 4 deg C	3 X 40 mL
		soil	analysis - 14 days	2" x 6" stainless steel tubes with Teflon liners	Store at 4 deg C	500 g

Table 6. Summary of Internal (Laboratory) QC Samples
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method Number	Parameters	Method Blanks	Matrix Duplicate	Laboratory Control Sample	Matrix Spike/ Matrix Spike Duplicate	Surrogate Spikes
8260	Volatile Organic Compounds	1 per analytical batch	NA	1 per analytical batch	1 per analytical batch	All samples

Note: Analytical batch is defined as a discrete group of 20 or fewer samples extracted and analyzed sequentially (e.g., without a break of more than two hours) by the laboratory.
NA Not applicable.

Table 7. Quality Assurance Goals:
Precision, Relative Percent Difference
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method and Parameters	Water Samples MS/MSD RPD	Water Samples Field Duplicate RPD(a)	Soil Samples MS/MSD RPD	Soil Samples Field Duplicate RPD(a)
EPA Method 8260				
Volatile Organic Compounds				
Benzene	20	20	35	50
Chlorobenzene	20	20	35	50
1,1-Dichloroethene	20	20	35	50
Toluene	20	20	35	50
Trichloroethene	20	20	35	50
Carbon Tetrachloride	20	20	35	50

(a) Field duplicate RPD applies to all target analytes in the test method.
NA Not applicable.

Table 8. Quality Assurance Goals:
Accuracy, Percent Recovery
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method and Parameters	Water Samples LCS Recovery	Water Samples MS/MSD Recovery	Water Samples Surrogate Recovery	Soil Samples LCS Recovery	Soil Samples MS/MSD Recovery	Soil Samples Surrogate Recovery
EPA Method 8260						
Volatile Organic Compounds						
Benzene	65-135	65-135	NA	65-135	65-135	NA
Chlorobenzene	65-135	65-135	NA	65-135	65-135	NA
1,1-Dichloroethene	65-135	65-135	NA	65-135	65-135	NA
Toluene	65-135	65-135	NA	65-135	65-135	NA
Trichloroethene	65-135	65-135	NA	65-135	65-135	NA
Carbon Tetrachloride	65-135	65-135	NA	65-135	65-135	NA
Bromochloromethane (a)	NA	NA	65-135	NA	NA	65-135
1-Chloro-2-fluorobenzene (a)	NA	NA	65-135	NA	NA	65-135
2-Bromochlorobenzene (a)	NA	NA	65-135	NA	NA	65-135

(a) = Other surrogate compounds may be substituted, if appropriate.
NA = Not applicable.

Table 9. Preventive Maintenance Activities
OU CTP RI/FS Work Plan
Former Fort Ord, California

Instrument	Maintenance Parameters	Frequency	Spare Parts
Gas chromatograph (GC)	Liner insert, column, glass wool plug, detector, thermal traps	As-needed basis; determined by analyst in order to meet method QA/QC requirements	Columns, traps, septa, liners, syringes, ferrules, fittings, tubing, detector-specific items
	Replace septa	As needed	
	Gas drying and purifying cartridges	When indicated to be necessary	
	Effluent absorbant traps	Monthly	
	Oven performance	Daily, as part of retention time check of standards	

Table 10. Summary of Calibration Procedures
OU CTP RI/FS Work Plan
Former Fort Ord, California

Method Number	Parameters	Calibration	Frequency	Acceptance Criteria	Corrective Action
8260	Volatile Organic Compounds	Multipoint calibration (minimum of 5 points)	Initially and as required	%RSD Š < 20% or r > 0.995	(1) Evaluate system (2) Recalibrate as necessary
		Method blanks and instrument blanks	After initial calibration	No target analytes present above half of the PQL	(1) Reanalyze blank (2) Clean system (3) Reanalyze affected samples
		Continuing calibration check standard	Every 10 injections and at beginning and end of analytical sequence	85-115% recovery	(1) Evaluate system (2) Reanalyze standard (3) Recalibrate as necessary (4) Reanalyze affected samples

RSD Relative standard deviation of response factors.

Table 11. Summary of Corrective Actions
OU CTP RI/FS Work Plan
Former Fort Ord, California

QC Parameter Out of Control	Corrective Action
Sample Handling (includes preservation and storage temperature)	(1) Do not proceed with analysis. (2) Collect new samples.
Holding Times	(1) Do not proceed with analysis. (2) Collect new samples.
Initial Calibration	(1) Evaluate system. (2) Recalibrate as necessary. (3) Analyze samples only after initial calibration is acceptable.
Continuing Calibration	(1) Evaluate system. (2) Reanalyze standard. (3) Recalibrate as necessary. (4) Reanalyze affected samples.
Method Blank	(1) Evaluate system. (2) Reextract and reanalyze method blank and associated samples. (3) Analyze samples only after method blank is acceptable.
LCS recovery	(1) Evaluate system. (2) Reextract and reanalyze LCS and associated samples within the holding time. (3) Report sample data only after LCS is acceptable.

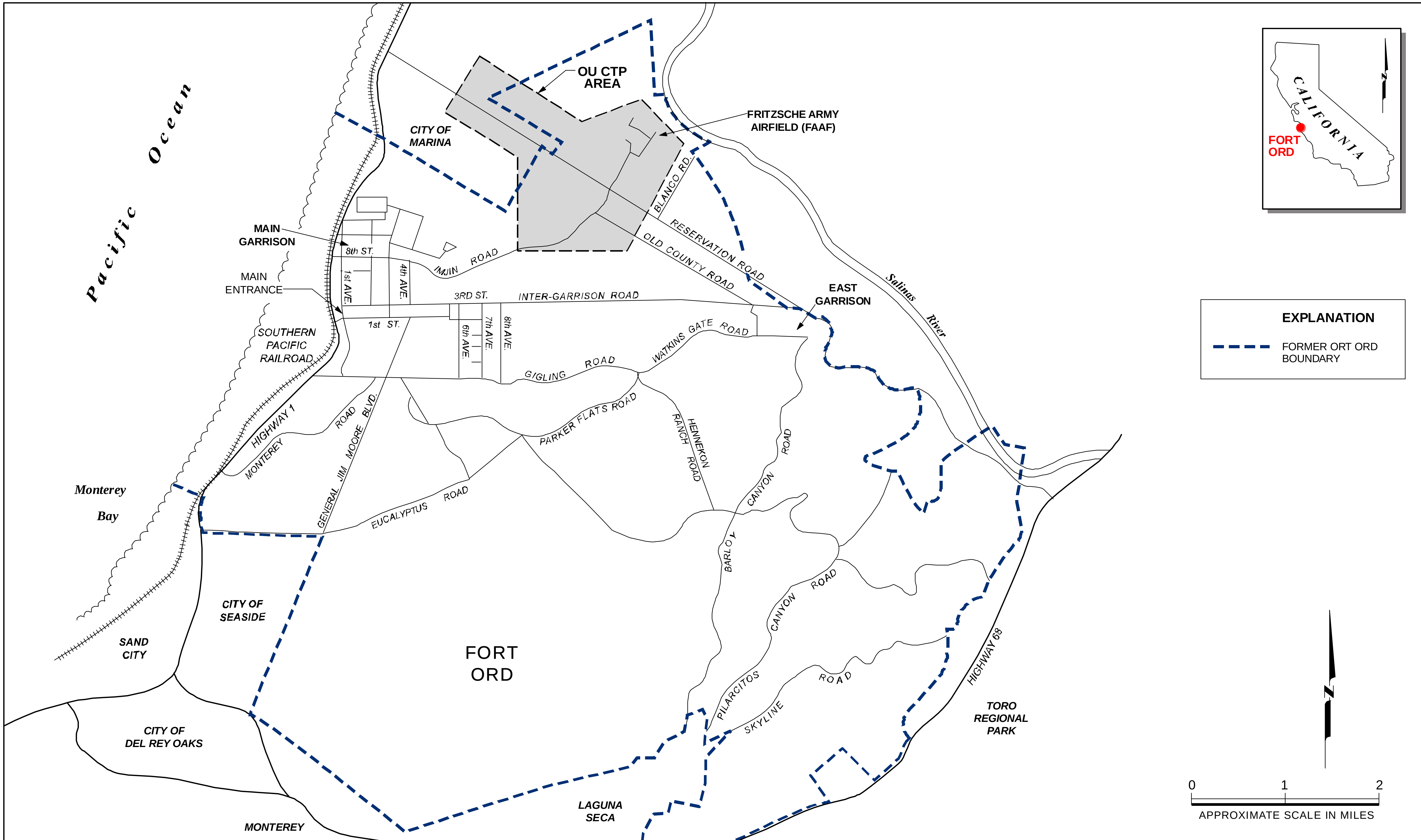
Table 11. Summary of Corrective Actions
OU CTP RI/FS Work Plan
Former Fort Ord, California

QC Parameter Out of Control	Corrective Action
Surrogate recovery	(1) Evaluate system. (2) Reanalyze sample within the holding time. If acceptable, report acceptable data only. (3) If unacceptable, attempt to reextract and reanalyze the sample within the holding time (expiration of holding time does not remove the need to reextract and reanalyze the sample). (4) If no control exceedance is observed and the reanalysis is within the holding time, report acceptable data for sample and surrogate. (5) If a control exceedance is observed, or if reanalysis not within the holding time, report both sets of sample and surrogate data.
MS/MSD recovery and RPD	(1) Evaluate system. (2) Reanalyze MS/MSD. If acceptable, report acceptable data only. (3) If unacceptable, reextract and reanalyze MS/MSD and report both sets of MS/MSD data.
Field-generated Blanks (includes trip blanks, equipment blanks, and field water blanks)	(1) Evaluate method blank. (2) Evaluate field sampling and decontamination procedures. (3) Evaluate field water source. (4) Modify sampling and decontamination procedures, as appropriate.

Table 12. Well Installation Task Three-Phase Inspection Checklist
OU CTP RI/FS Work Plan
Former Fort Ord, California

Preparatory Phase	Initial Phase	Follow-up Phase
• Notify USACE 72 hours prior • Review specifications • Verify pre-requisite work completed • Verify responsibilities are assigned and communicated • Verify capability and readiness • Hold Preparatory Meeting with field staff and laboratory • Update Schedule • Document in Daily QC Report	• Notify USACE 72 hours prior • Review Preparatory Meeting Minutes and verify corrective actions • Verify approved SOPs are being implemented • Verify initial compliance w/specifications • Verify proper techniques • Update Schedule • Document in Daily QC Report	• Verify continued compliance • Document in Daily QC Report • Verify corrective actions • Review progress vs. schedules • Update Inspection Schedule when completed • Verify that site plans are updated as required
• Sampling locations have been identified and documented • Field documentation requirements have been specified • Equipment has been scheduled for use • Sampling personnel are qualified and field ready • Specified sample containers, sample labels, custody seals and forms, and field logbooks/sheets have been reserved • SSHP prerequisites have been met • Sample coolers have been scheduled for use • Ice source has been identified • Chemical preservatives have been procured • Lab services have been procured from pre-qualified lab • Lab has been notified of sampling schedule and turnaround • Carrier, courier, or sample shipment services have been identified • Trip blanks have been requested	• Samples are being collected at identified locations, depths, and frequency • Field documentation is being generated as specified • QA and field QC sample requirements are being met • Specified sampling equipment is appropriate and in use • Sampling personnel are qualified, field ready, and have demonstrated acceptable proficiency • Samples are uniquely coded • Field practices and techniques are appropriate • Sufficient and appropriate sample containers and labels, custody seals and forms, and field logbooks and sheets are onsite and in use • Specified preservatives are available, properly stored and used • Sufficient sample coolers are available • Ice is readily available and used for sample packaging • Samples are preserved per SAP specifications • VOC samples are accompanied by trip blanks	• Approved SOPs are being implemented • SAP-specified field documentation is being generated and retained • Samplers continue to demonstrate acceptable proficiency

PLATES

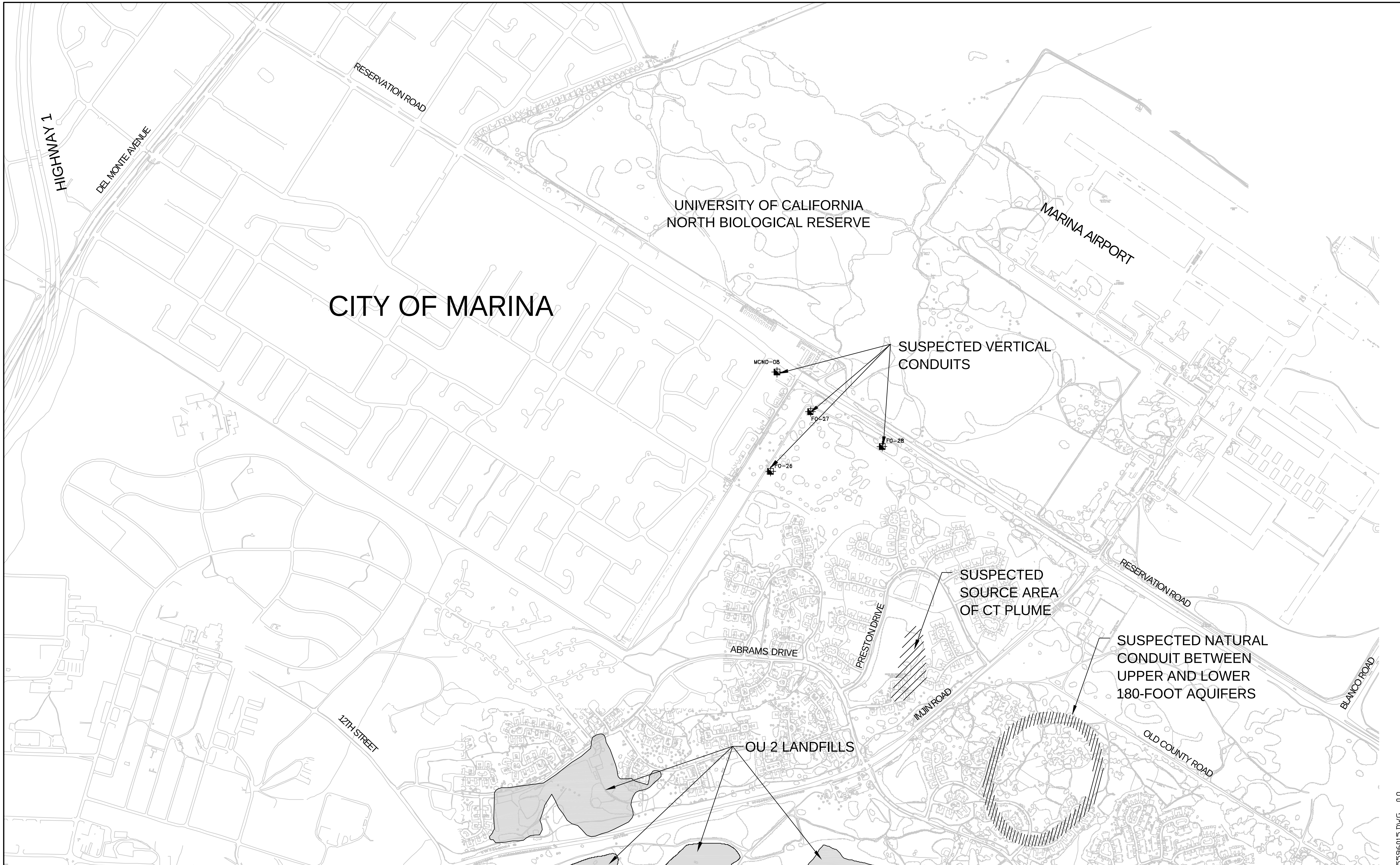


Harding ESE
A MACTEC Company

Area Map of Fort Ord
OU CTP RI/FS Work Plan
Former Fort Ord, California

PLATE
1

DRAWN	PROJECT NUMBER	APPROVED	DATE	REVISED DATE
CN	55596 00112		06/02	



NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	5/02			55596 00112			SS
2	10/02	ADD VERTICAL CONDUITS		55596.00112			SS

Harding ESE
A MACTEC COMPANY

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Site Map
Carbon Tetrachloride Study Area

PLATE:
2

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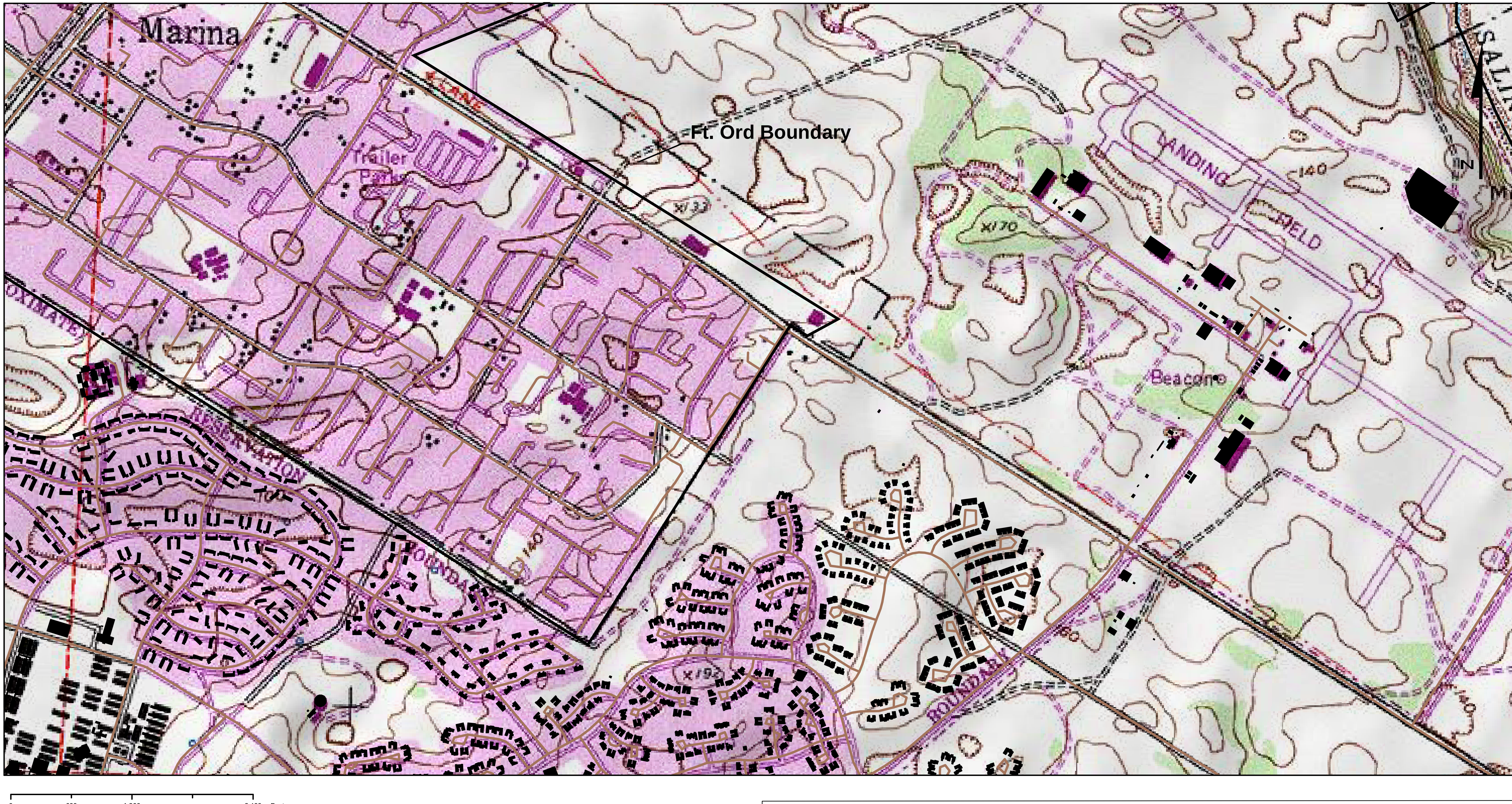

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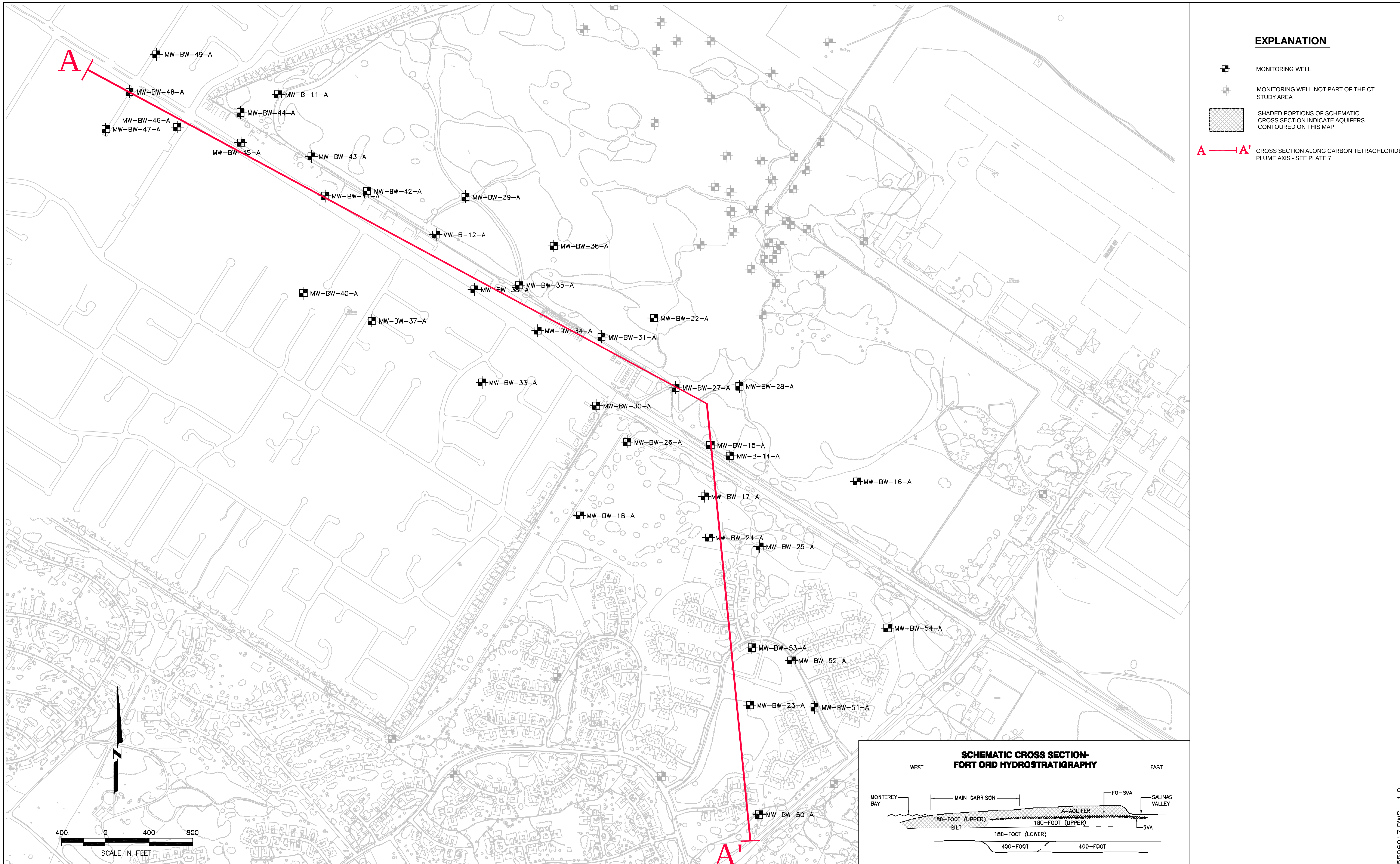
Harding ESE
A MACTEC COMPANY

Former Fort Ord OU CTP RI/FS
Topographic Elevations
Work Plan
Former Fort Ord, California

PLATE
3

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
JCF	55596 00112		06/02	



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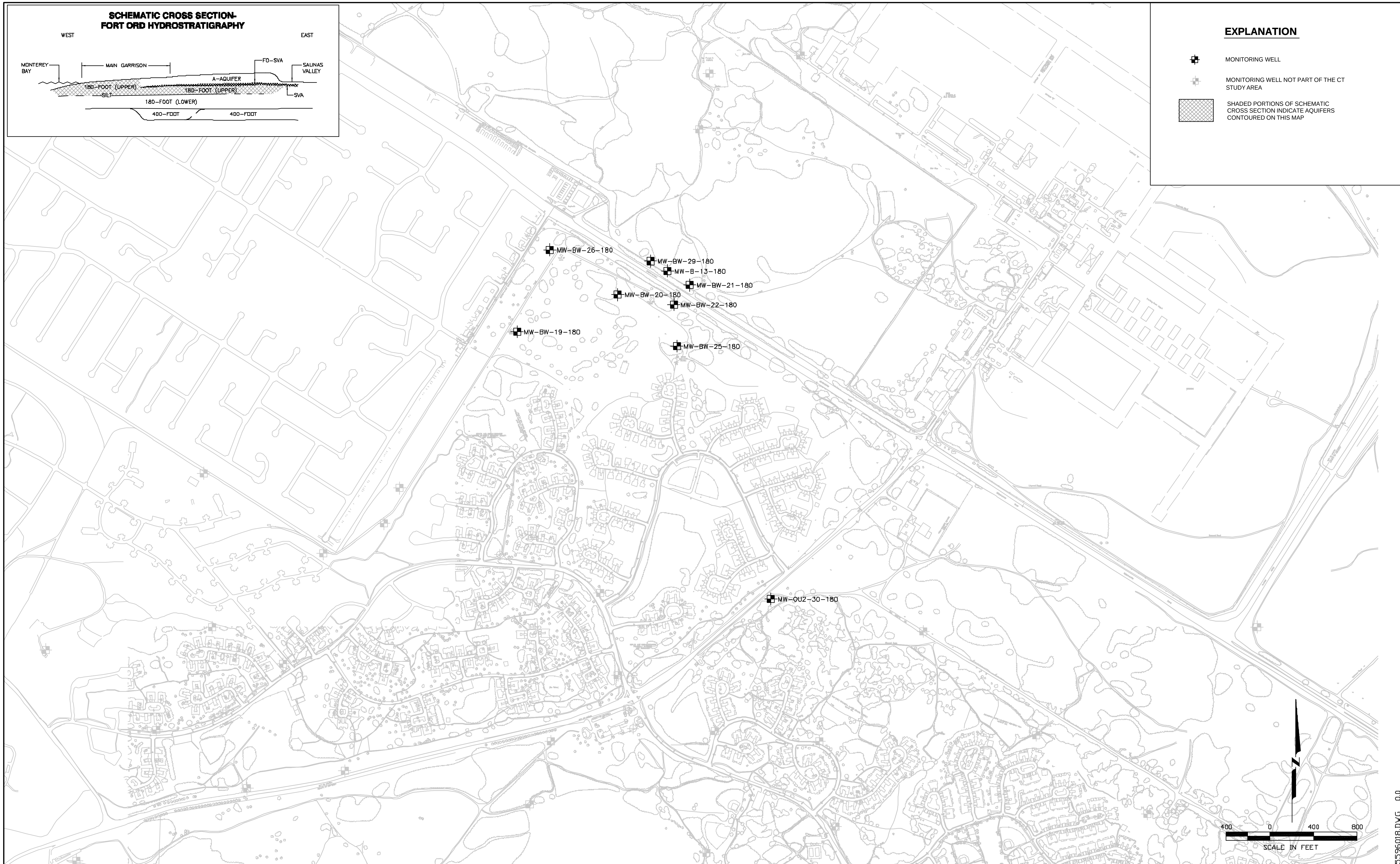
NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
	05/02			55596 00112			SS

Harding ESE
A MACTEC Company

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Monitoring Wells
A-Aquifer

PLATE:
4



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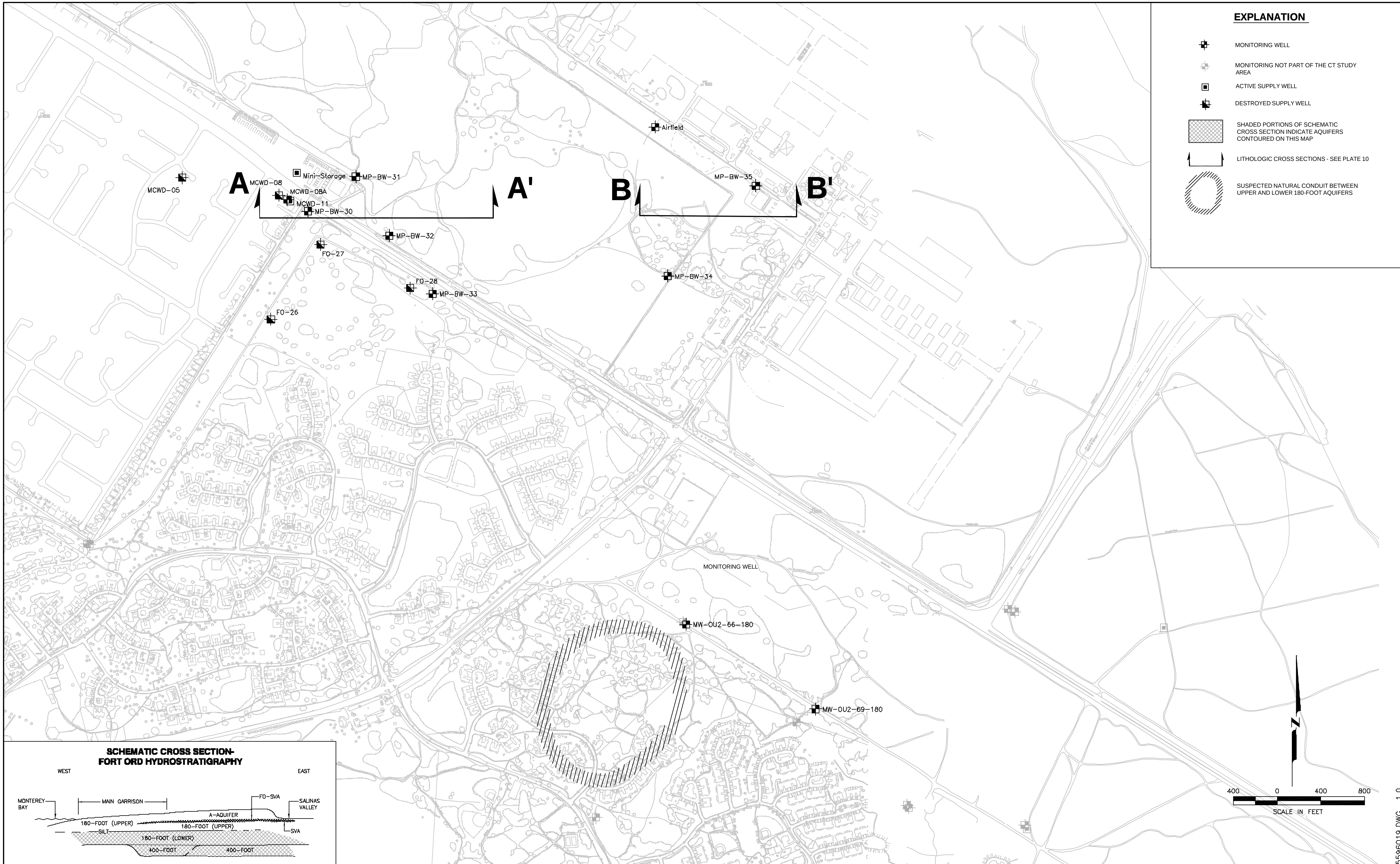
NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	5/02			55596 00112			SS

Harding ESE
A MACTEC COMPANY

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Monitoring Wells
Upper 180-Foot Aquifer

PLATE: 5



NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	05/02			55596 00112			SS
2	10/02	ADD VERTICAL CONDUITS		55596.00112			SS

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OU CTP RI/FS
Work Plan
Former Fort Ord, California

Monitoring Wells
Lower 180-Foot / 400-Foot Aquifers

PLATE: 6

55596019.DWG 1.0
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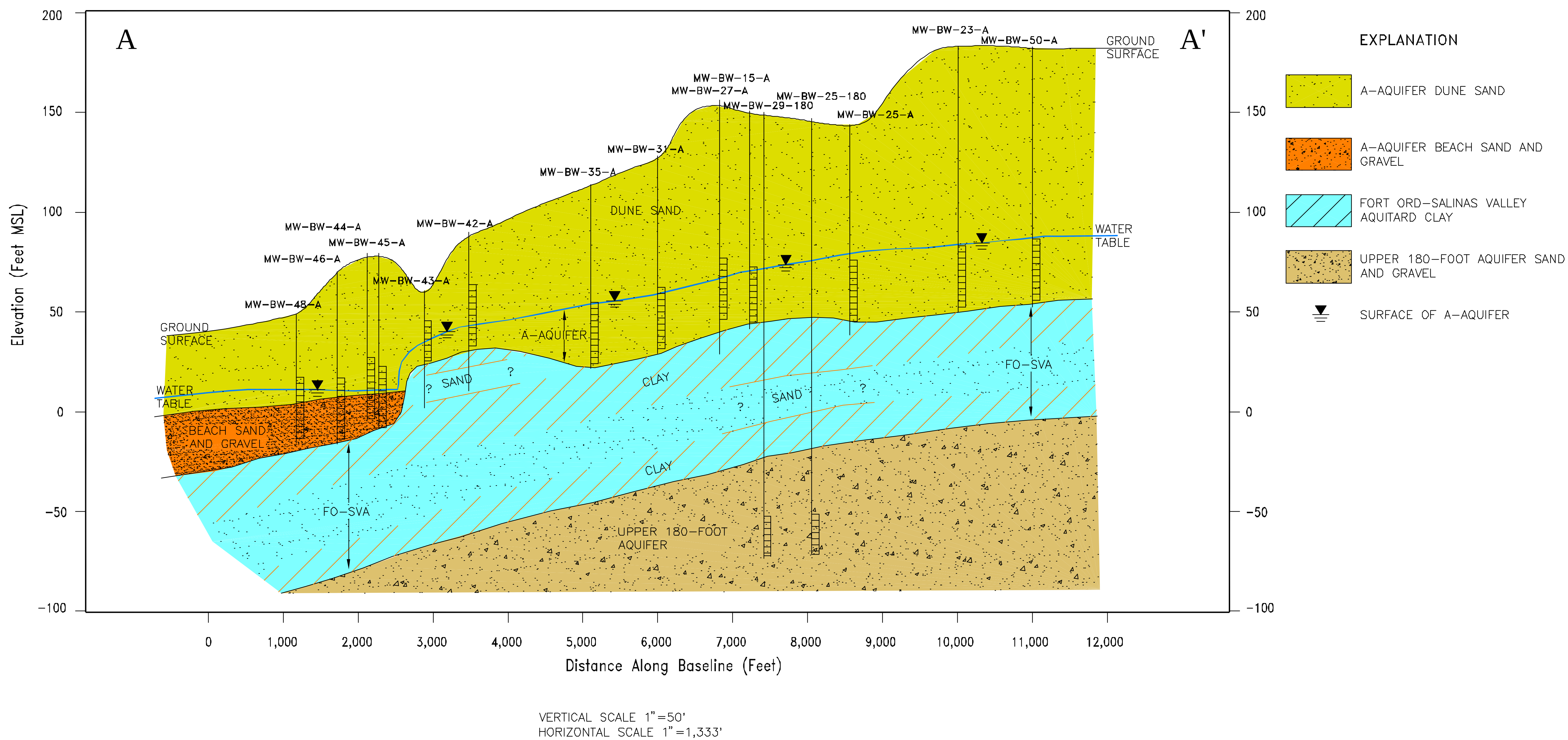

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Harding ESE
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Cross-Sectional View Along the Carbon Tetrachloride Plume Axis
OU CTP RI/FS Work Plan
Former Fort Ord
Monterey County, California

PLATE
7

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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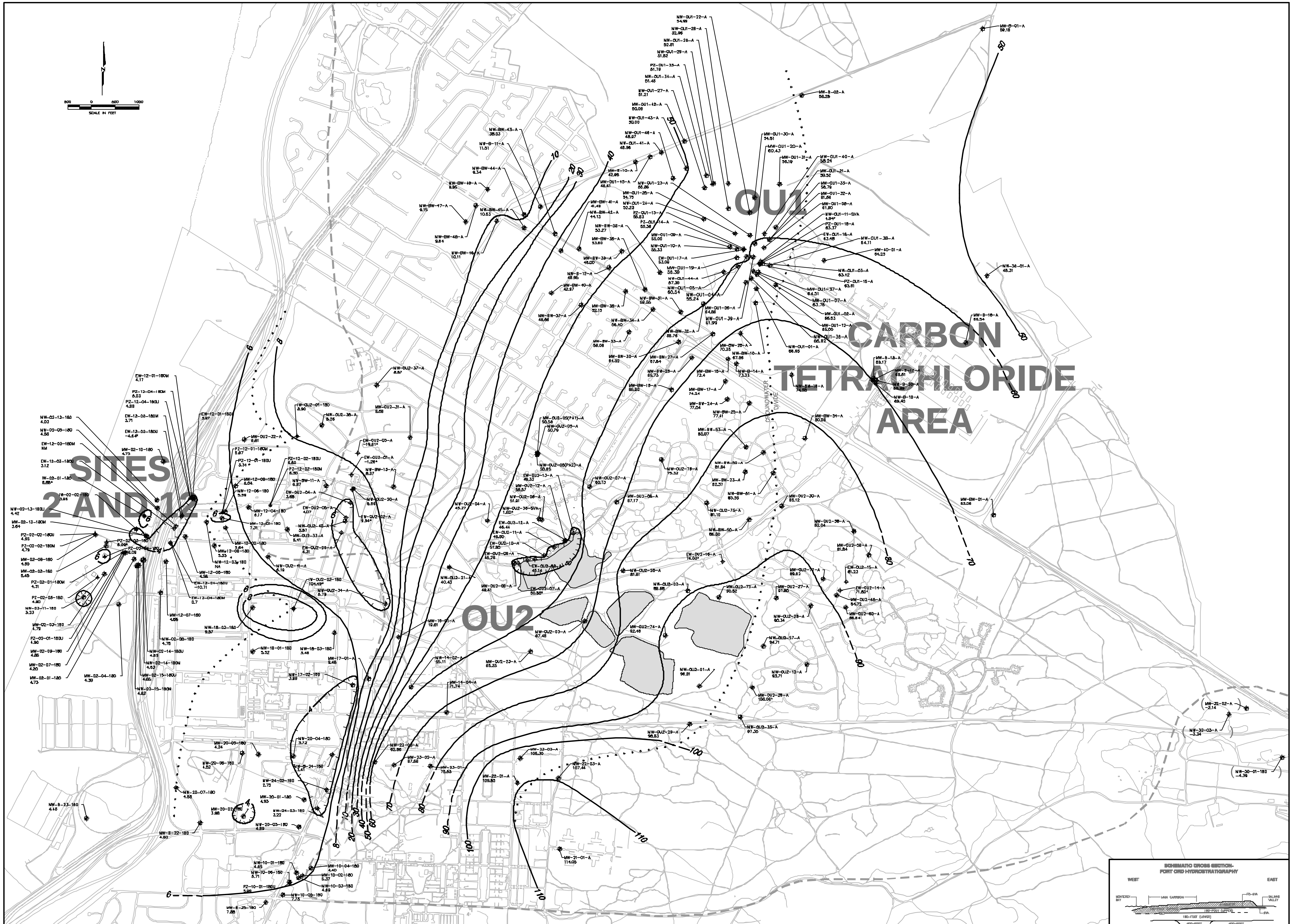

EXPLANATION

- MONITORING WELL
- PIEZOMETER NEST
- MONITORING WELL WATER LEVEL WAS NOT MEASURED
- INJECTION WELL
- EXTRACTION WELL
- INFILTRATION GALLERY, WATERLEVEL NOT MEASURED
- 49.17 WATER-LEVEL ELEVATION (IN FEET ABOVE OR BELOW MEAN SEA LEVEL)
- NM NOT MEASURED
- ( ) DENOTES WELL COMPLETED IN THE AROMAS SAND/PASO ROBLES FORMATION AQUIFERS
- * NOT USED FOR CONTOURING
- 50 GROUNDWATER ELEVATION CONTOUR (IN FEET ABOVE OR BELOW MEAN SEA LEVEL, CONTOUR INTERVAL 2 OR 10 FEET)
- GROUNDWATER DIVIDE APPROXIMATE LOCATION OF A GROUNDWATER DIVIDE
- APPROXIMATE EDGE OF FORT ORD-SALINAS VALLEY AQUICLUDE BOUNDARY, QUERIED WHERE UNCERTAIN
- APPROXIMATE EXTENT OF FORT ORD LANDFILLS. HLA, JANUARY 5, 1995
- SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP

NOTES:

(1) ALL MONITORING WELL WATER LEVELS MEASURED BETWEEN MARCH 11 AND 13, 2002, WITH THE EXCEPTION OF MW-OU1-04-A, MW-OU1-05-A, MW-OU1-07-A, MW-OU1-19-A, MW-OU1-20-A, MW-OU1-36-A, MW-OU1-37-A, MW-OU-38-A, MW-OU1-39-A AND MW-OU1-40-A, WHICH WERE MEASURED ON MARCH 19, 2002.

(2) EXTRACTION AND INJECTION WELL WATER LEVELS MEASURED ON MARCH 1, 2002.

(3) WATER-LEVEL ELEVATION CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

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				55596 00112			SS

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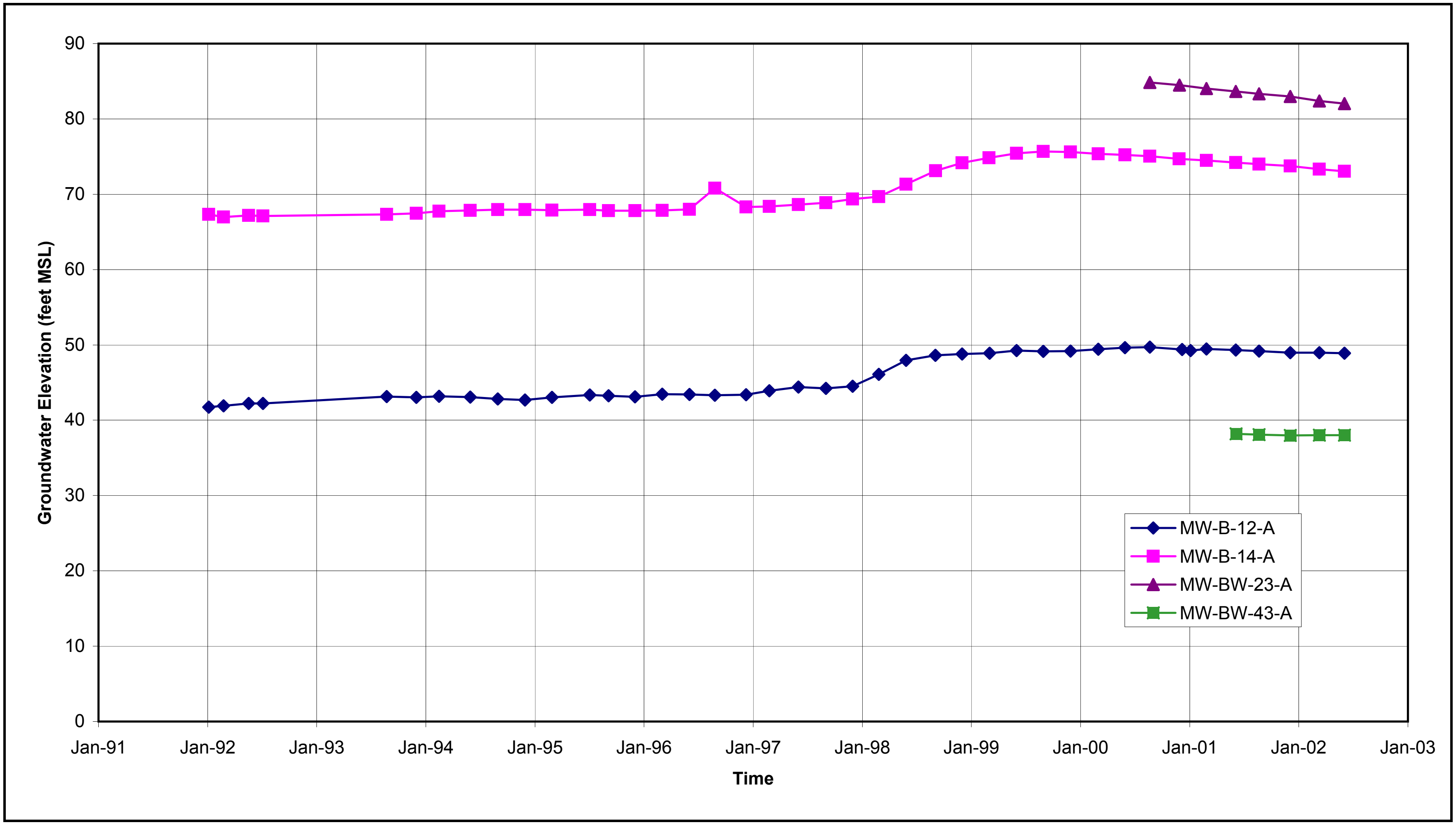
OU CTP RI/FS
Work Plan
Former Fort Ord, California

Groundwater Elevations
A-Aquifer and Upper 180-Foot Aquifer
West of FO-SVA, March 2002

PLATE:
8



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Harding ESE, Inc.
Engineering and
Environmental Services

Hydrograph
A-Aquifer
OU CTP RI/FS Work Plan
Former Fort Ord, California

PLATE
9

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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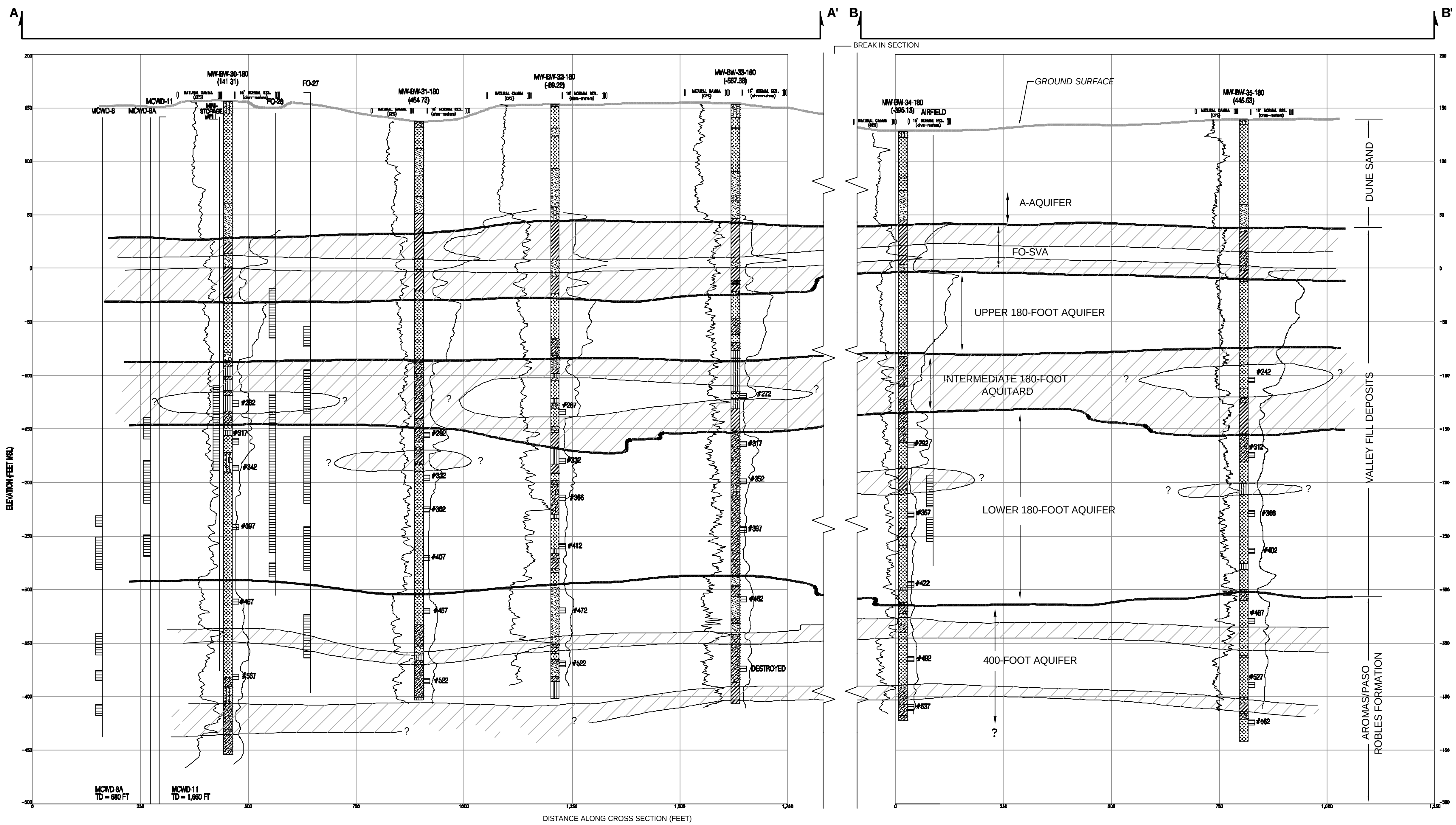

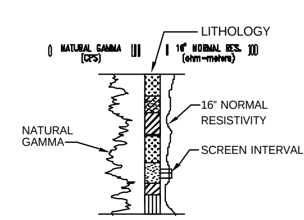

EXPLANATION

- CLAYEY SANDS WITH OR WITHOUT GRAVEL
- INORANIC CLAYS OF HIGH PLASTICICTY, FAT CLAYS
- POORLY GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
- INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS, FINE SANDY OR SILTY SOILS, ELASTIC SILTS
- SILTY GRAVELS, SILTY GRAVELS WITH SAND
- CLAYEY GRAVELS, CLAYEY GRAVELS WITH SAND
- INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, CLAYS WITH SANDS AND GRAVELS, LEAN CLAYS
- WELL GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES

NOTE:
PORT NAMES ARE IDENTIFIED BY "MP-BW" FOLLOWED BY THE BOREHOLE NUMBER (30 THROUGH 35) THEN BY THE NUMBER SHOWN ADJACENT TO EACH SCREEN, FOR EXAMPLE "MP-BW-30-282."

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ENGINEER:
CHECKED:
DATE:
PROJECT NO: 55596 00112
SCALE: 1"=50' Vert., 1"=125' Horiz.
APPROVED:
DATE:

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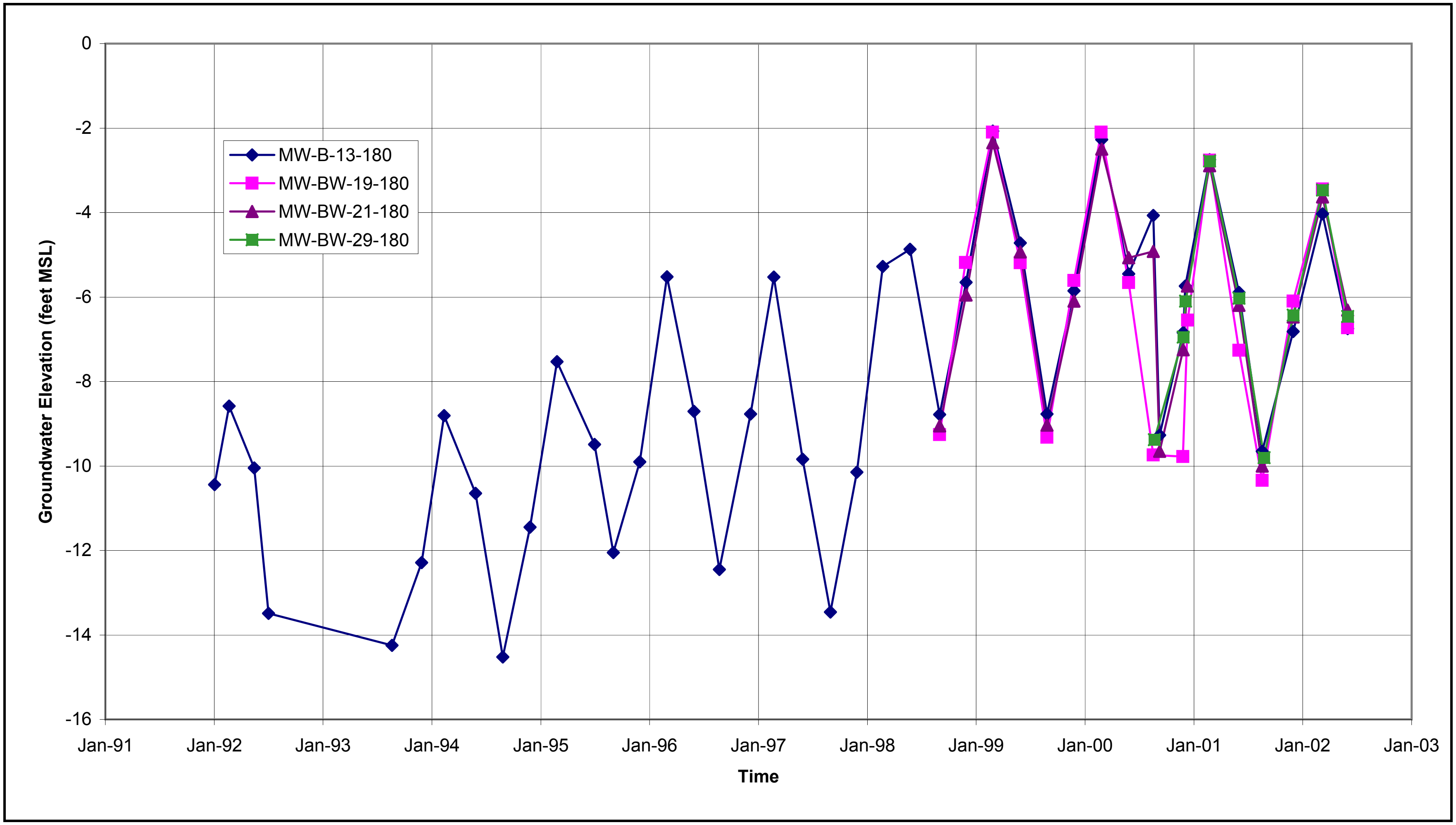
OU CTP RI/FS
Work Plan
Former Fort Ord, California

Lithologic Cross-Section and Well Construction Diagram

PLATE 10
SHEET: OF
REVISION NUMBER: 0
DATE: 12/01



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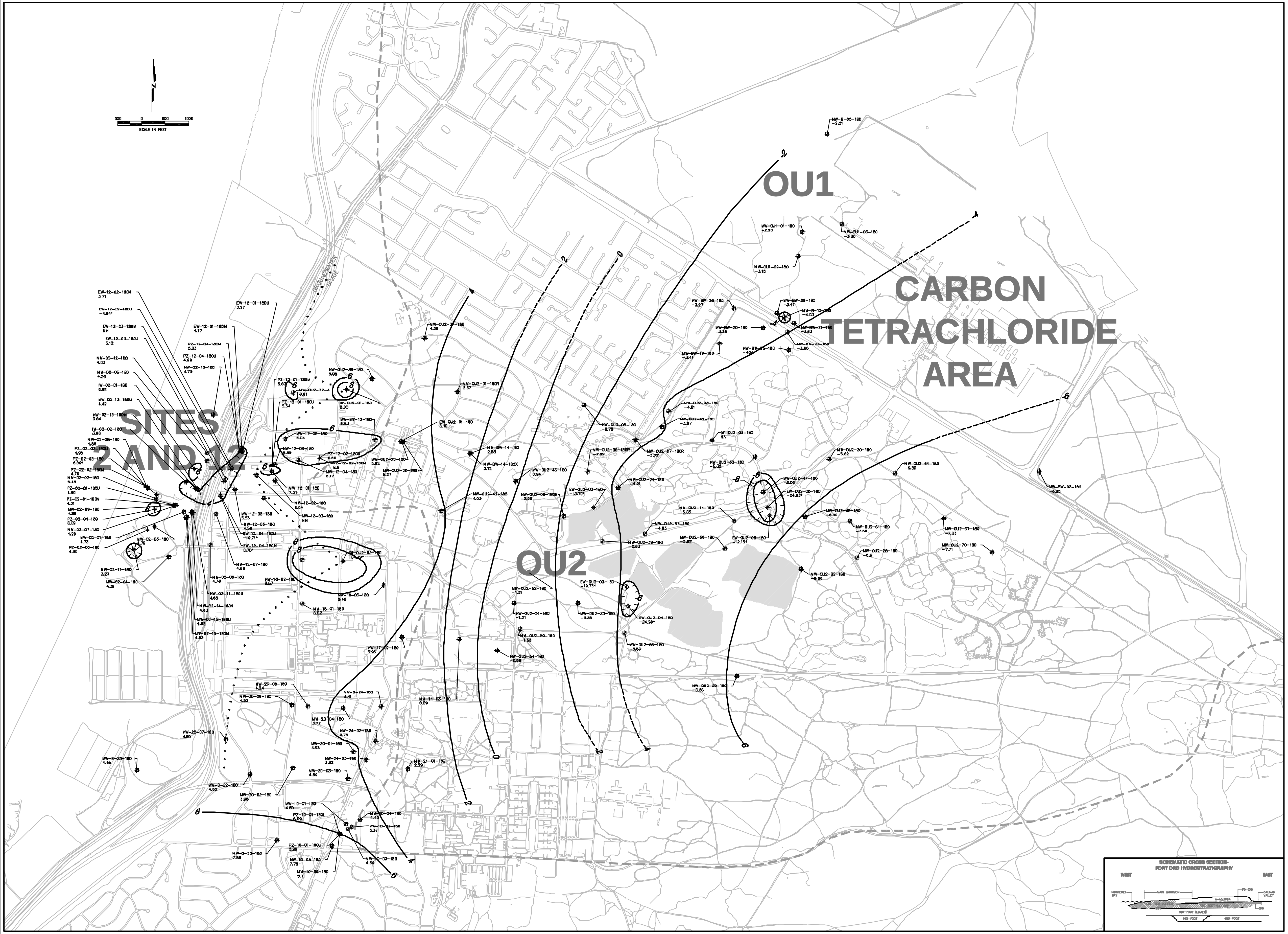
Harding ESE, Inc.
Engineering and
Environmental Services

Hydrograph
Upper 180-Foot Aquifer
OU CTP RI/FS Work Plan
Former Fort Ord, California

PLATE
11

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
MDT	55596.00112		6/02	



EXPLANATION

- ACTIVE DRINKING WATER SUPPLY WELL WAS NOT MEASURED
- MONITORING WELL
- PIEZOMETER NEST
- MONITORING WELL WATER LEVEL WAS NOT MEASURED
- INJECTION WELL
- EXTRACTION WELL
- INFILTRATION GALLERY, WATERLEVEL NOT MEASURED
- 49.17 WATER-LEVEL ELEVATION (IN FEET ABOVE OR BELOW MEAN SEA LEVEL)
- NM NOT MEASURED
- * NOT USED FOR CONTOURING
- GROUNDWATER ELEVATION CONTOUR (IN FEET ABOVE OR BELOW MEAN SEA LEVEL, CONTOUR INTERVAL 2 OR 10 FEET)
- GROUNDWATER DIVIDE — APPROXIMATE LOCATION OF A GROUNDWATER DIVIDE
- APPROXIMATE EDGE OF FORT ORD-SALINAS VALLEY AQUICLUDE BOUNDARY, QUERIED WHERE UNCERTAIN
- APPROXIMATE EXTENT OF FORT ORD LANDFILLS. HLA, JANUARY 5, 1995
- SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP

NOTES:

(1) ALL MONITORING AND WATER LEVELS MEASURED BETWEEN MARCH 11 AND MARCH 13, 2002, EXCEPT MW-001-12-A MEASURED ON MARCH 18, 2002.

(2) EXTRACTION AND INJECTION WELL WATER LEVELS MEASURED ON MARCH 1, 2002.

(3) WATER-LEVEL ELEVATION CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

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NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
				55596 00112			SS

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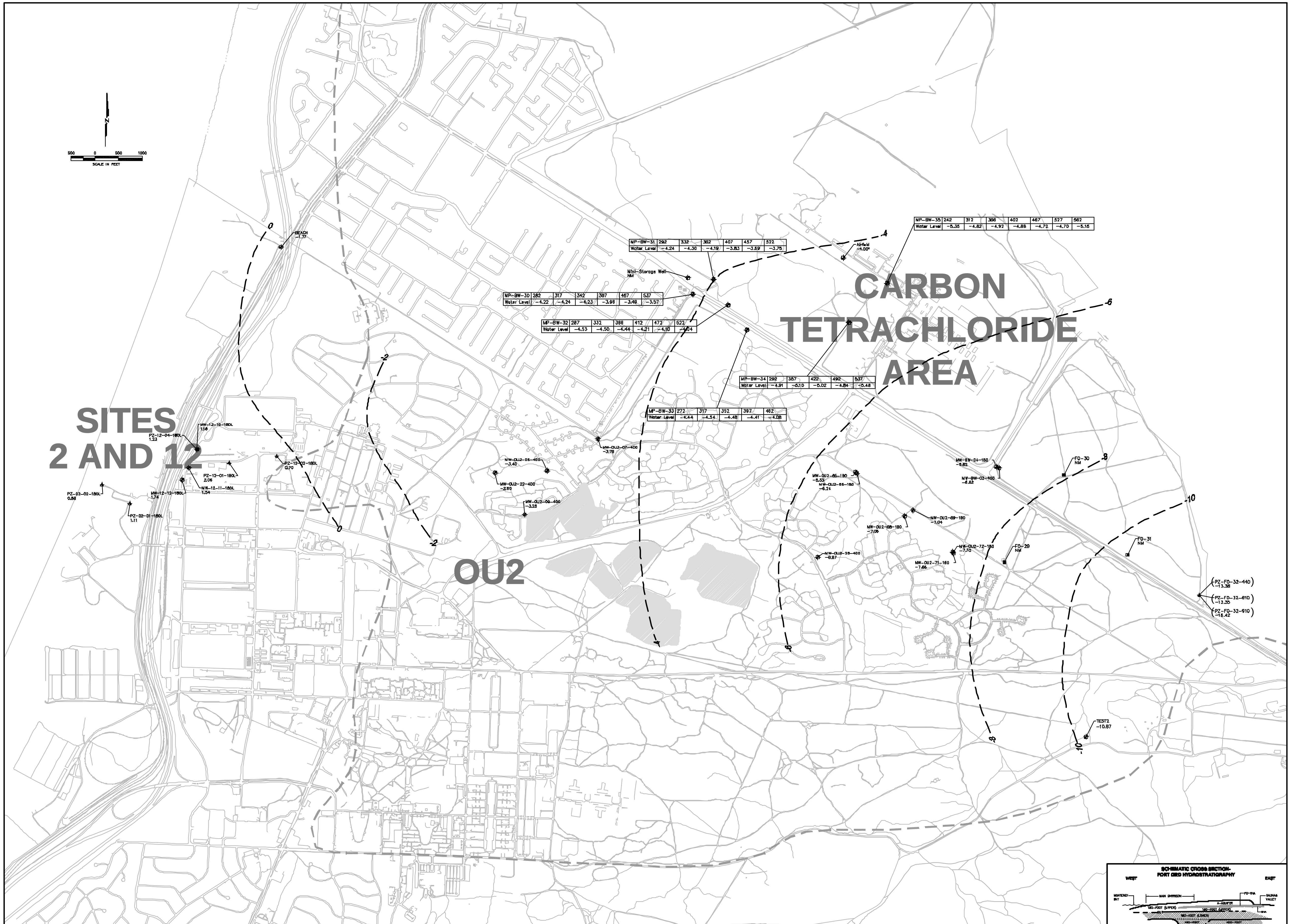
A MACTEC COMPANY

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Groundwater Elevations
Upper 180-Foot Aquifer
March 2002

PLATE:
12



EXPLANATION

- MONITORING WELL
- PIEZOMETER NEST
- MONITORING WELL WATER LEVEL WAS NOT MEASURED
- INJECTION WELL
- EXTRACTION WELL
- ACTIVE DRINKING WATER SUPPLY WELL

MP-BW-35	242	312	366
Water Level	-7.63	-8.82	-7.04

WELL NAME

PORT NAME REPRESENTING DEPTH FROM GROUND SURFACE (FEET)

GROUNDWATER ELEVATION (FEET MSL)

49.17 GROUNDWATER ELEVATION (IN FEET ABOVE OR BELOW MEAN SEA LEVEL)

NM NOT MEASURED

( ) DENOTES WELL COMPLETED IN THE AROMAS SAND/PASO ROBLES FORMATION AQUIFERS

* NOT USED FOR CONTOURING

-8 GROUNDWATER ELEVATION CONTOUR (IN FEET ABOVE OR BELOW MEAN SEA LEVEL, CONTOUR INTERVAL 2 OR 10 FEET)

APPROXIMATE EDGE OF FORT ORD-SALINAS VALLEY AQUICLUDE BOUNDARY, QUERIED WHERE UNCERTAIN

APPROXIMATE EXTENT OF FORT ORD LANDFILLS. HLA, JANUARY 5, 1995

SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP

NOTES:

(1) ALL MONITORING WELL WATER LEVELS MEASURED BETWEEN MARCH 11 AND 13, 2002 WITH THE EXCEPTION OF MP-BW-30, MP-BW-31, MP-BW-32, MP-BW-33, MP-BW-34, MP-BW-35, WHICH WERE MEASURED BETWEEN MARCH 4 AND MARCH 6, 2002.

(2) WATER-LEVEL ELEVATION CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

(3) THE AVERAGE WATER ELEVATION FROM ALL PORTS MEASURED WITHIN EACH MONITORING WELL WERE USED FOR CONTOURING MP-BW-30 THROUGH MP-BW-35.

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20020613.1241

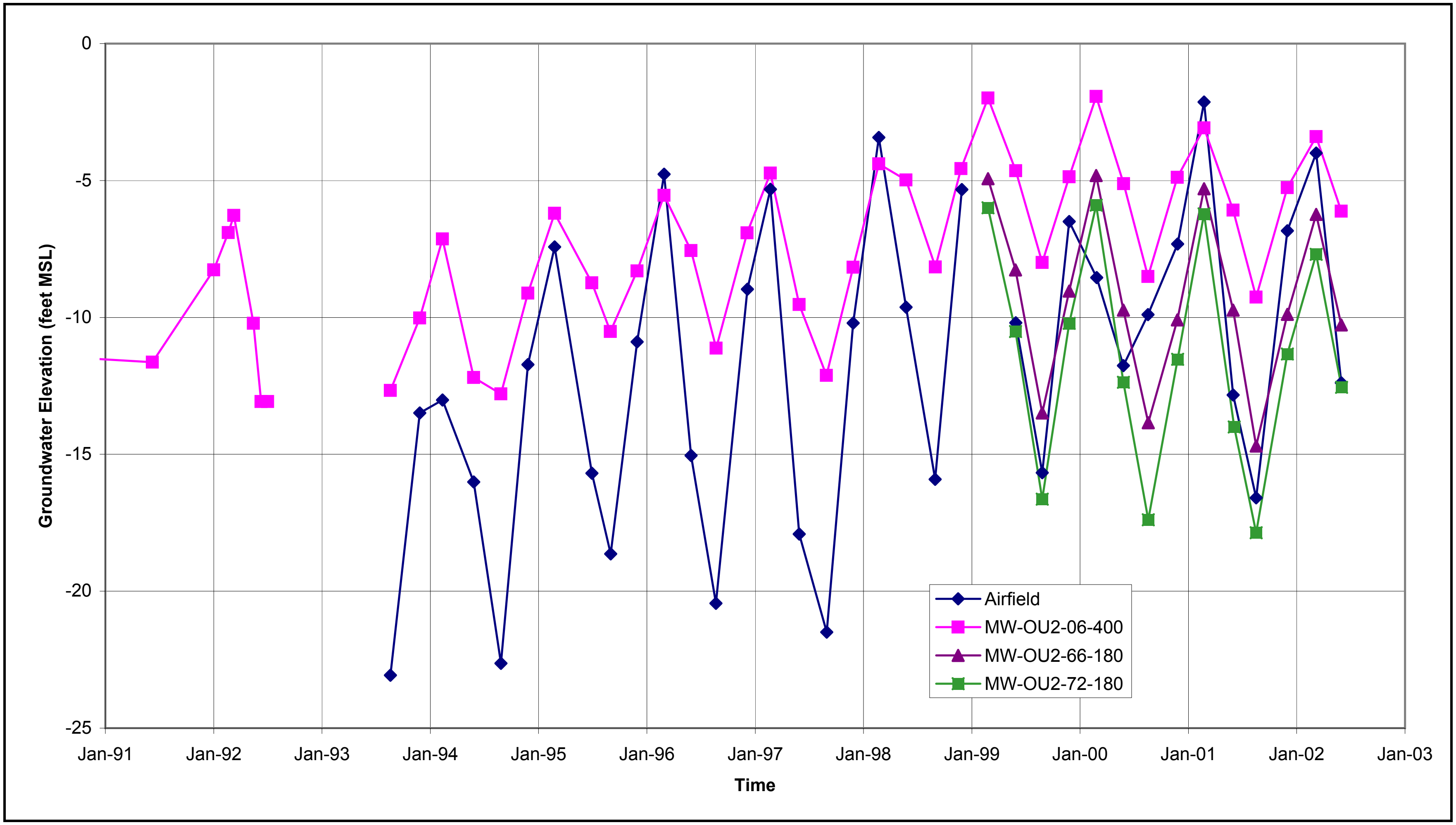
NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	03/2002			55596 00112			SS

Harding ESE
A MACTEC COMPANY

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Groundwater Elevations
Lower 180-Foot / 400-Foot Aquifers
March 2002

PLATE:
13



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Engineering and
Environmental Services

Hydrograph
Lower 180-Foot Aquifer
OU CTP RI/FS Work Plan
Former Fort Ord, California

PLATE
14

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
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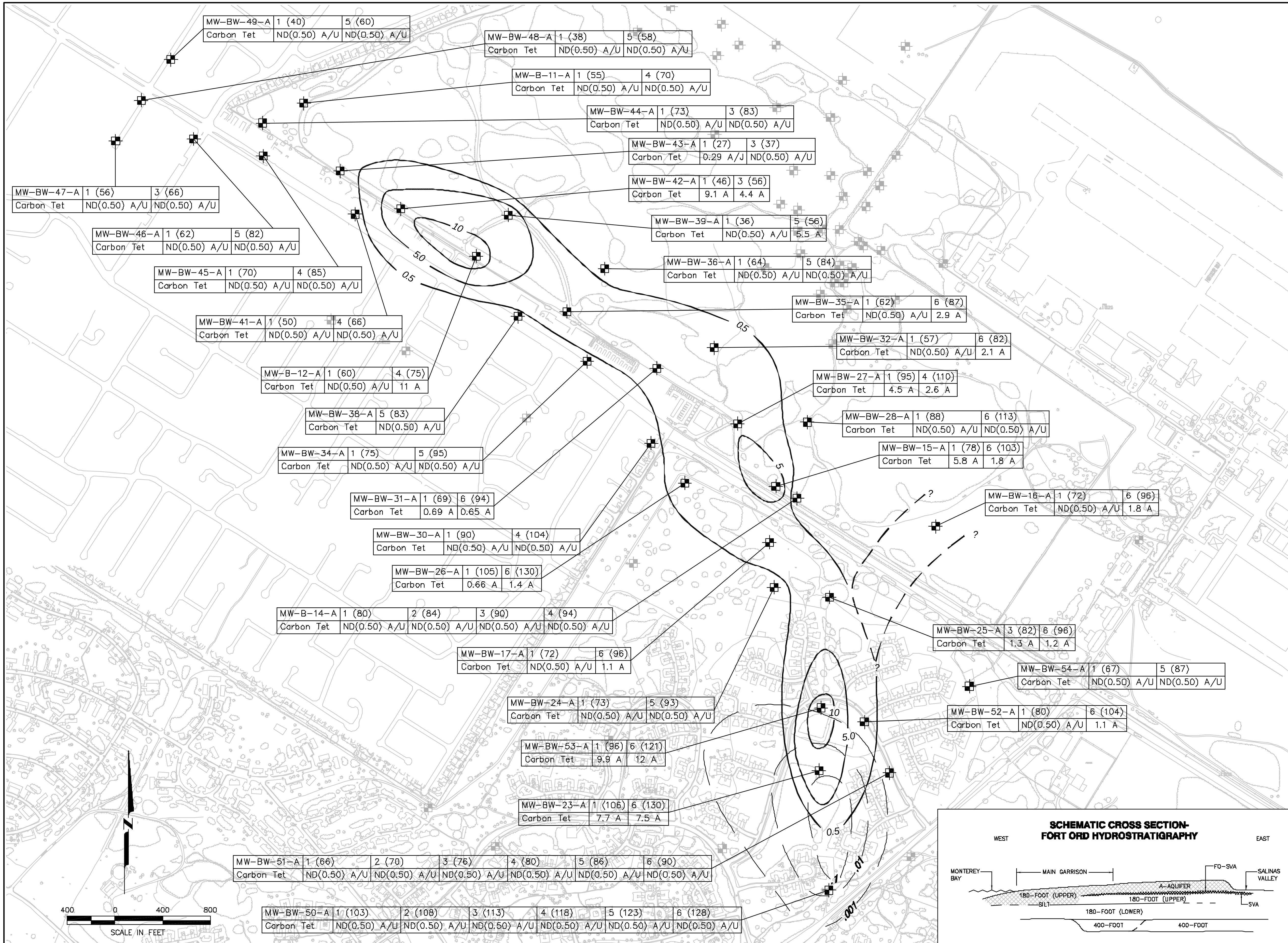

EXPLANATION

- MONITORING WELL
- MONITORING WELL WAS NOT SAMPLED THIS QUARTER OR IS BEYOND THE FOCUS AREA OF THIS PLATE
- INACTIVE WATER SUPPLY WELL WAS NOT SAMPLED FOR CARBON TETRACHLORIDE
- 2.32 A — MARCH 2002 CONCENTRATIONS OF CARBON TETRACHLORIDE IN µg/L WITH HARDING QUALIFIER
- ND(0.50) — NOT DETECTED AT THE REPORTING LIMIT SHOWN IN PARENTHESES
- 1 — CHEMICAL CONCENTRATION CONTOUR IN µg/L; DASHED WHERE INFERRED (CARBON TETRACHLORIDE MCL = 0.5 µg/L)
- SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP
- .1 — SOIL GAS CARBON TETRACHLORIDE CONCENTRATIONS (µg/kg) MEASURED IN 1987 AND PRESENTED IN PRELIMINARY HYDROGEOLOGIC INVESTIGATION REPORT (HLA, 1990)

MW-BW-16-180	1 (72)	6 (96)
CARBON TET	ND(0.50) A/U	1.4 A

WELL NAME; BAG POSITION; BAG DEPTH; CHEMICAL; CONCENTRATION IN µg/L WITH HARDING QUALIFIER

NOTES: (1) CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

(2) CONTOURS BASED ON HIGHEST VALUE OBTAINED FROM MULTIPLE BAGS WHERE APPLICABLE.

(3) MONITORING WELLS WERE SAMPLED BETWEEN MARCH 13 AND MARCH 15, 2002.

NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
	05/02			55596 00112			SS

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OU CTP RI/FS
Work Plan
Former Fort Ord, California

Carbon Tetrachloride Concentrations
A-Aquifer
March 2002

PLATE: 15

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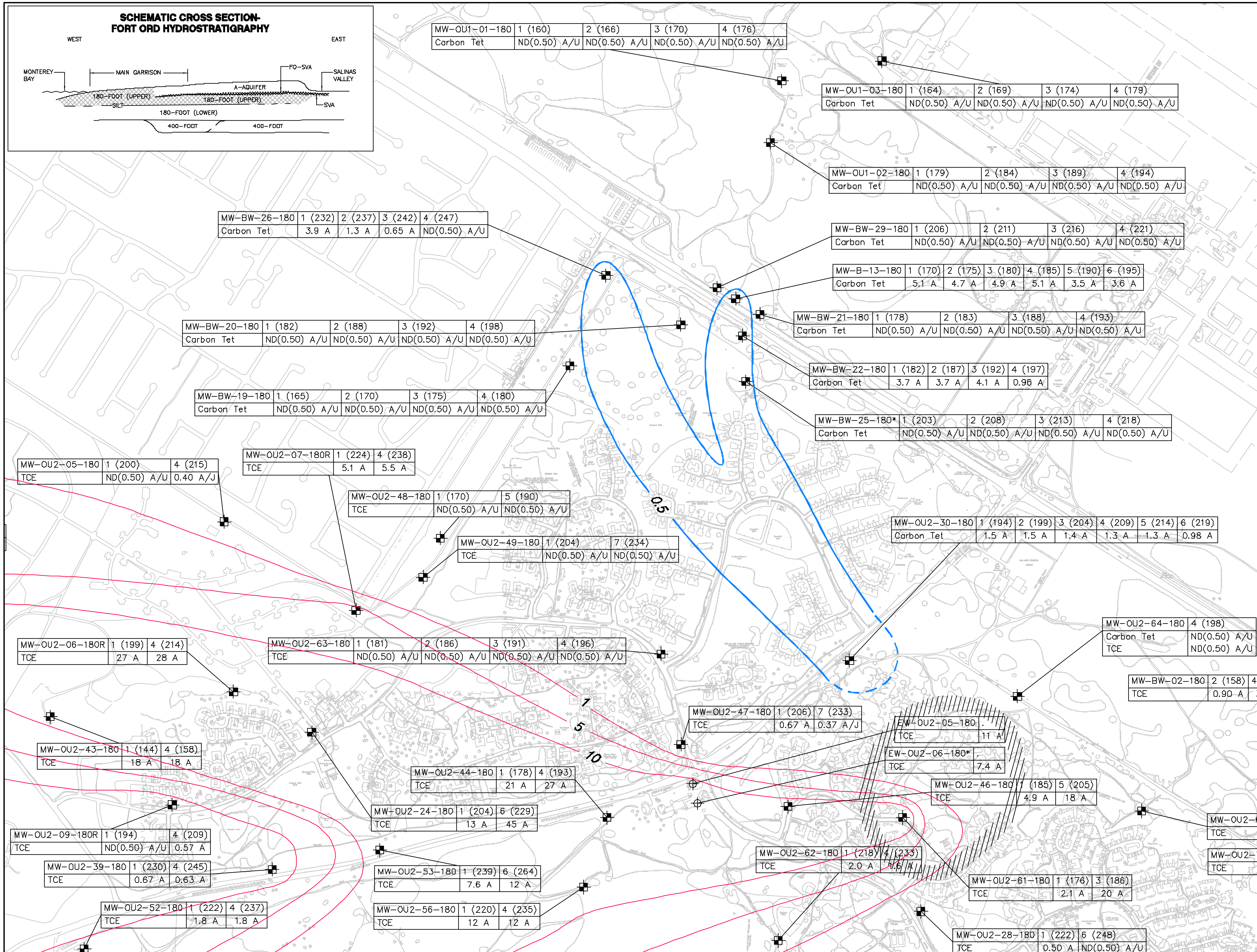

EXPLANATION

- MONITORING WELL
- EXTRACTION WELL
- INJECTION OR INFILTRATION WELL
- MONITORING WELL WAS NOT SAMPLED
- INACTIVE SUPPLY WELL
- ACTIVE SUPPLY WELL
- ND(0.50) — NOT DETECTED AT THE REPORTING LIMIT SHOWN IN PARENTHESES
- 5 — CARBON TETRACHLORIDE CONCENTRATION CONTOUR IN µg/L; DASHED WEHRE INFERRED.
- 1 — TCE CONCENTRATION CONTOUR IN µg/L; DASHED WHERE INFERRED. ASSOCIATED WITH THE OU 2 PLUME.
- SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP
- * NOT USED FOR CONTOURING
- SUSPECTED NATURAL CONDUIT BETWEEN UPPER AND LOWER 180-FOOT AQUIFERS

WELL NAME	BAG POSITION (BAG DEPTH)		BAG POSITION (BAG DEPTH)
MW-BW-16-180	1 (72)		6 (96)
CARBON TET	ND(0.50) A/U		1.4 A

CHEMICAL; CONCENTRATION IN µg/L WITH HARDING QUALIFIER

NOTES: (1) CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

(2) CONTOURS BASED ON HIGHEST VALUE OBTAINED FROM MULTIPLE BAGS WHERE APPLICABLE.

(3) MONITORING WELLS WERE SAMPLED BETWEEN MARCH 13 AND MARCH 15, 2002.

(4) MW-BW-25-180, MW-BW-26-180, AND, MW-BW-29-180 ARE SCREENED IN THE LOWER PORTION OF THE AQUIFER AND RESULTS MAY INDICATE VERTICAL STRATIFICATION OF GROUNDWATER QUALITY.

(5) IF NO VALUE IS ASSIGNED THE BAG POSITION BOX, THE WELL WAS NOT SAMPLED USING PDB SAMPLERS.

NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	5/02			55596 00112			SS
2	10/02	ADD VERTICAL CONDUIT		55596.00112			SS

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A MACTEC Company

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Carbon Tetrachloride Concentrations
Upper 180-Foot Aquifer
March 2002

PLATE: 16

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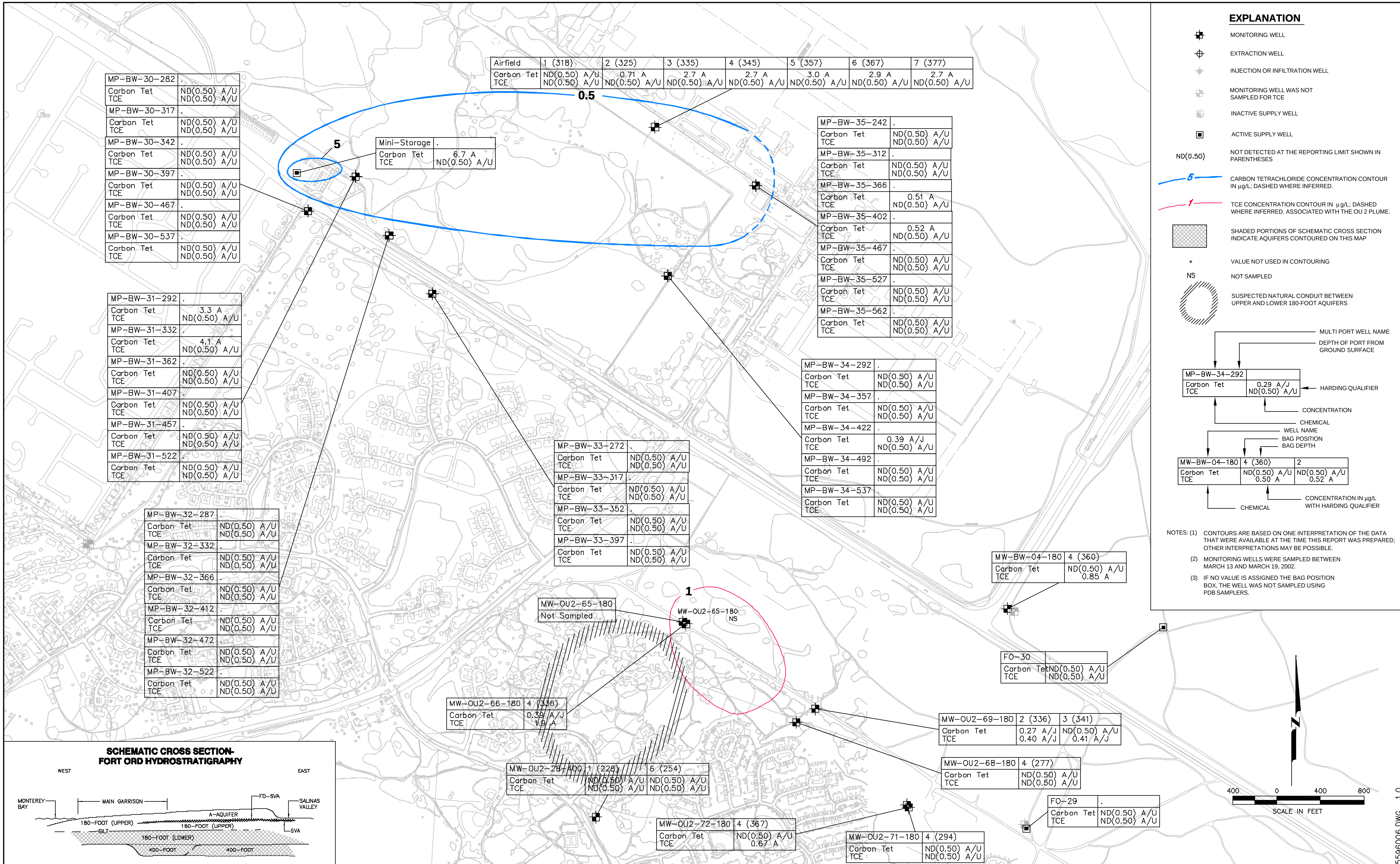

NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
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1	10/02	ADD VERTICAL CONDUIT		55596.00112			SS

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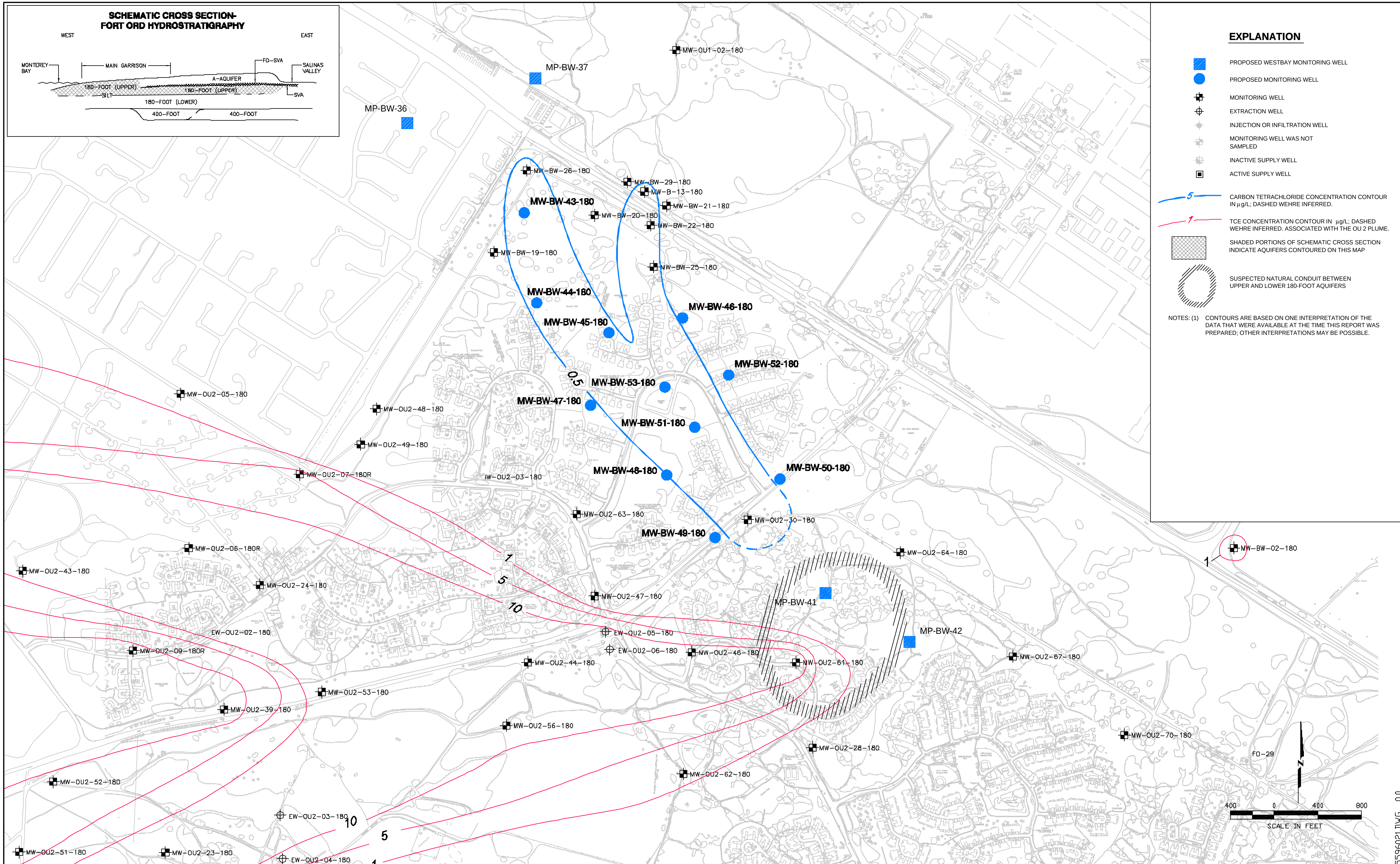
A MACTEC COMPANY

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Carbon Tetrachloride Concentrations
Lower 180-Foot / 400-Foot Aquifers
March 2002

PLATE:
17



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NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
1	5/02			55596 00112			SS
2	7/02	Moved MP-BW-41 SW, Added MP-BW-36					
3	10/02	ADD VERTICAL CONDUIT		55596.00112			SS

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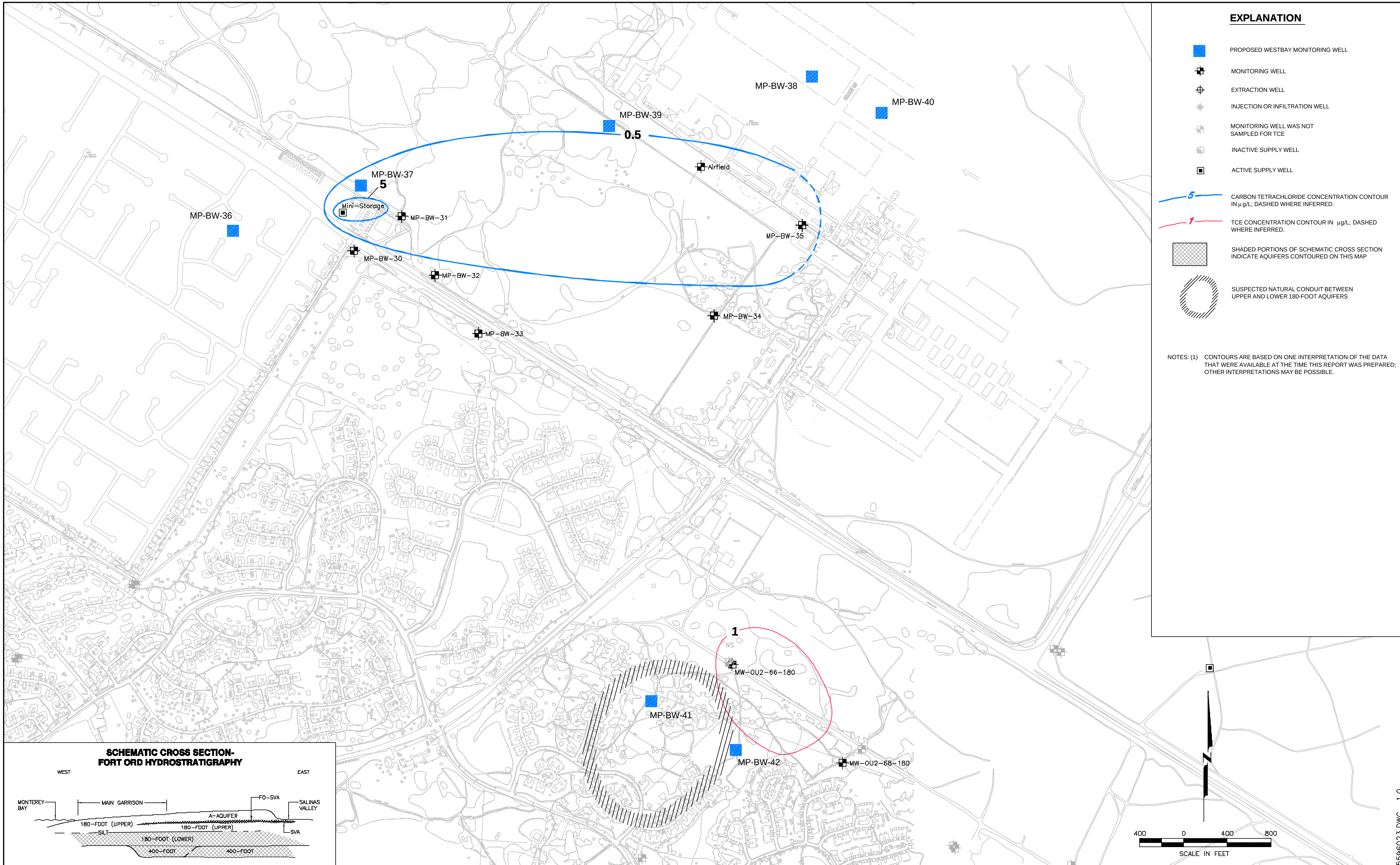
A MACTEC Company

OU CTP RI/FS
Work Plan
Former Fort Ord, California

Proposed Monitoring Wells
Upper 180-Foot Aquifer
March 2002

PLATE:
18



NO.	DATE	REVISIONS	HLA FILE NO.	PROJECT NO.	APPROVED	APPROVAL DATE	DRAWN BY
2	07/02	Moved MP-BW-41 SW, Added MP-BW-38		55596 00112			SS
3	08/02	Moved MP-BW-40 NE, Moved MP-BW-36 SW					
4	10/02	ADD VERTICAL CONDUIT		55596.00112			SS

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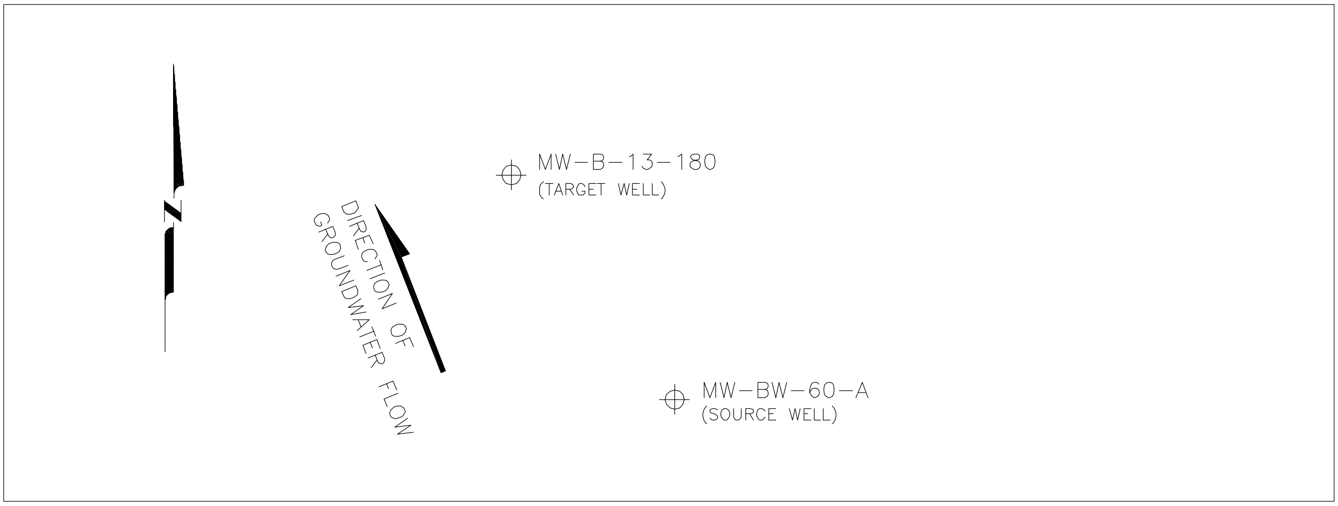
A MACTEC Company

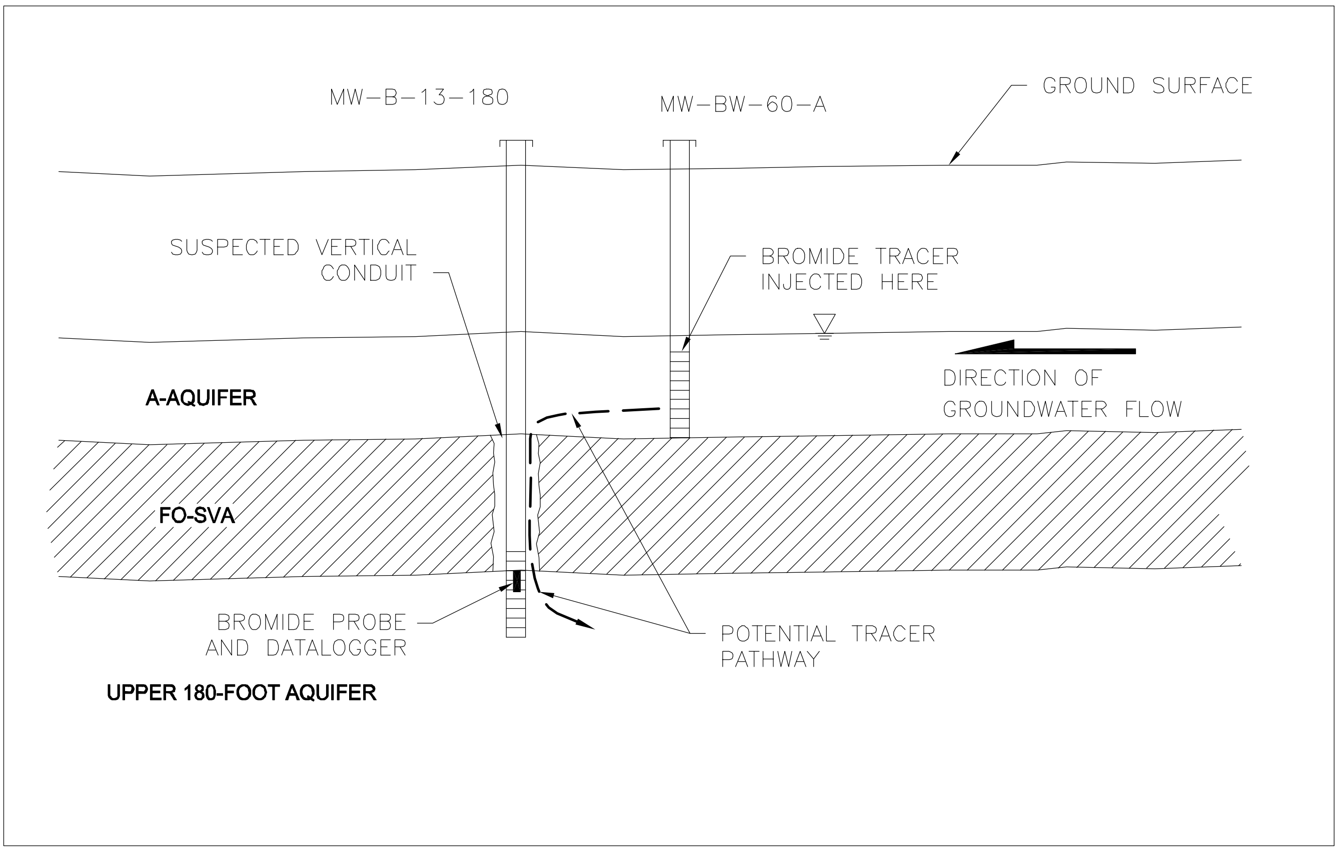
OU CTP RI/FS
Work Plan
Former Fort Ord, California

Proposed Monitoring Wells
Lower 180-Foot / 400-Foot Aquifers
March 2002

PLATE:
19



PLAN VIEW
NOT TO SCALE



CROSS SECTION
NOT TO SCALE

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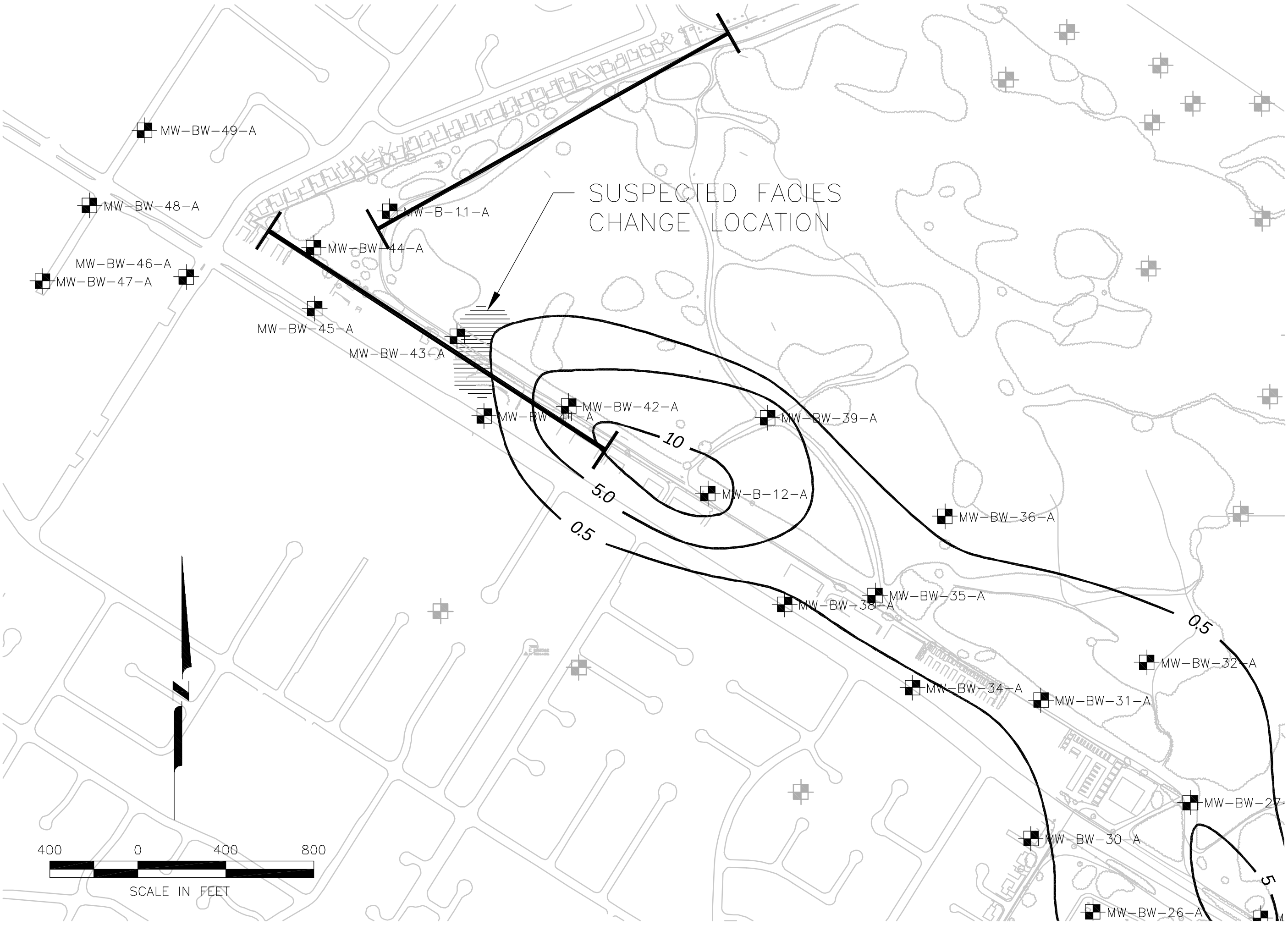
A MACTEC COMPANY

Tracer Test Site
Schematic Diagram
OU CTP RI/FS Work Plan
Former Fort Ord, California

PLATE
20

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
SS	55596 00112		05/02	



EXPLANATION

PROPOSED GEOPHYSICAL TRANSECT

MONITORING WELL

MONITORING WELL WAS NOT SAMPLED THIS QUARTER OR IS BEYOND THE FOCUS AREA OF THIS PLATE

INACTIVE WATER SUPPLY WELL WAS NOT SAMPLED FOR CARBON TETRACHLORIDE

CHEMICAL CONCENTRATION CONTOUR IN µg/L; DASHED WHERE INFERRED (CARBON TETRACHLORIDE MCL = 0.5 µg/L)

SHADED PORTIONS OF SCHEMATIC CROSS SECTION INDICATE AQUIFERS CONTOURED ON THIS MAP

NOTES:

(1) CONTOURS ARE BASED ON ONE INTERPRETATION OF THE DATA THAT WERE AVAILABLE AT THE TIME THIS REPORT WAS PREPARED; OTHER INTERPRETATIONS MAY BE POSSIBLE.

(2) CONTOURS BASED ON HIGHEST VALUE OBTAINED FROM MULTIPLE BAGS WHERE APPLICABLE.

(3) MONITORING WELLS WERE SAMPLED BETWEEN MARCH 13 AND MARCH 15, 2002.

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Harding ESE
A MACTEC COMPANY

Proposed Geophysical Transect Locations
OU CTP RI/FS Workplan
Former Fort Ord, California

PLATE
21

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
SS	55596 00112		06/02	

APPENDIX A

PROPOSED SCHEDULE

Federal Facility Agreement
Draft Timetable and Deadlines
Carbon Tetrachloride (OU3) ROD/RD/RA, Former Fort Ord

Deliverable/Event	Current Deadlines (Previous Deadlines)	Deadline Revision Rationale
OU CTP ROD Activities		
Draft RI/FS Work Plan	7/02	
Comments Due	9/02	
Draft Final RI/FS Work Plan	10/02	
Comments Due	11/02	
Draft RI/FS	10/03	
Comments Due	12/03	
Draft Final RI/FS	1/04	
Comments Due	2/04	
Draft Proposed Plan	3/04	
Comments Due	5/04	
Draft Final Proposed Plan	6/04	
Comments Due	7/04	
Final Proposed Plan	8/04	
Public Comment Period	9/04	
Draft ROD	10/04	
Comments Due	12/04	
Draft Final ROD	1/05	
Comments Due	2/05	
Final ROD Signed	3/05	

APPENDIX B

HARDING ESE RESPONSES TO AGENCY COMMENTS

The Department of Toxic Substances Control (DTSC) has reviewed the document titled "Draft Operable Unit Carbon Tetrachloride Plume, Remedial Investigation/Feasibility Study, Work Plan, Former Fort Ord, Monterey County, California". The document was prepared for the Department of the Army by Harding ESE. Comments regarding this document are included within the text of this letter and in an enclosed Memorandum to me from our Geologic Services Unit (GSU). Please review and address these comments in the draft final version of the document.

GENERAL COMMENTS:

1. The work plan rationale described in Chapter 4 describes additional groundwater sampling for assessing monitored natural attenuation. DTSC agrees that further evaluation of natural attenuation parameters is useful and necessary. However, remedial alternatives other than monitored natural attenuation should also be fully considered during the RI/FS. The discussion of treatability studies, remedial alternatives evaluation, and remedial alternatives screening in Chapter 5 should be revised to emphasize that natural attenuation is not the only remedial alternative which will be evaluated.

Response: Specific remedial alternatives were not specified in Section 5.0 because their selection is dependent upon further data collection as will be discussed in the feasibility study. Section 4.0 will be amended to specify that the collection of analytes used to assess the viability of natural attenuation processes will not preclude the evaluation of other remedial alternatives.

2. The draft schedule presented in Appendix A includes a time period of approximately 11 months to prepare the draft RI/FS report for submittal to regulatory agencies for review. This timeline may be overly ambitious if pilot studies or treatability studies are initiated. It is recommended that additional time be built into the schedule to accommodate pilot studies and/or treatability studies which may be necessary to evaluate remedial options other than monitored natural attenuation.

Response: The need for a pilot or treatability study has not been identified in the RI/FS process for OU CPT. In accordance with EPA Guidance, if the need for additional studies is identified later in the RI/FS process, the RI/FS completion may be delayed until completion of the studies. The schedule will be modified in the future if the BCT decides a pilot or treatability study is necessary.

3. In Chapter 3 and Table 2, state maximum contaminant levels are discussed as action levels in lieu of aquifer cleanup levels assigned by a record of decision. DTSC agrees that one of the goals of the investigation is to construct a ROD for the OU CTP area. The risk assessment portion of the RI/FS will be instrumental in establishing the risk based aquifer cleanup levels for the OU CTP ROD. Chapter 5.5 of the work plan should be revised to include a discussion of the role of the risk assessment in establishing clean up levels for the site.

Response: Additional language describing the importance of the risk assessment concerning the risk-based aquifer cleanup levels will be included in Chapter 5.5 as suggested.

GENERAL COMMENTS AND RECOMMENDATIONS (submitted by the GSU):

The GSU refers the reader to the GSU's January 29, 2002, memorandum reviewing the November 29, 2001 Draft Natural Attenuation Summary Report Carbon Tetrachloride Investigation prepared by Harding ESE. In the January, 2002, memorandum, the GSU recommended that Harding ESE use U.S. EPA's Office of Solid Waste and Emergency Response Directive 9200.4-17 (1997) as a guide when developing, implementing, and reporting monitored natural attenuation (MNA) at the Site.

1) The GSU recommends that prior to implementing a feasibility study that the screening criteria as presented in the U.S. EPA's 1997 Technical Protocol document be used to evaluate the potential for MNA as an effective alternative. If the screening criteria for effective MNA are met, then the next steps, as presented in Section 2 of the Protocol should be conducted. These steps include: 1) refining the conceptual model based on site characterization data; 2) completing pre-modeling calculations, and documenting indicators of natural attenuation; 3) simulating, if necessary, natural attenuation using analytical or numerical solute fate and transport models that allow incorporation of a biodegradation term; 4) identifying potential receptors and exposure points and conducting an exposure pathways analysis; 5) evaluating the need for supplemental source control measures; and 6) preparing a long-term monitoring and verification.

Response: The U.S. EPA OWSER Directive 9200.4-17 (1997) will be used as a guideline prior to the implementation of the feasibility study.

SPECIFIC COMMENTS AND RECOMMENDATIONS:

1) Page 5, Section 2.4.1, Paragraph 1: Former Fort Ord drinking water supply wells Nos. 26, 27, and 28 are referred here to have been located within the current OU CTP. Later in the Draft OU CTP RI/FS Work Plan these wells are stated as at one time being possible conduits for contaminant flow from the shallow to deep aquifers beneath the Site. However, these wells do not appear on any of the plan-view drawings included with the Work Plan. Wells FO-27 and FO-28 do appear in geologic cross-section A-A' on Plate 10.

Recommendation

The GSU recommends including Fort Ord drinking water supply wells Nos. 26, 27, and 28 on all appropriate Plates (at a minimum, Plate 6, Plate 13, Plate 17, and Plate 19).

Response: The appropriate Plates will be modified to include Well Nos. 26, 27, and 28.

2) Page 12, Section 2.9.2, Paragraph 2: Groundwater flow within the A-Aquifer is reported to shift subtly toward the south, west of well MW-BW-45-A. However, upon viewing Plate 8 (Groundwater Elevations A-Aquifer and Upper 180-Foot Aquifer), the GSU is unable to observe said southward shift of flow.

Recommendation

The GSU recommends further explanation of the suggested southward flow of groundwater within the A-Aquifer in the area west of well MW-BW-45-A.

Response: The subtle southern shift in groundwater flow is not apparent at the scale with which Plate 8 was presented; however, we would refer you to the *Draft Final, Carbon Tetrachloride Study Area, Drilling Letter Report – Monitoring Wells MW-BW-43-A through MW-BW-54-A, Former Fort Ord, California*, dated February 6, 2002. Plate 2 of this document illustrates A-Aquifer groundwater elevation contours at a site-specific scale where the subtle southern shift in groundwater flow direction near the toe of the A-Aquifer plume is more apparent. The RI report will include a map similar to this Plate 2 but will include the most current and complete data.

3) Page 12, Section 2.9.2, Paragraph 3: A reference is made to a rise in the water table of over 5 feet

occurring as the result of unusually large amounts of rainfall in the winter of 1997/1998. However, upon review of the hydrograph presented on Plate 9, it appears that the rise in the water table referred to actually occurred during the winter of 1998/1999.

Recommendation

The GSU recommends correction of the text, or an explanation provided for the apparent discrepancy between the text and the hydrograph on Plate 9.

Response: A significant response was observed at MW-B-12-A during the 1997/1998 winter months, correlating with an El Niño event. There is no clear reason for the delayed response at MW-B-14-A, although it may be related to the slightly thicker vadose zone at this well (70 feet) relative to MW-B-12-A (50 feet) or a local dynamic between MW-B-14-A and the suspected vertical conduit at MW-B-13-180 (which will be confirmed with the proposed tracer test). Recharge from the 1997/1998 winter storms are responsible for the rise in water levels, regardless of the reason for the delay at MW-B-14-A.

4) Page 21, Section 3.2, Paragraph 2: It is stated that the conceptual migration route connecting the plumes in the A-Aquifer and the Upper 180-Foot Aquifer is described in Section 3.3.2. However, the migration routes are actually described in Section 3.2.2.

Recommendation

The GSU recommends making the appropriate changes in the text.

Response: The text will be corrected appropriately.

5) Page 49, Section 4.3: A tracer test is here proposed to be conducted in the area of groundwater monitoring well MW-B-13-180, based upon the potential that well MW-B-13-180 may be acting as a vertical conduit for contaminant flow. As stated in Section 2.4.1, municipal water-supply well Nos. MWCWD-5, -8, -8a, and -11, and the Marina Mini-Storage water supply well may be acting, or may have acted, as vertical conduits for contaminant flow. In addition to the tracer test proposed for well MW-B-13-180, it may be prudent to also conduct tracer tests in the area of wells MWCWD-8a and –11 and the Marina Mini-Storage well. Wells MWCWD-5 and –8 have been destroyed.

Recommendation

The GSU recommends conducting tracer tests in the area of wells MWCWD-8a, and –11, and the Marina Mini-Storage well, to aid in determining whether these wells are acting, or may have acted, as vertical conduits for contaminant flow.

Response: The text will be corrected to clarify that MCWD-8a, MCWD-11, and the mini-storage well are not suspected of having been or being vertical conduits. Monitoring water levels at the Westbay wells will provide ample data to determine whether stresses from active pumping in the area is being transferred to from one aquifer to another.

Only MCWD-5 and -8, FO-26, FO-27, and FO-28 are suspected of having been constructed so as to hydraulically connect the A-Aquifer with the Upper and Lower 180-Foot Aquifers. We do not concur that a tracer test at these locations is feasible because these wells have already been destroyed.

6) Page 53, Section 4.5, Paragraph 2: As stated here, in lieu of pump tests to determine aquifer characteristics within the lower 180-foot aquifer, it is proposed to monitor groundwater levels within wells MP-BW-30 and MP-BW-31 as they may, or may not, respond to routine pumping from the private irrigation well and active drinking water well MCWD-11. As the GSU understands it, the reason for proposing passive monitoring is a concern that an inordinate amount of impacted groundwater would be produced when pumping from the lower-180 foot aquifer as it consists of a coarser material than the overlying formations, and is likely of a higher hydraulic conductivity. However, if these wells are already being used for some purpose, than there must be some means of addressing the fact that water from these wells is, or may be, impacted with VOCs. Would the additional amounts of water produced from a pump test be so great that they could not be accommodated by the existing system(s)?

<u>**Recommendation**</u>

The GSU recommends a more thorough discussion of the basis for deeming pump tests on the lower 180-foot aquifer to be infeasible.

Response: The text will be clarified; however, it is most likely that MCWD-8a would suffice as a pumping well with at least two Westbay observation wells. If possible, discharge would be sent to the city storm drain or sanitary sewer system if they can accommodate the necessary flow. This would also require proper coordination with the public works department and depend upon the approval of a NPDES permit.

The only alternative pumping well screened in the Lower 180-Foot Aquifer is the privately-owned mini-storage well, which is currently plumbed to a pressure-demand system. Using this well would require permission from the well owner and minor temporary re-plumbing.

The use of slug tests at representative Westbay pumping ports should result in useful hydraulic characterization data with the added benefit of being depth-specific, whereas values derived from pumping tests will tend to reflect the entire aquifer thickness.

7) Page 54, Section 4.6: Based on the uncertainties identified in this section regarding contaminant source(s), as well as the use of qualitative data obtained from the proposed "passive monitoring" of groundwater response within the lower 180-foot Aquifer, the usefulness of modeling to predict contaminant fate and transport of the CT plume is highly questionable.

<u>**Recommendation**</u>

The GSU questions the appropriateness of predictive fate and transport modeling based on the problems discussed above. The GSU recommends clarifying the model results based on qualitative data. Significant assumptions are highly suspect.

Response: Aquifer parameter data have been estimated at other locations at Former Fort Ord for each aquifer in question at the OU CTP. Specific capacity from previously operated water supply wells at former Fort Ord and Marina will also be useful in estimating transmissivity and will be included to define the model. Although limited knowledge of source terms (a common problem) and limited historical data will prevent the ability to verify historical groundwater quality conditions, the current delineation of each plume will be primarily used to calibrate the model which will result in a solid foundation upon which to forecast alternative future conditions.

8) Page 55, Section 4.7: It is stated here that the groundwater well management plan will be

updated with the proposed monitoring wells, and provided in a GIS-format.

Recommendation

The GSU recommends all data associated with the GIS groundwater well management plan be made available in an open format that will allow for export into software of the users choice.

Response: The final well management plan will be available online in a format similar to information currently available to the regulatory agencies and will be an extension of currently available data describing basic well information in an open format.

The U.S. Environmental Protection Agency has reviewed the subject document and submits the following comments:

GENERAL COMMENTS:

1. It is understood that this Remedial Investigation/Feasibility Study Work Plan (work plan) only references the soil gas study to be conducted in the carbon tetrachloride plume area. However, to allow for the results of the soil gas survey to be used in the remedial investigation report, please address the following two issues:

    a) As the presumed location of the carbon tetrachloride release was redeveloped for housing, it is possible that considerable grading was performed to provide level home sites. Please assure, by comparing historical and current topographic maps, that the soil gas survey is being conducted in native materials and not fill.

    Response: Although significant grading did occur in the Preston Park housing area, the soil gas survey was conducted behind or around the houses where the original grade was left undisturbed. Additionally, multiple samples were collected at depths that exceed the maximum amount of grading.

    b) Please assure that the soil gas survey covers any potential sources identified in the specific comment on Section 3.2.1, below.

    Response: See response to Specific Comment #1.

2. While Tables 2 through 10 include important data quality methods and requirements as would normally be found in a Quality Assurance Project Plan, the work plan introduction includes reference to the Chemical Data Quality Management Plan (CDQMP; HLA, 2002h) which is described in Section 7 (References) as "In press". The CDQMP as well as the Sampling and Analysis Plan (SAP; Harding ESE, 2002f) are critical RI/FS planning documents which should be finalized in conjunction with the RI/FS work plan.

Response: Both documents were in the process of finalization at the time the Work Plan was submitted and have since been finalized.

SPECIFIC COMMENTS:

1) Section 3.2.1, Chemical Sources, Page 22: The work plan indicates that previous activities that took place at the presumed source of the carbon tetrachloride plume include light military vehicle training and a wireman training area, which are not normally associated with solvent usage. However, carbon tetrachloride (also known as Halon 104) was commonly used in military fire extinguishers (including almost certainly the standard issue 1-quart fire extinguisher supplied with every World War II-era Jeep). Carbon tetrachloride fire extinguishers were phased out in the late 1950's due to safety concerns (carbon tetrachloride when sprayed on hot metal can generate both chlorine and phosgene gas). Please review any Fort Ord records, including any aerial photographs from the 1930s to 1960, that might indicate if there was a motor pool for the Jeeps used at the light military vehicle training area. Potentially, 100s of 1-quart extinguishers could have been discarded from the motor pool when the Army phased out these extinguishers. The extinguishers may have been emptied prior to being discarded or recycled (they were manufactured out of brass and may have had some salvage value). Similarly, please review base records for any indications that wiremen received training in extinguishing electrical fires. Carbon tetrachloride is well-suited to extinguishing electrical fires as it is non-conducting

Additionally, because of their light weight and carbon tetrachloride's insulating properties, carbon tetrachloride fire extinguishers were commonly placed in airplanes and thus the neighboring air field is also a potential source of carbon tetrachloride.

Response: Available aerial photos have been reviewed dating to the early 1940's and there is no indication that a motor pool of any kind had been developed in the light vehicle driving course area. Harding ESE is attempting to locate personnel who may have had firsthand experience at Fort Ord during this period to further identify potential uses of CT. To date, no information has been gathered that would suggest CT fire extinguishers were used extensively on-base or collectively disposed of at a central location. Similarly, historical maps of the area make no indication that electrical fire training facilities existed. The Fritzsche Army Airfield was not constructed until the 1960's, by which time the use of CT for fire extinguishing purposes had already been phased out. Historical data review will continue throughout the RI/FS process.

2) Section 3.2.1, Chemical Sources, Page 22: If an electrical fire fighting training area is located, soil samples should be collected from it and analyzed for polychlorinated biphenyls (PCBs). If PCBs are detected in these samples, additional soil samples should be collected and analyzed for Chlorinated Dibenzo-P-Dioxin (CDDs) and Chlorinated Dibenzo Furans (CDFs).

Response: If an electrical fire training facility is identified and located, the expansion of the analyte list will be discussed with the BCT.

3) Section 3.3.2.3, Identify Inputs to the Decision, Page 34; Section 3.3.2.5, Development of Decision Rules, Page 37; and Table 2: The text mentions that because a ROD is not in place, aquifer cleanup levels have not been established so state MCLs will be used as regulatory compliance criteria or action levels. However, Table 2 labels the state MCLs as aquifer cleanup levels. In the text, please add that the state MCL (0.50 µg/L) is being used because it is more stringent that the federal MCL of 5.0 µg/L, and that the final aquifer cleanup level may change based on risk assessment calculations. In the table, please add a column showing all federal MCLs, and replace "Aquifer Cleanup Levels" in the title with "Regulatory Compliance Criteria" or "Action Levels", to be consistent with the text. Also include a footnote indicating that the most stringent level will be used (and possibly identify the most stringent value with bold or italics text), but that the final aquifer cleanup level may change based on the risk assessment.

Response: The text will be modified as suggested. An additional column will be included to specify federal values and the title of Table 2 will be changed as suggested. The intent of Table 2 was not to imply or suggest aquifer cleanup levels. We agree that final aquifer cleanup levels may change based on the risk assessment and this issue will be fully addressed in the RI/FS report.

4) Section 4.1.2, Upper 180-Foot Aquifer, Page 46: Five of the eleven monitoring wells proposed for installation (MP-BW-37, MW-BW-46-180, MW-BW-53-180, MW-BW-51-180, and MW-BW-48-180) are to be installed through the A-Aquifer carbon tetrachloride plume. Two of the new wells (MW-BW-53-180, MW-BW-51-180) are proposed for installation through the areas of the highest concentration of carbon tetrachloride detected in A-Aquifer monitoring wells. While it is understood that these wells can be sealed from the overlying groundwater and are unlikely to pose a continuing threat to the underlying groundwater, because the maximum contaminant level (MCL) for carbon tetrachloride is so low and the existing concentrations in 180-Foot Aquifer groundwater samples are right at the edge of the laboratory method detection limits, there is a concern that any carbon tetrachloride that is transmitted to the 180-Foot Aquifer during well installation will confound the Army's attempts to interpret the data collected in these new wells.

Please consider moving the proposed locations for the new wells outside of the footprint of the A-Aquifer carbon tetrachloride plume. Moving the wells toward the two extraction wells (EW-OU2-05-180 and EW-OU2-06-180) might be beneficial as they are likely to be pulling any carbon tetrachloride in the 180-Foot Aquifer in their vicinity toward them. Alternatively, if there is a very good reason to install the wells in the currently-proposed location, please assure that the drilling technique used to install the new wells in the 180-Foot aquifer includes installing a casing grouted into the aquitard below the A-Aquifer and installing the 180-Foot Aquifer wells through this casing. Regardless of the method used (e.g., double casing, ARCH or some other method), it is vital that the Army assure that the A-Aquifer and 180-Foot aquifers are hydraulically isolated from each other both during well installation and afterwards.

Response: Unfortunately, site access restrictions do not permit the well locations to be moved significantly from the proposed locations. The method of installation with the sonic drilling rig will require that drive casing of varying diameter (typically between 6 and 8 inches) will be telescoped to attain the desired depth. Therefore, each location will have one and possibly two sets of drive casing in addition to the 6-inch diameter drive casing that will each further isolate the A-Aquifer from the deeper aquifers. Because the casing drive shoe is flush with the sonic drive casing, the chance of vertical leakage through the FO-SVA during well installation is even more remote than with previous successful ARCH drilling/well installation tasks.

5) Section 4.1.2, Upper 180-Foot Aquifer, Page 46: As the additional wells are to be installed through the A-Aquifer and groundwater quality data in the vicinity of the proposed wells is not abundant, please revise the work plan to consider collecting A-Aquifer groundwater samples (using Hydropunch techniques) during the well installation prior to advancing the borings through the confining layer below the A-Aquifer.

Response: Harding ESE has conducted this type of water sample collection in previous Upper 180-Foot Aquifer well installation tasks using Hydropunch techniques with limited success. Hydropunch samples at Fort Ord have historically not been successful due to depth to water and dense sand of the A-Aquifer. Water samples were collected at the top and bottom of the A-Aquifer during the installation of MW-BW-19-180, MW-BW-20-180, MW-BW-21-180, and MW-BW-22-180. CT was only detected in samples collected at MW-BW-21-180 which were grab samples; the Hydropunch samples were extremely time consuming and resulted in very poor quality samples reflected in the non-detection of CT. Although it is, of course, possible that CT was not present in the A-Aquifer at these locations, the sample collection difficulties have lowered the reliability and confidence levels of the analytical results.

Nonetheless, we will consider collecting A-Aquifer groundwater samples with an appropriate technique at select locations that may provide additional data to delineate the A-Aquifer plume.

6) Section 4.2, Natural Attenuation Monitoring, Page 48: As a carbon source is usually required to drive dechlorination of volatile organic compounds, please include total organic carbon (TOC) in the analyte list for any natural attenuation sampling.

Response: Section 4.2 will be amended to include TOC in the analyte list.

The Regional Water Quality Control Board reviewed the subject document, received on July 30, 2002, and submits the following comments. In general the work plan is well documented, complete, and provided the following comments are addressed to our satisfaction, we have no objection to its implementation.

GENERAL COMMENTS:

1. This is the first report for which the Army has substituted all printed text, excluding graphics, on a compact laser disc to save on copying and storage costs. We appreciate the Army's goal, yet we have found document review and commenting from a CD file to be a significant encumbrance. For future reports, we request a hard copy (for review and comment) and a CD copy (for long term storage).

Response: Future Draft reports will be submitted in hard copy formatting for ease of review.

2. We request the final report have the title page signed and stamped on paper regardless of whether text is placed on CD.

Response: The Draft Final version of this and other reports will be submitted in hard copy format, included a signed title page.

3. A Hanna Instruments soil conductivity probe is proposed for use on well cores. While in-situ conductivity measurements are preferred, using a drive-casing drilling rig precludes any open-hole conductivity logging. We have examined Hanna Instrument's web site and have no objection to using their tools for ex-situ measurements.

Response: Comment noted.

SPECIFIC COMMENTS:

1. *Page 45, Section 4.1:* Upon further discussion with the Army's consultant, we understand a sonic drilling rig has been selected for the wells requiring depths beyond the A-aquifer. We accept this proposal. Because this type of rig inherently uses a drive casing, the potential use of other shallow surface or concentric casing to protect against aquifer cross contamination would be infeasible. The Army's consultant (Harding ESE) has considerable experience drilling across these particular aquifers, and provided the Army proceeds at its own risk, we will allow this practice as proposed.

Response: Comment noted.

2. *Page 46, Section 4.1.2:* In the first paragraph, the text refers to a subsurface hydraulic connection or vertical conduit located along Old County Road. Either Old County Road or the approximate area of the conduit needs to be identified on all relevant plates, or at a minimum, Plates 16, 17 and 18.

Response: Old County Road had been identified on Plate 2 but will be identified on the additional appropriate plates. The suspected conduit will also be illustrated on appropriate plates for further clarification.

3. *Page 48, Section 4.2:* Although the wells surveyed for water quality parameters indicative of natural attenuation processes did not include the full extent of the carbon tetrachloride plume, we believe the likelihood of drawing any new conclusions from an extended survey to be problematic at best. We therefore request that minimal time be spent before presenting the complete list of representative wells for each aquifer's water quality parameter survey.

Response: The development of a technical memorandum is not anticipated to require a significant amount of time and will be based primarily on the delineation of the CT plume at the end of the RI program.

4. *Page 49, Section 4.3:* We support the concept of the proposed tracer test. The report's text does not indicate which well will be used as the tracer source. Our understanding from Plate 20 is that MW-BW-60-A, yet to be installed, has been selected. Please indicate if our understanding is correct and note the selected source well in the report text and its approximate lateral separation from MW-B-13-180.

Response: MW-BW-60-A was specifically installed for the tracer test, as described in the *Draft Final Addendum to the December 15, 1998 Draft Final Carbon Tetrachloride Investigation Work Plan, Former Fort Ord, California* and is located in the A-Aquifer approximately 15 feet upgradient from MW-B-13-180.

5. *Page 50, Section 4.4, Paragraph one:* Regarding the geologic facies change from marine sands and clays to high-energy beach sands and gravels, we agree with the interpretation of this feature, though believe that most of the contaminant attenuation is due to physical dilution as groundwater passes into the beach sands and gravels of higher hydraulic conductivity. We understand the Army is interested in taking soil samples from each of these differing facies, and fully support this endeavor.

Response: The collection of soil samples is being considered at this time, although plans to do so have not been developed yet. We anticipate that water quality data, to be collected as part

of the natural attenuation sampling task, may further illustrate what, if any, chemical reactions may be occurring that may also explain the attenuation of CT in this area.

DISTRIBUTION

Draft Final
Operable Unit Carbon Tetrachloride Plume
Remedial Investigation/Feasibility Study
Work Plan
Former Fort Ord, California

October 16, 2002

Copy No. ___

Copies 1 - 22:	Mr. Glen Mitchell Department of the Army Sacramento District Corps of Engineers 1325 J Street Sacramento, California 95814-2922
Copies 23 - 28:	Harding ESE Project Files

Quality Control Reviewer

Edward J. Ticken

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