SECTION 2

Decision Summary

The Decision Summary identifies the Selected Remedy, explains how the remedy fulfills statutory and regulatory requirements, and provides a substantive summary of the Administrative Record file that supports the remedy selection decisions.

2.1 Site Name, Location, and Description

Travis AFB is located midway between San Francisco and Sacramento, California, on low-lying ground within 1 mile of Suisun Marsh, an estuary of San Francisco Bay. It is located 3 miles east of downtown Fairfield and 8 miles south of downtown Vacaville in Solano County (see Figure 2.1-1). Travis AFB is an active military facility. The Base occupies more than 6,000 acres and maintains ownership of, or administrative control over, several properties at off-base locations.

As a result of past waste management and disposal practices, groundwater contamination is present at multiple locations on Travis AFB, as identified by the following site designations: Sites FT004, FT005, LF006, LF007, LF008, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, SD037, DP039, SS041, and SD043. Site LF007 is a landfill and has three (3) separate contaminant plumes that are identified as Subareas LF007B, LF007C, and LF007D. These sites are organized into two (2) OUs, NEWIOU and WABOU, to facilitate the overall cleanup program.

As the lead agency for remedial activities, the AF has conducted environmental restoration at Travis AFB in accordance with CERCLA under DERP, which was established by SARA Section 211.

As the support agencies, EPA Region 9, the California DTSC, and San Francisco Bay Regional Water Board provide primary oversight of the environmental restoration actions, in accordance with CERCLA and a Federal Facilities Agreement (FFA) signed by the AF and regulatory agencies in September 1990 (Travis AFB, 1990).

Funding for remedial activities is provided by the Defense Environmental Restoration Account, a funding source approved by Congress to clean up contaminated sites on U.S. Department of Defense (DoD) installations.

Descriptions of the sites within the NEWIOU and WABOU and the historical activities that resulted in groundwater contamination are provided in the following sections. More detailed descriptions of the sites are provided in Appendix A – Conceptual Site Models of this ROD, in Section 3 of the FFS (CH2M HILL, 2011a), and in the *Groundwater Sampling and Analysis Program 2010-2011 Annual Report* (GSAP 2010-2011 Annual Report) (CH2M HILL, 2012a).

2.1.1 NEWIOU ERP Sites

The NEWIOU encompasses the following sites:

- **Site FT004 (FTA-3):** Area used for fire training exercises from approximately 1953 through 1962. During this period, waste fuels, oils, and solvents were burned on open ground. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site FT005 (FTA-4):** Area used for fire training exercises from approximately 1962 through 1987. During this period, waste fuels, oils, and solvents were burned on open ground. Historical practices resulted in groundwater contamination with chlorinated VOCs. The contaminant plume extends onto off-base privately owned property.
- **Site LF006 (Landfill 1):** A general refuse landfill that used trench and burn methods from approximately 1943 through 1950. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site LF007, including Subareas LF007B, C, and D (Landfill 2):** A general refuse landfill that used trench and cover methods from approximately 1950 through 1970. Historical practices resulted in groundwater contamination with chlorinated VOCs, dioxins, and polychlorinated biphenyls (PCBs). The Subarea LF007C contaminant plume extends onto off-base privately owned property.
- **Site SS015 (Solvent Spill Area [SSA] and Facilities 808, 1832, 552):** Facilities used between approximately 1964 and 1980 for solvent stripping of aircraft parts, aircraft maintenance and repair, OWS activities, and hazardous waste accumulation. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SS016 (OSA; Facilities 11, 13/14, 18, 20, and 42/1941; and Portions of the Storm Sewer System):** Flight line support areas subject to oil spills, degreasing operations, leaking OWS, equipment maintenance and repair, aircraft and vehicle maintenance, hazardous materials storage, aircraft and vehicle washing, and stormwater runoff. Most of the areas were used from the 1940s through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site ST027-Area B (Facilities 1918, 1919, and 1754):** Formerly used as a test stand area for aircraft engine testing. Currently, only Facility 1918 is used. Historical activities have resulted in contamination of groundwater at the site with chlorinated VOCs, primarily TCE and petroleum-fuel constituents. The portion of the plume containing only petroleum-fuel contamination is designated as Site ST027-Area A (Site ST027A) and continues to be managed under the Travis AFB POCO program with regulatory oversight provided by the San Francisco Bay Regional Water Board. The portion of the plume with TCE contamination is designated as Site ST027-Area B (Site ST027B) and is addressed as an ERP site.
- **Site SS029 (Monitoring Well [MW]-329 Area):** Undeveloped land near the southern Base boundary. The historical uses resulting in groundwater contamination with chlorinated VOCs are unknown.

- **Site SS030 (MW-269 Area):** Mostly undeveloped land near the southern Base boundary. Historical practices associated with Building 1125, formerly located in the northernmost portion of the site near the South Base Boundary Groundwater Treatment Plant, are believed to have resulted in groundwater contamination with chlorinated VOCs. The original Building 1125 and associated infrastructure were demolished and replaced with a new building. This area currently consists of a concrete slab, a new single antenna tower, and a small shed housing electronic equipment used to support airfield operations. The contaminant plume extends onto off-base privately owned property.
- **Site SD031 (Facility 1205):** Area used for maintenance and repair of diesel generators, wash rack activities, OWS activities, and aircraft maintenance from approximately 1957 through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SD033 (Storm Sewer II, South Gate Area, Facilities 810 and 1917, and West Branch of Union Creek):** Support areas used for management of stormwater runoff, fuel transport, aircraft maintenance, and aircraft washing, including the use of wash racks and OWS. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site SD034 (Facility 811):** An active aircraft wash rack facility with OWS and overflow pond. Leaks from the OWS resulted in free-phase Stoddard solvent floating on the groundwater table. The leaking OWS was replaced in 1994. Historical practices resulted in dissolved groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons. The Stoddard solvent non-aqueous medium also contains dissolved chlorinated VOCs.
- **Site SS035 (Facilities 818/819):** Active facilities used for aircraft repair, painting, and washing. A wash rack with OWS was constructed in 1970. Historical practices resulted in groundwater contamination with chlorinated VOCs.
- **Site SD036 (Facilities 872/873/876):** Facilities 872/873/876 consists of multiple-use shops, including a wash rack and OWS. Current uses include paint shops, electrical shops, landscape maintenance, paint mixing, and paint accumulation. The buildings were constructed in 1953 and are still in use. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.
- **Site SD037 (Sanitary Sewer System; Facilities 837/838, 919, 977, 981; Ragsdale/V Street Area; and Area G Ramp):** Support areas used for management of domestic and industrial wastewater, aircraft maintenance, heavy equipment maintenance, air cargo handling, vehicle washing, fuel transport, and waste accumulation. Operations began in the 1940s and continue through the present day. Historical practices resulted in groundwater contamination with chlorinated VOCs and petroleum-fuel hydrocarbons.

2.1.2 WABOU ERP Sites

The WABOU encompasses the following sites:

- **Site LF008 (Landfill 3):** An inactive historical landfill consisting of a series of small, unlined trenches used to dispose of old pesticide containers. Historical practices resulted in groundwater contamination with organochlorine pesticides.
- **Site DP039 (Building 755, Travis AFB Battery and Electric Shop):** Prior to 1978, battery acid solutions and solvents were discharged from Building 755 into a sump. These historical practices resulted in contamination of the groundwater with chlorinated VOCs, primarily TCE.
- **Site SS041 (Building 905):** The Base Entomology Shop used Building 905 from 1983 to 1992 to prepare pesticides and herbicides for on-base use. A concrete wash rack in the back of the building was used to clean pesticide applicator vehicles, and the overspray from the washing resulted in pesticide contamination in the groundwater.
- **Site SD043 (Building 916):** An emergency electric power facility. Historical practices resulted in contamination of the groundwater with TCE.

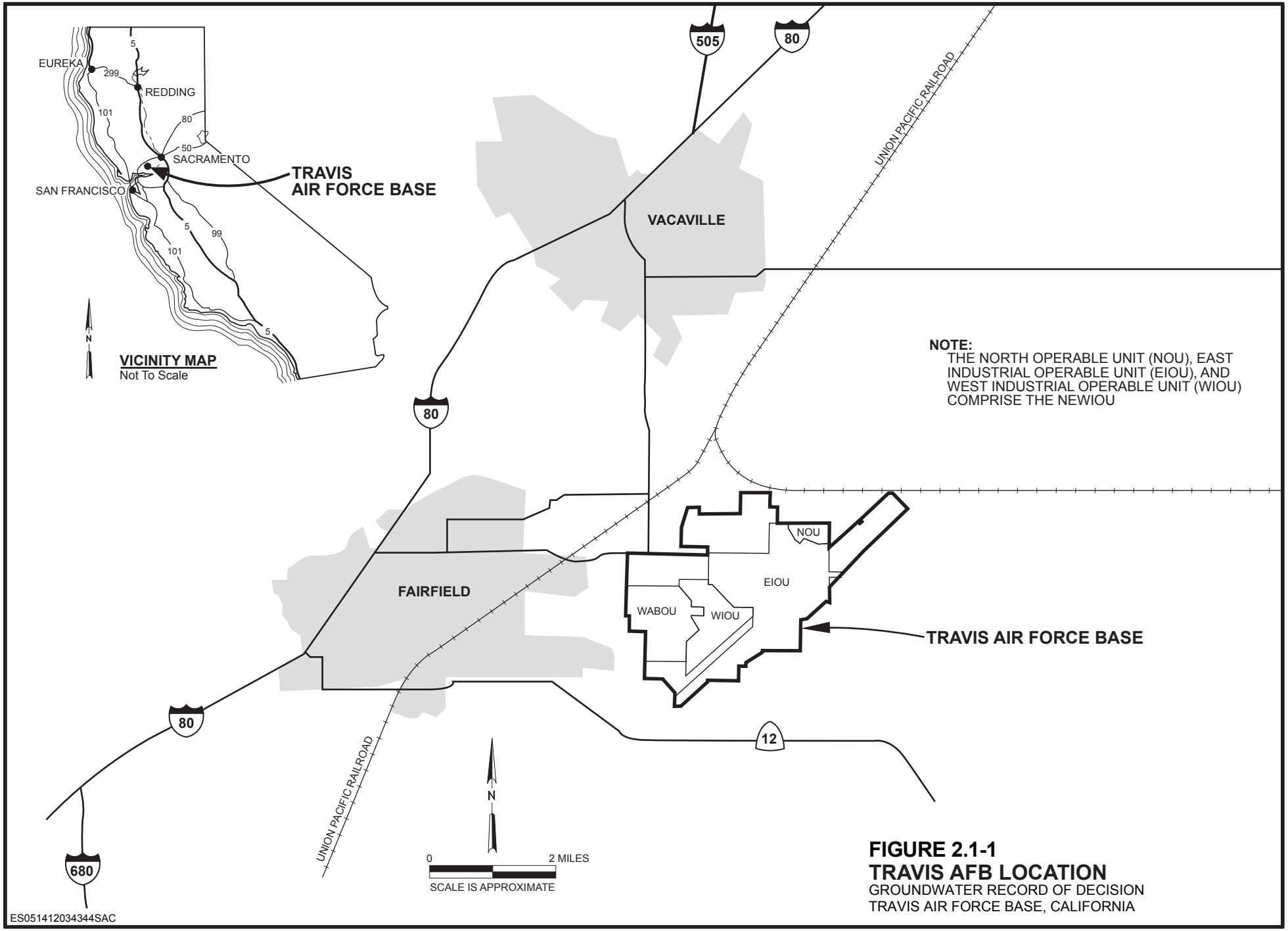

FIGURE 2.1-1
TRAVIS AFB LOCATION
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

2.2 Site History and Enforcement Activities

This section provides background information, summarizes the series of previous site activities and investigations that led to this ROD, and describes the response actions undertaken for groundwater, soil, sediment, and surface water at Travis AFB. There have been no CERCLA enforcement activities with regard to these sites.

In 1983, the AF initiated the Installation Restoration Program (IRP) (now the ERP) to investigate the nature and extent of hazardous waste releases to the environment. On the basis of IRP data evaluated by EPA, Travis AFB was placed on the National Priorities List (NPL) on November 21, 1989 (54 *Federal Register* 48187). Approximately 1 year later, on September 27, 1990, the AF, EPA, the California DTSC, and San Francisco Bay Regional Water Board negotiated and signed the FFA that established the framework and schedule for environmental cleanup at Travis AFB (Travis AFB, 1990). A brief chronology of the key events related to the management of groundwater, soil, sediment, and surface water contamination at Travis AFB is summarized in Table 2.2-1.

Under the original FFA (Travis AFB, 1990), Travis AFB was treated as a single entity with one (1) associated comprehensive cleanup schedule. Then, in May 1993, the FFA was amended to divide the Base into four (4) OUs to facilitate the overall cleanup program. The four (4) OUs were as follows:

- East Industrial Operable Unit (EIOU)
- WIOU
- North Operable Unit (NOU)
- WABOU

In October 1995, the EIOU, WIOU, and NOU were combined into the composite NEWIOU. Currently, the OUs at Travis AFB are the NEWIOU and the WABOU.

This ROD addresses groundwater contamination at sites within both of these OUs. Soil, sediment, and surface water contamination within these OUs has been previously addressed in the final *Soil Record of Decision for the West/Annexes/Basewide Operable Unit* (Soil ROD for the WABOU) *(*Travis AFB, 2002b) and the final *North, East, West Industrial Operable Unit Soil, Sediment, and Surface Water Record of Decision* (NEWIOU Soil, Sediment, and Surface Water ROD) (Travis AFB, 2006a). A summary of the key events related to the management of contaminated groundwater, soil, sediment, and surface water at Travis AFB is provided in Table 2.2-1 and in the following list:

- **Preliminary Assessment (PA)/Site Inspection (SI):** Between approximately 1983 and 1994, early IRP investigations, data gathering, and work planning efforts were conducted to preliminarily assess the nature of environmental contamination at Travis AFB (Jacobs Engineering Group, Inc., 1994).
- **Remedial Investigations (RIs):** Additional RI field investigations were completed from approximately 1994 to 1997 and used to further characterize the nature and extent of contaminated groundwater at the sites within the NEWIOU and WABOU and support completion of risk assessments. The RIs concluded that groundwater contamination at Travis AFB has resulted from past waste management and disposal practices typical of

an active AF facility and identified COCs in groundwater (Radian, 1996a [WIOU]; Radian, 1995 [NOU]; Weston, 1995 [EIOU]; CH2M HILL, 1997 [WABOU]).

- **Feasibility Studies (FSs):** Two (2) FSs were completed in 1996 (NEWIOU) and 1998 (WABOU) to evaluate interim remedial alternatives for contaminated groundwater sites within the NEWIOU (Radian, 1996b) and WABOU (CH2M HILL, 1998a).
- **Decision Documents:** Two (2) RODs for soil, sediment, and surface water and two (2) IRODs for groundwater were finalized to select the final soil, sediment, and surface water remedial actions and groundwater IRAs:
  - **RODs for Soil and for Soil, Sediment, and Surface Water:** The Soil ROD for the WABOU (Travis AFB, 2002a) and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a) were finalized to select the remedial alternatives for contaminated soil sites within the WABOU and contaminated soil, sediment, and surface water sites within the NEWIOU.
  - **Potrero Hills Annex Operable Unit:** As described in Part I, Table I-1 and Item C of "Assessment of the Site" of the final Soil ROD for the WABOU (Travis AFB, 2002a), the Potrero Hills Annex was transferred from the WABOU to another OU to manage its future remedial activities and will be addressed in a subsequent ROD. The Potrero Hills Annex is a 25-acre noncontiguous parcel of property under the jurisdiction of the Travis AFB installation commander that was originally part of a former NIKE missile battery. The WABOU RI detected PCB-1254 adjacent to an electrical transformer pad and metals and explosives in the vicinity of currently active explosive test facilities.

    On September 22, 1999, the California Regional Water Quality Control Board issued a Site Cleanup Requirements Order to OEA Aerospace (OEAA) and Travis AFB. The order tasks both parties with the environmental investigation of the Annex and the adjacent 525-acre OEAA property and the selection and implementation of appropriate remedial actions on both properties.

    To allow Travis AFB to comply with this order, the AF and regulatory agencies agreed in the WABOU ROD to pull the Annex out of the WABOU and postpone the application of CERCLA to the Annex while OEAA, its successors, and Travis AFB take action under the order. Investigative activities under the order at the Annex continue, primarily to determine the nature and extent of perchlorate contamination. Additionally, since removal from the WABOU, remedial activities conducted at the Annex under the order have resulted in the removal of the PCB and metals contaminated soil. Once the perchlorate-related investigative activities are complete, and any appropriate remedial action is in place, the agencies will review the results of the order and determine whether any other CERCLA-related activities are required.
  - **IRODs for Groundwater:** IRAs for groundwater were selected in the final NEWIOU Groundwater IROD (Travis AFB, 1998) and the final WABOU Groundwater IROD (Travis AFB, 1999).

- **Remedial Actions for Soil, Sediment, and Surface Water:** From 2003 through 2012, soil, sediment, and surface water remedial actions were completed at the WABOU and NEWIOU sites in accordance with the Soil ROD for the WABOU (Travis AFB, 2002a) and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a). Documentation of these remedial actions is provided in multiple reports, including the final *FT005 Remedial Action Report* (ITSI Gilbane, 2012), the final *Sites SD001 and SD033 Remedial Action Report* (ITSI, 2010), the final *NEWIOU and WABOU Soil Remedial Action for Sites SD045, FT003, FT004, FT005, Union Creek SD001, and SD033, and LF007 Area E Report* (Shaw Environmental, Inc., 2008), the final *Remedial Action Report for Soil Remedial Action at Site LF008* (Shaw Environmental, Inc., 2004a), the final *Project Summary Report for the Site LF007 Phase 2 Soil Remedial Action* (Shaw Environmental, Inc., 2004b), the final *Project Summary Report for the LF007 Soil Remedial Action Phase 1, Landfill Cap, Corrective Action Management Unit Subgrade, Wetlands Mitigation* (Shaw Environmental, Inc., 2003), the final *Remedial Action Report for Soil Remedial Actions at Site LF044* (Environmental Chemical Corporation, 2003a), the final *Remedial Action Report for Soil Remedial Actions at Site RW013* (Environmental Chemical Corporation, 2003b), the final *Remedial Action Report for Soil Remedial Actions at Site SS041* (Environmental Chemical Corporation, 2003c), the final *Remedial Action Report for Soil Remedial Actions at Site LF044* (Environmental Chemical Corporation, 2003d),and the final *Reevaluation of Soil and Groundwater Contamination at Building 916 (SD043) Technical Memorandum* (CH2M HILL, 2000). Additional supporting documents are provided in the Travis AFB Administrative Record.

- **IRAs for Groundwater:** After finalization of the NEWIOU Groundwater IROD (Travis AFB, 1998) and the final WABOU Groundwater IROD (Travis AFB, 1999), groundwater IRAs were implemented to expedite remediation of groundwater contamination, reduce the levels of contamination and potential risk, and collect data necessary for the selection of final cleanup levels and technically and economically feasible long-term actions. The IRAs began in 1998 and have continued until the present. The entirety of Site ST027 was formerly managed under the POCO program and was undergoing MNA. An IRA was not specified for this site in the NEWIOU Groundwater IROD, because CERCLA contamination was not detected until after the IROD was finalized. In 1999, a portion of the plume found to be contaminated with TCE was designated Site ST027B and is now managed under the ERP.

- **Performance Monitoring, LUCs, and Five-year Reviews:** Performance monitoring of the groundwater IRAs was conducted and reported under the Travis AFB GSAP and GRIP. Descriptions of groundwater treatment plant O&M activities have been regularly reported to the regulatory agencies in monthly data sheets and in annual O&M reports. LUCs have been enforced in accordance with the NEWIOU Groundwater IROD (Travis AFB, 1998), the WABOU Groundwater IROD (Travis AFB, 1999), the Soil ROD for the WABOU (Travis AFB, 2002a), and the NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a). The status of the LUCs is documented in annual LUC reports. The most recent LUC report is the *Annual Report on the Status of Land Use Controls on Restoration Sites in 2012* (Travis AFB, 2013). Three (3) five-year reviews for the groundwater IRAs were completed in 2003, 2008, and 2013 (CH2M HILL, 2003, 2008a, 2013b).

- **IRA Optimizations, Technology Demonstrations, and MNA Assessments and Studies:** Following the second five-year review, measures were implemented to optimize the performance of the groundwater IRAs, demonstrate the viability of alternative in situ treatment processes, and further assess the performance of natural attenuation processes (CH2M HILL, 2012d; Parsons, 2010; CH2M HILL, 2010b; CH2M HILL, 2012b).
- **FFS:** The FFS was completed in 2011 and re-evaluated remedial alternatives that could address the concentrations of COCs remaining in groundwater above levels that allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. It supports the transition from the current interim actions to final remedies, incorporation of successfully performing components of the existing interim actions into the final remedies, optimization of the interim actions, incorporation of successful treatment demonstrations, and actions based on the results of supporting studies (CH2M HILL, 2011a).
- **Vapor Intrusion Assessments:** An evaluation was completed in 2010 to assess the potential for vapor intrusion into buildings located in proximity to areas of contaminated groundwater. The assessment included field sample collection; laboratory analyses of groundwater, soil gas, and ambient air samples; and assessments of human health risks from soil vapor. An update to this evaluation was finalized in 2013, to incorporate updated toxicity values for several chemicals.
- **Technical and Economic Feasibility Analysis (TEFA):** A TEFA was completed in 2012 to evaluate the technical and economic feasibility of reducing groundwater contaminant concentrations to background levels in accordance with the intent of State Water Board Resolution 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304).

2.2.1 Interim Remedial Actions for Groundwater

The following subsections provide descriptions of the IRAs implemented for groundwater at the NEWIOU and WABOU sites and their performance, optimizations of interim GET systems, technology demonstrations, MNA assessments and studies, Remedial Process Optimization (RPO), vapor intrusion assessments, and the TEFA. Site-specific descriptions of the IRAs are provided in Appendix A – Conceptual Site Models.

The following IRAs for groundwater at NEWIOU Sites FT004, FT005, LF006; Subareas LF007B, LF007C, and LF007D; and Sites SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037 were initiated in 1998 (Travis AFB, 1998):

- **Natural Attenuation/Monitoring (i.e., MNA assessment) –** Collection of performance data and assessment of the viability of MNA as a final remedy for all, or part, of contaminated groundwater at Sites FT004 and LF006; Subareas LF007B and LF007D; and Sites SS015, SD031, SD033, SD034, SS035, SD036, and SD037.
  - Addressed the entirety of groundwater contamination at Site LF006, Subarea LF007B, Subarea LF007D, and Site SS015.
  - Taken in combination with groundwater extraction, treatment, and discharge (GET) at Sites FT004, SD031, SD033, SD034, SS035, SD036, and SD037.

  - Addressed the entirety of the plume at Site ST027. The entirety of Site ST027 was formerly managed under the POCO program with MNA as the presumptive remedy for petroleum fuel contamination in groundwater. An IRA was not specified in the NEWIOU Groundwater IROD, because CERCLA contamination was not detected until after the IROD was finalized. In 1999, a portion of the plume found to be contaminated with TCE was designated Site ST027B and is now managed under the ERP. The Site ST027A portion of the plume, with only petroleum-fuel contamination, continues to be managed under the POCO program.

- **Extraction/Treatment/Discharge (GET) –** Hydraulically capture areas of groundwater contamination and remove contaminant mass at Sites FT004 and FT005, Subarea LF007C, and Sites SS016, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037.

  - Addressed the entirety of groundwater contamination at Site FT005, Subarea LF007C, and Sites SS016, SS029, and SS030.

  - Taken in combination with MNA assessment at Sites FT004, SD031, SD033, SD034, SS035, SD036, and SD037.

- **Passive Skimming –** Physical removal of floating Stoddard solvent, containing dissolved COCs, at Site SD034 using passive skimmers.

The following IRAs for groundwater at WABOU Sites LF008, DP039, SS041, and SD043 were initiated in 1999 (Travis AFB, 1999):

- **Containment/Treatment/Discharge (i.e., GET) –** Prevent the migration of groundwater contamination into hydraulically downgradient areas of contaminated groundwater at Sites LF008, SS041, and SD043.

- **Source Area and Groundwater Extraction/Treatment/MNA (i.e., GET in combination with MNA) –** Vacuum-enhanced version of GET to hydraulically contain and remove relatively high concentrations of VOCs from the vadose zone and groundwater at the source of contamination and collection of performance data and assessment of the viability of MNA as a final remedy for all, or part, of the groundwater plume at Site DP039.

The IRAs have generally operated successfully from the late 1990s and early 2000s through the current date, as described in the *Second Five-year Review Report* (CH2M HILL, 2008a), FFS (CH2M HILL, 2011a), *Natural Attenuation Assessment Report* (NAAR) (CH2M HILL, 2010b), and FFS, Appendix C – Lines of Evidence for MNA (CH2M HILL, 2011a). After approximately a decade of interim remediation, concentrations of COCs in groundwater at multiple sites have been reduced. Preliminary cleanup goals (PCGs) were achieved by the interim action for Site SS041, which consisted of successful long-term operation of a GET system. However, for the other sites, concentrations of VOCs and organochlorine pesticides in groundwater remain above the lowest of either the state or federal MCLs. A summary of the performance and status of the IRAs is provided in Table 2.2-2. Further discussion of the performance and status of the IRAs is provided in Appendix A.

The locations of the sites and an overview of the current distribution of groundwater contamination are shown on Figures 2.2-1 and 2.2-2. Site-specific figures that compare the historical distribution of groundwater contamination prior to implementation of the IRAs and the current distribution of contamination after 8 to 10 years of interim remediation are shown on Figures 2.2-3 through 2.2-10. Plan view and cross section figures of each site are provided in Appendix A.

2.2.2 Optimization of Interim GET Systems

Evaluations of IRA GET system performance concluded that optimization measures were needed to improve the performance of the systems at Subarea LF007C and Sites SS016 and SS030. Summaries of these optimization measures are provided below.

2.2.2.1 Subarea LF007C GET System

The Subarea LF007C plume had migrated off-base, and the IRA GET system had not significantly reduced contaminant concentrations in the site monitoring wells. As described in the *Site LF007C Data Gaps Investigation Results Technical Memorandum* (CH2M HILL, 2012e), optimization measures were conducted in 2011-2012 to improve GET system performance. These measures included additional characterization to improve understanding of off-base contaminant distribution and groundwater flow directions. Additional optimization measures that will be conducted during 2013 include installing a higher-capacity solar-powered groundwater pump, installing larger solar panels, and rerouting the extraction well discharge pipeline. These modifications will improve the hydraulic capture of the plume, improve contaminant mass removal rates, and provide for more efficient beneficial reuse of treated groundwater in the on-base Duck Pond.

The Subarea LF007C GET system includes a provision for GSR through the use of solar-powered groundwater extraction pumps.

All Site LF007C GET optimization measures will be conducted in accordance with the U.S. Fish and Wildlife Service (USFWS) biological opinions (USFWS, 2011, 2002). Most of the contaminated groundwater at this site is located off-base and lies beneath a large vernal pool. In accordance with the USFWS biological opinions, the site will only be accessed by personnel or vehicles, and the GET system will be operated when the vernal pool is dry.

2.2.2.2 Site SS016 GET System

Although the overall IRA objectives at Site SS016 were being largely achieved, the following optimization actions described in Section 3 of the *Remedial Process Optimization Baseline Implementation Report* (BIR) (CH2M HILL, 2012f) and in Section 2.1 of the *2011 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (2011 Annual RPO Report) (CH2M HILL, 2012d) were taken within the OSA portion of the plume with the highest concentrations of residual contamination during September 2010 to improve the overall effectiveness of the existing GET system:

- Discontinuing operation of an inefficient and energy-intensive 2-Phase® extraction and thermal oxidation (ThOx) soil vapor treatment system within the OSA.

- Conversion of the groundwater treatment process at the Central Groundwater Treatment Plant (CGWTP) from an energy-intensive ultraviolet oxidation (UV/Ox) system to LGAC.

The cost-efficiency of the groundwater treatment process at the CGWTP was improved, resulting in lower treatment costs, less energy usage, and a reduced carbon footprint.

2.2.2.3 Site SS030 GET System

A portion of the off-base Site SS030 plume appeared to be migrating eastward and under the hydraulic influence of the adjacent Site FT005 GET system. Therefore, operation of the Site SS030 GET system was modified in 2011 to improve the hydraulic capture of the off-base plume. As described in Section 8.3 of the 2011 Annual RPO Report (CH2M HILL, 2012d), operational changes (i.e., RPO) to the existing GET system were made to maintain hydraulic capture for the entirety of the plume by increasing the rate of groundwater extraction. Groundwater monitoring data obtained under the GSAP and GRIP demonstrated that hydraulic capture of the plume was achieved and that TCE concentrations within the eastern side of the plume are declining (CH2M HILL, 2012d). Further optimization of the GET system will be conducted during 2013 by installing an additional extraction well to improve hydraulic capture of the off-base plume and reduce the wear on the existing extraction well pumps resulting from sustained high-speed operation.

2.2.3 Demonstrations of ERD Treatment Processes

Over time, the energy-intensive IRA GET systems used at several sites became less efficient and cost-effective as VOC concentrations within the portions of the plumes with the highest concentrations of residual contamination declined at an ever-decreasing rate. Therefore, beginning in 2008, in situ ERD treatment within the portions of the plumes with highest concentrations of residual contamination, consisting of in situ bioreactors and injection of EVO, was initiated to demonstrate the viability of ERD and support selection of final groundwater remedies. These demonstrations include provisions for GSR by reducing energy usage and generation of greenhouse gases (GHGs). Summaries of these bioreactors and EVO injections are provided below.

2.2.3.1 Bioreactors

Beginning in 2008, in situ bioreactors were installed within the portions of the Site SS016 and Site DP039 plumes with the highest concentrations of residual contamination as described further below:

- **Site SS016 Bioreactor –** During September 2010, operation of an existing 2-Phase® extraction and ThOx treatment system within the OSA was discontinued. Following additional plume characterizations, as described in Section 3 of the BIR (CH2M HILL, 2012f) and in Section 5.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d), an in situ bioreactor was installed within the portion of the plume with the highest concentrations of residual contamination, operation of an existing OSA horizontal extraction well (EW003x16) was modified to use a solar-power pump to provide source water to the bioreactor, and the performance monitoring well network was expanded. The bioreactor at Site SS016 has been in operation since 2010.

- **Site DP039 Bioreactor –** In November 2008, as described in Section 5.1 of the 2011 Annual RPO Report (CH2M HILL, 2012d), a bioreactor was installed in the portion of the Site DP039 plume with the highest concentrations of residual contamination, operation of the existing IRA GET system was discontinued, a solar-power system was installed to provide contaminated groundwater to the bioreactor from a nearby extraction well, and the performance monitoring well network was expanded. The bioreactor at Site DP039 has been in operation since 2008.

The bioreactors installed at Sites SS016 and DP039 have successfully demonstrated the viability of in situ ERD treatment processes as a component of groundwater remediation at Travis AFB. At both sites, performance monitoring results indicate that in situ ERD processes are achieving a high rate of VOC removal efficiency, as discussed in Sections 5.1 and 5.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d). Chlorinated VOCs, including TCE, cis-1,2-DCE, and vinyl chloride are being effectively degraded within each bioreactor. There is also evidence of TCE reduction in the aquifer hydraulically downgradient of each bioreactor, although the zone of treatment appears limited to the groundwater within approximately 30 feet of each bioreactor.

2.2.3.2 EVO Injections

Beginning in 2010, EVO was injected within the portions of the Site SS015, SD036, SD037, and DP039 plumes with the highest concentrations of residual contamination as described further below:

- **Site SS015 EVO Injection –** Data collected during the period of MNA assessment indicated increasing concentrations of COCs in some site monitoring wells and that the plume was likely migrating. As described in Section 2 of the BIR (CH2M HILL, 2012f) and in Section 6.4 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization conducted in 2010, supplemental injection of EVO within the portion of the plume with the highest concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.
- **Site SD036 EVO Injection –** Relatively high concentrations of COCs remained in a localized portion of the plume after about 10 years of IRA GET system operation, which provided a continuing source of contamination into hydraulically downgradient portions of the plume. As described in Section 5 of the BIR (CH2M HILL, 2012f) and in Section 6.2 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization conducted in 2010, operation of the GET system was discontinued, injection of EVO within a portion of the plume with the highest concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.
- **Site SD037 EVO Injection –** Similar to Site SD036, relatively high contaminant concentrations remained in a localized portion of the Site SD037 plume after years of IRA GET system operation, providing a continuing influx of contamination into hydraulically downgradient portions of the plume. As described in Section 6 of the BIR (CH2M HILL, 2012f) and in Section 6.3 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization in 2010, operation of the GET system was discontinued, injection of EVO within a portion of the plume with the highest

concentrations of residual contamination was conducted, and the performance monitoring well network was expanded.

- **Site DP039 EVO Injection –** A portion of the Site DP039 plume appeared to be migrating hydraulically downgradient of the former Site DP039 acid neutralization sump. As described in Section 7 of the BIR (CH2M HILL, 2012f) and in Section 6.1 of the 2011 Annual RPO Report (CH2M HILL, 2012d), following additional characterization in 2010, a PRB of injected EVO was installed during the summer of 2010 to intercept the plume at the 500-microgram-per-liter (µg/L) TCE isocontour, and the performance monitoring well network was expanded. The EVO PRB demonstration is located hydraulically downgradient of the Site DP039 bioreactor and an area of trees planted to study the viability of phytoremediation at the site.

The EVO injections conducted at Sites SS015, SD036, SD037, and DP039 have successfully demonstrated the viability of in situ ERD treatment processes as a component of groundwater remediation at Travis AFB. At each of the sites, performance monitoring results indicate that in situ ERD processes are achieving a high rate of VOC treatment efficiency. Chlorinated VOCs, including TCE, cis-1,2-DCE, and vinyl chloride, are being effectively degraded within the treatment zones (CH2M HILL, 2012d).

2.2.4 Demonstration of Phytoremediation

A treatability study of phytoremediation at Site DP039 was initiated in August 1998 to assess the effectiveness of planted trees to hydraulically control and remove VOC contamination from groundwater and to support selection of final groundwater remedies. A total of 2.24 acres of red ironbark eucalyptus trees were planted. In 2005, the initial evaluation concluded that, as the eucalyptus trees continue to mature, they have the potential to remediate the TCE-contaminated groundwater at the site (Parsons, 2005). At the time of the evaluation, the root systems of the trees were found to have reached the water table and contaminants were being removed through transpiration processes.

In 2010, as described in the *Phytostabilization at Travis Air Force Base, California* technical report (Parsons, 2010), another evaluation was conducted to further assess the potential of the tree stand as a remedy component at Site DP039. After approximately 14 years of study, it was successfully demonstrated that phytoremediation can be a viable component of groundwater remediation at the site. Among the key findings of the study was that phytoremediation poses a beneficial impact to the goal of reducing groundwater contaminant concentrations. Tree growth has been good, and the trees are taking up TCE in the contaminated groundwater. The overall TCE removal rate within the phytoremediation study area is currently about 2 pounds per year. In the future, maximum removal rates could rise to more than 15 pounds per year as the trees mature (Parsons, 2010).

2.2.5 MNA Assessments and Studies

With the exception of Site LF006, for which an IRA of MNA was specified, the IRODs deferred formal selection of MNA as an interim remedy, at all or portions of groundwater sites, until assessments of the viability of natural attenuation processes were conducted. Consequently, MNA assessments and studies have been conducted on an ongoing basis for approximately a decade to evaluate the viability of natural attenuation processes and to

support selection of final groundwater remedies. These assessments and studies included the following three (3) basic components or lines of evidence:

- **Interim MNA Assessments –** As described in the NAAR (CH2M HILL, 2010b) and the FFS, Appendix C – Lines of Evidence for MNA (CH2M HILL, 2011a), long-term groundwater sampling, laboratory analyses, and data evaluation were conducted at all or part of Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, and DP039 over the interim period leading up to this Groundwater ROD to assess the viability of using natural attenuation processes to remediate groundwater. Of these, only Site LF006 was specified for an IRA of MNA. MNA assessment over the interim period was specified for Site FT004, Subareas LF007B and LF007D, and Sites SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, and DP039. No IRA was established for NEWIOU Site ST027B, because the presence of chlorinated VOCs was unknown when the Groundwater IROD for the NEWIOU was finalized; however, MNA assessment has been ongoing at this site since 2008. Data supporting the physical attenuation process of volatilization at Travis AFB were also provided by the Site DP039 phytoremediation treatability study (Parsons, 2010).
- **Aerobic Chlorinated Cometabolism Enzyme Study –** As described in the *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b), groundwater sampling, laboratory analyses, and data evaluation were conducted at two (2) sites in 2012 to assess whether there may be a biological component to MNA at Travis AFB through aerobic chlorinated cometabolism. Data supporting a biological component of attenuation were provided by the aerobic cometabolism enzyme study. The aerobic cometabolic enzyme study indicated potential for aerobic cometabolism at similar, but non-contiguous, Sites FT004 and DP039. It is likely that cometabolic enzymes are widespread at Travis AFB sites, assuming site geochemical and contaminant histories are consistent. The study concluded that cometabolic activity may be contributing to contaminant natural attenuation at other Travis AFB sites.
- **Rebound Studies –** As described in Section 7 of the 2011 Annual RPO Report (CH2M HILL, 2012d), after approximately a decade of GET system operation, GET was discontinued, and site-specific groundwater sampling, laboratory analyses, and data evaluation were conducted at multiple sites starting in 2007 to assess whether natural attenuation processes can be used to remediate groundwater contamination. Post-GET rebound studies were conducted at the following sites: FT004, FT005, LF008, SD031, SD033, SD034, SS035, SD036, SD037, SS041, and SD043.

Based on data collected from one (1) or more of the assessments and studies listed above, the performance of natural attenuation over the interim period (referred to below as "Interim MNA Performance") at Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, SS015, ST027B, SD031, SD033, SD034, SS035, SD036, SD037, DP039, and SD043 is summarized in the following subsections and in Table 2.2-3.

2.2.5.1 Interim MNA Performance at Sites FT004 and SD031

The primary groundwater COCs are TCE (Site FT004) and 1,1-DCE (Site SD031). More than a decade of groundwater monitoring data are available for these sites. The NAAR concluded that natural attenuation was occurring in the distal portion of the plume beyond the influence of the GET system (CH2M HILL, 2010b).

A rebound study began in 2007 and lasted for 1 year, when select Site FT004 and all of the Site SD031 extraction wells were shut down (CH2M HILL, 2012d). No significant rebound occurred over the 1-year period and it was determined that the rebound study would continue during the interim period and include all of the Site FT004 and Site SD031 extraction wells. As a whole, the groundwater plume has remained stable. TCE concentrations have remained stable or continued to decline in 74 percent of the wells monitored (CH2M HILL, 2012d). Similarly, 1,1-DCE concentrations have been stable or continued to decline in 100 percent of the wells monitored. In addition, continued decreasing concentrations in the portions of the Site FT004 plume with the highest concentrations of residual contamination indicate that these portions of the plume have been effectively addressed by groundwater extraction (CH2M HILL, 2012d). The rebound study at Sites FT004 and SD031 is ongoing.

Data supporting a biological component of attenuation were provided by the aerobic cometabolism enzyme study performed subsequent to the NAAR. The aerobic cometabolism enzyme study demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site FT004 and that the cometabolic enzymes are active in samples collected from the site. The study results indicated potential for intrinsic aerobic biodegradation (cometabolism) at Site FT004 (CH2M HILL, 2012d).

The absence of a continuing source and decreasing contaminant concentration trends indicate that the conditions at Sites FT004 and SD031 are suitable for an MNA remedy.

2.2.5.2 Interim MNA Performance at Site FT005

Site FT005 was not included in the NAAR because MNA assessment was not included in the IRA. However, by 2007, the concentrations of the primary contaminant (1,2-DCA) at Site FT005 had decreased, and the plume had contracted to such an extent that continued extraction had become cost-ineffective. A contaminant rebound study was initiated in 2007. Over the course of the rebound study (2007 through 2011), 1,2-DCA concentrations rebounded in only three (3) wells, indicating that GET is reaching its limit of effectiveness (CH2M HILL, 2012d).

The absence of a continuing source, generally decreasing contaminant concentration trends over the course of the rebound study, and a receding plume indicate that Site FT005 will soon be suitable for an MNA remedy. However, the rebound study data do not fully support an MNA remedy at the site. Recently observed increases in the concentrations of COCs at some wells indicate that continuation of GET system operation within those portions of the plumes is warranted.

2.2.5.3 Interim MNA Performance at Site LF006

The primary groundwater COC at Site LF006 is TCE. More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that natural attenuation

was occurring at Site LF006 and that MNA is an appropriate remedy for the site (CH2M HILL, 2010b). Data from 13 years of groundwater monitoring at Site LF006 indicate that the plume is contained and has decreased in size over time (CH2M HILL, 2012a). TCE concentrations are decreasing throughout the plume. In 2011, TCE was the only contaminant to exceed interim remediation goals (IRGs). The maximum concentration of TCE detected in 2011 was 7.1 J- (estimated value) µg/L (CH2M HILL, 2012a).

The absence of a continuing source, decreasing contaminant concentration trends, and a receding plume indicate that Site LF006 is suitable for an MNA remedy.

2.2.5.4 Interim MNA Performance at Subarea LF007B

More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that MNA is an appropriate remedy for the site because no groundwater COCs have been detected at Subarea LF007B for several years (CH2M HILL, 2010b). Since the NAAR was completed, the site has continued to be monitored for natural attenuation. No groundwater contaminants have been detected in the years following the NAAR (CH2M HILL, 2010b). However, in accordance with regulatory agencies requirements, at least 2 more years of monitoring will be conducted to confirm that cleanup levels have been achieved.

2.2.5.5 Interim MNA Performance at Subarea LF007D

The primary groundwater COCs at Subarea LF007D are 1,4-DCB and benzene. More than a decade of groundwater monitoring data are available for this site. The NAAR concluded that natural attenuation was occurring at Subarea LF007D and that MNA is an appropriate remedy for the site (CH2M HILL, 2010b). Groundwater contaminants (1,4-DCB and benzene) exceed MCLs at only one (1) monitoring well, MW261x07 (CH2M HILL, 2012a). The 1,4-DCB plume is contracting, as evidenced by decreasing concentration trends. The benzene plume is stable and was only detected at one (1) well at concentrations that fluctuate between 2 and 3 µg/L (compared with an MCL of 1 µg/L) (CH2M HILL, 2012a; CH2M HILL, 2012g).

The NAAR concluded that the portion of the plume where contaminants exceed MCLs is anaerobic and that anaerobic biodegradation of 1,4-DCB is occurring (CH2M HILL, 2010b). During this biodegradation process, 1,4-DCB degrades to chlorobenzene, and chlorobenzene degrades to benzene. This degradation pathway is likely contributing to the relatively constant concentrations of benzene observed in the site groundwater. In the portion of the plume where contaminant concentrations are below MCLs, geochemical data indicate aerobic conditions. After degradation of 1,4-DCB is complete (estimated to reach 5 µg/L in approximately 19 years), aquifer conditions near well MW261x07 are expected to gradually become aerobic and more conducive to the aerobic biodegradation of benzene. Oxygen reduction potential (ORP) and dissolved oxygen (DO) will continue to be monitored at this well to evaluate whether aquifer conditions are aerobic or anaerobic.

If conditions at well MW216x07 do change from anaerobic to aerobic once 1,4-DCB has been degraded, physical attenuation of benzene will occur. In the absence of biodegradation, benzene concentrations are estimated to reach 1 µg/L in approximately 4 years through physical attenuation processes only (CH2M HILL, 2012g).

The absence of a continuing source, decreasing 1,4-DCB concentration trends, receding 1,4-DCB plume, and stable benzene plume indicate that Subarea LF007D is suitable for an MNA remedy.

2.2.5.6 Interim MNA Performance at Site LF008

A contaminant rebound study was conducted at Site LF008 after the IRA GET system was shut down during the period of interim remediation. Groundwater contamination at Site LF008 consists of organochlorine pesticides, primarily alpha-chlordane. The source of the pesticides in soil was remediated in 2003 by excavation (Shaw Environmental, Inc., 2004). Site LF008 was not included in the NAAR because natural attenuation assessment was not included in the IRA. However, by 2008, after 7.5 years of groundwater extraction, no significant change in pesticide concentrations was evident at Site LF008. Therefore, a contaminant rebound study was initiated in 2008.

Over the course of the rebound study (2008 through 2011), no rebound of the pesticide plume has been evident (CH2M HILL, 2012d). The primary mechanism for attenuation at Site LF008 is likely sorption of the pesticides to the soil. The physical properties of pesticides result in a very low subsurface mobility because of strong sorption to the soil. The site sediments have a high clay content, which increases sorption and also reduces permeability (CH2M HILL, 2011a). Comparisons of filtered and non-filtered groundwater samples indicated that no detectable concentrations were in the filtered samples. This result indicates that the contamination is not dissolved in the groundwater, but rather sorbed to the fine soil particles suspended in the groundwater (CH2M HILL, 2012g).

The absence of a continuing source, stable or decreasing contaminant concentration trends over the course of the rebound study, a contracting plume, and the results of filtered versus non-filtered sample analyses indicate that Site LF008 is suitable for an MNA remedy.

2.2.5.7 Interim MNA Performance at Site SS015

The primary groundwater COCs at Site SS015 are TCE, cis-1,2-DCE, and vinyl chloride. The plume was stable for several years, but by 2009 appeared to be migrating (CH2M HILL, 2010b). In response to the plume migration, injection of EVO within the portion of the plume with the highest concentrations of residual contamination was initiated to demonstrate the viability of ERD during 2010 and 2011 (CH2M HILL, 2012d). Since the EVO injection, the combined mass of TCE, cis-1,2-DCE, and vinyl chloride declined by more than 99 percent in the treatment zone (CH2M HILL, 2012d).

The distal portion of the plume, beyond the treatment zone, is being monitored for natural attenuation. Because the extent of downgradient contamination was recently defined (2010), the monitoring history in the distal plume is insufficient to determine long-term concentration trends. However, the limited monitoring history does indicate declines in TCE, cis-1,2-DCE, and vinyl chloride concentrations in several distal monitoring wells between 2010 and 2011 (CH2M HILL, 2012d, 2012a). Between 2010 and 2011, TCE concentrations declined 70 percent and cis-1,2-DCE concentrations declined 77 percent at a monitoring well located approximately 75 feet downgradient. The decline in contaminant concentrations is likely primarily due to reduction in mass loading from the portion of the plume with the highest concentrations of residual contamination (CH2M HILL, 2012d).

Since EVO injection, only one (1) monitoring well located approximately 175 feet downgradient of the injection area, MW625x15, has continued to have increasing TCE, cis-1,2-DCE, and vinyl chloride concentrations (CH2M HILL, 2012d). COC concentrations are expected to decline in response to the reduction in mass loading to the aquifer, as they have at wells located closer to the injection area.

The decreasing contaminant concentrations in most of the distal plume wells since their installation in 2010 indicate that natural attenuation processes are a suitable component of a remedy at the site.

2.2.5.8 Interim MNA Performance at Site ST027B

The primary groundwater COC is TCE. The monitoring history for the TCE plume at Site ST027B is relatively short (4 years) when compared with the other chlorinated solvent plumes at Travis AFB. However, over the 4 years, the TCE plume has been stable. No plume or downgradient monitoring wells have increasing TCE concentration trends (CH2M HILL, 2012a). In addition, a TCE bulk attenuation rate constant of 1.1 per year has been calculated for the Site ST027B TCE plume. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring (CH2M HILL, 2011a).

The absence of a continuing source and a stable TCE plume indicate that Site ST027B is suitable for an MNA remedy.

2.2.5.9 Interim MNA Performance at Sites SD033, SD034, SS035, SD036, SD037, and SD043

The primary groundwater COC is TCE. More than a decade of groundwater monitoring data are available for the commingled groundwater plume from Sites SD033, SD034, SS035, SD036, SD037, and SD043. While the GET that addressed the groundwater plume was operational, the contaminant concentrations in the area beyond the influence of the GET system declined, and the plume was receding. The NAAR concluded that natural attenuation was occurring in the distal portion of the plume beyond the influence of the GET (CH2M HILL, 2010b).

The GET systems were shut down in April 2010 to support injection of EVO within the portions of the Site SD036 and Site SD037 plumes with the highest concentrations of residual contaminations to demonstrate the viability of ERD and to initiate a rebound study. Over a period of 1.5 years (April 2010 through December 2011), the groundwater plume has remained stable, with contaminant concentrations either stable or continuing to decline in 85 percent of the wells monitored for rebound (CH2M HILL, 2012d).

Portions of the Site SD036 and SD037 plumes with the highest concentrations of residual contamination are being addressed by the ongoing demonstrations of ERD treatment via EVO injection. Groundwater COCs at Sites SS035 and SD043 are now below MCLs (CH2M HILL, 2010c, 2012a). At Site SD034, the presence of hydrocarbons (Stoddard solvent) may enhance biodegradation; in 2011, the only volatile COCs to exceed MCLs at this site were TCE and vinyl chloride. The maximum detections of both COCs only slightly exceeded the MCLs. TCE was detected at a maximum concentration of 5.8 µg/L (the MCL is 5 µg/L), and vinyl chloride was detected at a maximum concentration of 1.6 µg/L (the MCL is 0.5 µg/L) (CH2M HILL, 2012a). Residual groundwater contamination at Site SS033 is commingled with groundwater contamination from Sites SD036 and SD037; monitoring

wells from all three (3) of these sites are used to monitor the distal portion of the plume. Stable and decreasing contaminant concentrations in most of the distal plume wells at Sites SS033, SD036, and SD037 over the rebound study period indicate that MNA is a suitable component of the remedy for the plume.

2.2.5.10 Interim MNA Performance at Site DP039

The IRA at Site DP039 is GET within the portion of the plume with the highest concentrations of residual contamination combined with natural attenuation in the distal portion of the plume. The primary groundwater COC is TCE. In addition to GET, which was performed from 2000 to 2008, several technology demonstrations and treatability studies have been performed at Site DP039, including a bioreactor, a phytoremediation treatability study/demonstration, and an EVO PRB. Operation of the IRA GET system within the portion of the plume with the highest concentrations of residual contamination was discontinued in 2008 to support the installation and operation of the in situ bioreactor. The initial planting of the trees within the phytoremediation area was performed in 1998.

The portion of the plume evaluated by the NAAR was hydraulically downgradient and outside the area of influence of the GET system, bioreactor, and area of phytoremediation. The NAAR concluded that attenuation was occurring in portions of the plume; however, increasing concentrations in some monitoring wells indicated natural attenuation alone would likely be inadequate to prevent future plume migration (CH2M HILL, 2010b). In response to this potential migration of portions of the plume, a demonstration of ERD treatment using an EVO PRB was begun in 2010. The EVO PRB intercepted the portion of the plume where TCE concentrations exceed 500 µg/L. Monitoring data indicate that the EVO PRB is successfully performing as designed (CH2M HILL, 2012d).

Data supporting the occurrence of the physical attenuation process of volatilization at Site DP039 were obtained as part of the Site DP039 phytoremediation treatability study (Parsons, 2010).

The aerobic cometabolism enzyme study demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site DP039 and that the cometabolic enzymes are active in samples collected from the site. The study results indicated potential for intrinsic aerobic biodegradation at the site (CH2M HILL, 2012b).

The portion of the Site DP039 plume where TCE concentrations exceed 500 µg/L is being addressed by a combination of an in situ bioreactor, phytoremediation, and an EVO PRB. These remedies reduce the mass loading to the aquifer and enhance the natural attenuation at the site. The stable and decreasing contaminant concentrations in several hydraulically downgradient wells in addition to data supporting the occurrence of the physical attenuation process of volatilization and the biological attenuation process of aerobic cometabolism indicate that MNA is a suitable component of the remedy for Site DP039.

2.2.6 Vapor Intrusion Assessment

During 2008-2009, Travis AFB conducted a vapor intrusion assessment to evaluate whether inhalation of VOCs migrating from groundwater into indoor air pose a risk to human health based on current and future site conditions at Sites FT004, FT005, LF006, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS016, ST027B, SS029, SS030, SD031,

ST032 (now a POCO site), SD033, SD034, SS035, SD036, SD037, DP039, and SD043. Investigations, including monitoring of shallow soil gas, soil vapor under building floor subslabs, building indoor air, and outdoor air, were conducted in accordance with the *Vapor Intrusion Assessment Work Plan* (CH2M HILL, 2008c), and the findings of the assessment are provided in the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a).

An update to the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a) was completed in 2013 because the toxicity values for several of the chemicals evaluated, including TCE and PCE, had changed since the vapor intrusion assessment was performed during 2008-2010. This 2013 update included all of the sites previously assessed. The results are provided in the final *Vapor Intrusion Assessment Report Update* (CH2M HILL, 2013a).

2.2.7 Technical and Economic Feasibility Analysis

In 2012, a TEFA was conducted to evaluate the technical and economic feasibility of reducing groundwater contaminant concentrations to background levels in accordance with the intent of State Water Board Resolution 92-49 (Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304. The TEFA concluded that it was not technically feasible, and thus also not economically feasible, to achieve cleanup of contaminated groundwater at Travis AFB to background concentrations (CH2M HILL, 2012h).

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
1983	Phase I PA
1983 to 1994	IRP investigations
1983 to 1989	Pre-NPL responses
November 1989	NPL listing
September 1990	FFA signed (Travis AFB, 1990)
1991	Travis AFB CRP
1993 to present	Fact sheets describing restoration program activities and milestones published
1993	FFA renegotiated to create four (4) OUs: NOU, EIOU, WIOU, and WABOU
1995	Final CRP
1995	Travis AFB RAB formed
1995	CGWTP online
1995 to present	Quarterly restoration program newsletter published and mailed
1995 to 1997	CERCLA RI for NOU, EIOU, WIOU, and WABOU (Radian, 1995; Weston, 1995; Radian, 1996a; CH2M HILL, 1997)
May 1995	Comprehensive Basewide ERA – Tier 1 (CH2M HILL, 1995)
October 1995	FFA amended to consolidate NOU, EIOU, and WIOU into the NEWIOU
May 1996	Comprehensive Basewide ERA – Tier 2 (CH2M HILL, 1996)
1996 to 1998	CERCLA FS for NEWIOU and WABOU (Radian, 1996b; CH2M HILL, 1998a)
January 1998	Final NEWIOU Groundwater IROD (Travis AFB, 1998); groundwater IRAs initiated at NEWIOU Sites FT004, FT005, LF006; Subareas LF007B, LF007C, and LF007D; and Sites LF008, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037
1998	Travis AFB CRP revised
1998	SBBGWTP online; interim GET system operation initiated at Sites FT005, SS030, and SS029
1998	Site DP039 phytoremediation treatability study began (CH2M HILL, 2012a)
June 1999	Final WABOU Groundwater IROD (Travis AFB, 1999); groundwater IRAs initiated at WABOU Sites LF008, DP039, SS041, and SD043
2000	WTTP online; interim GET system initiated at Sites LF008, SD033, SD034, SS035, SD036, SD037, SS041, SD043, and DP039
2000	NGWTP online; interim GET system initiated at Sites FT004 and SD031
2000 to 2001	Site SS015 vegetable oil treatability study (CH2M HILL, 2012a)
August 2001	CIP (initial)
December 2002	Final Soil ROD for the WABOU (Travis AFB, 2002a)
December 2002 to April 2003	ThOX system offline for rebound study (CH2M HILL, 2012d)
February 2003	WTTP SVE system offline for rebound study (CH2M HILL, 2012d)

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
July 2003	CIP updated
July 2003	First Five-year Review of groundwater IRAs
January 2004	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2003* (Travis AFB, 2004)
January 2005	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2004* (Travis AFB, 2005b)
December 2005	Final Category IV No Further Remedial Action Planned Consensus Statement for Site SS041 (Travis AFB, 2005a)
February 2006	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2005 Annual Report* (CH2M HILL, 2006)
February 2006	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2005* (Travis AFB, 2006b)
April 2006	CIP updated
May 2006	Final NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a)
January 2007	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2006 Annual Report* (CH2M HILL, 2007)
January 2007	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2006* (Travis AFB, 2007)
December 2007	Rebound studies initiated at Site FT004 (partial GET system shutdown) and Site SD031 (full GET system shutdown); rebound study initiated at Site FT005 (partial GET system shutdown) (CH2M HILL, 2012a)
January 2008	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2007* (Travis AFB, 2008)
February 2008	*Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant 2007 Annual Report* (CH2M HILL, 2008c)
September 2008	Second Five-year Review of groundwater IRAs
October 2008	Site DP039 groundwater and vapor extraction offline for bioreactor sustainability study (CH2M HILL, 2012d)
December 2008	Rebound study initiated at Site LF008 (full GET system shutdown) (CH2M HILL, 2012a)
January 2009	Site SS015 natural attenuation assessment (CH2M HILL, 2012a)
January 2009	ERD treatment demonstration using a bioreactor initiated at Site DP039 (CH2M HILL, 2012d)
February 2009	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2008* (Travis AFB, 2009)
February 2009	Remaining Site FT004 extraction wells taken offline for rebound study (CH2M HILL, 2012d)
June 2009	*2008 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2009b)
August 2009	WTTP SVE extraction system offline for rebound study (CH2M HILL, 2012d)
March 2010	Final *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)

TABLE 2.2-1
Chronology of Key Events
Groundwater Record of Decision, Travis Air Force Base, California

Date(s)	Event
April 2010	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2009* (Travis AFB, 2010)
April 2010	Rebound studies initiated at WIOU Sites SD033, SD034, SS035, SD036, SD037, and SD043; WTTP offline and ThOx system taken offline (CH2M HILL, 2012d)
June – July 2010	ERD treatment demonstration using an injected EVO PRB initiated at Site DP039 (CH2M HILL, 2012f)
July 2010	*2009 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2010d)
July 2010	Final NAAR (CH2M HILL, 2010b)
September 2010	ERD treatment demonstration using a bioreactor initiated at Site SS016 (CH2M HILL, 2012f)
October – December 2010	ERD treatment demonstrations using EVO injection initiated at Sites SD036 and SD037 (CH2M HILL, 2012f)
December 2010 – January 2011	ERD treatment demonstration using EVO injection initiated at Site SS015 (CH2M HILL, 2012f)
February 2011	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2010* (Travis AFB, 2011)
September 2011	*2010 Annual Remedial Process Optimization Report for the Central Groundwater Treatment Plant, North Groundwater Treatment Plant, and South Base Boundary Groundwater Treatment Plant* (CH2M HILL, 2011b)
October 2011	Final FFS (CH2M HILL, 2011a)
February 2012	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2011* (Travis AFB, 2012a)
March 2012	Final BIR (CH2M HILL, 2012f)
May 2012	Final TEFA (CH2M HILL, 2012h)
September 2012	Final *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes* (CH2M HILL, 2012b)
October 2012	2011 Annual RPO Report (CH2M HILL, 2012d)
October 2012	Final *Proposed Plan for Groundwater Cleanup* (Travis AFB, 2012b)
December 2012	Final *2012 Groundwater Sampling and Analysis Program Technical Memorandum* (CH2M HILL, 2012g)
January 2013	Final *Annual Report on the Status of Land Use Controls on Restoration Sites in 2012* (Travis AFB, 2013)
February 2013	Final *Vapor Intrusion Assessment Report Update* (CH2M HILL, 2013a)
September 2013	Third Five-year Review of groundwater IRAs

Notes:

CIP = Community Involvement Plan
CRP = Community Relations Plan
ERA = Ecological Risk Assessment
NGWTP = North Groundwater Treatment Plant
RAB = Restoration Advisory Board
SBBGWTP = South Base Boundary Groundwater Treatment Plant
SVE = soil vapor extraction
WTTP = West Treatment and Transfer Plant

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
FT004 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for source control	The combination of GET in the portion of the Site FT004 plume with the highest concentrations of residual contaminations and MNA in the downgradient portions of the plume has been effective. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved using GET. The effectiveness of GET is further demonstrated by declining VOC concentrations observed in the majority of site monitoring wells. Declining trends are observed in both shallow and deep monitoring wells, indicating that both the horizontal and vertical extents of the target areas are being addressed. The Site FT004 GET system has been shut down for a rebound study for the remaining period of interim remediation because the VOC concentrations in the portion of the plume with the highest concentrations of residual contamination have declined. The maximum TCE concentrations during the 2010 GSAP were observed within two (2) localized and noncontiguous portions of the plume. These included 165 µg/L in MW266x04 and 130 µg/L in MW131x04. No other concentrations above 100 µg/L were observed at the site. MNA also appears to be a viable remedy at Site FT004. Overall, contaminant concentrations are stable or declining in the downgradient MNA assessment monitoring wells. The MNA network includes both shallow and deep monitoring wells. MNA appears to be effective throughout the entire thickness of the plume.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at NGWTP. Rebound study: GET system shut down for a rebound study in 2007.	The preponderance of data obtained between 4Q07and 2Q11 indicates that significant rebound of chlorinated VOC concentrations is not occurring in the absence of GET system operations.
FT005 (NEWIOU)	GET	GET for migration control[a] GET for off-base remediation	The Site FT005 GET system has been effective. The existing GET system has achieved hydraulic capture of the plume and is controlling off-base contaminant migration. A large portion of the plume has been remediated to below detectable concentrations. The extraction wells in the areas of the plume where IRA objectives have been achieved have been shut down for a rebound study for the remainder of the interim period of remediation. GET system operations are continuing in areas of the plume where contaminant concentrations are above IRGs.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at SBBGWTP. Rebound study: GET system partially shut down for a rebound study in 2007.	The preponderance of data obtained between 4Q07 and 4Q11 indicates that rebound of chlorinated VOC contamination within the plume is not generally occurring in the absence of GET system operations. Extraction well operation was resumed in several wells that exhibited localized rebound of contaminant concentrations.
LF006 (NEWIOU)	MNA	Use natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Site LF006. Data from monitoring wells indicate that groundwater contamination at Site LF006 is not migrating, and no contaminants were detected at a concentration exceeding the IRG.	None	Monitoring to evaluate natural attenuation processes is continuing.
LF007B Subarea (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Subarea LF007B. No contaminants were detected in Subarea LF007B wells sampled during the 2009-2010 GSAP events.	None	Monitoring to evaluate MNA processes is continuing.
LF007C Subarea (NEWIOU)	MNA Assessment and GET	GET for migration control[b] GET for off-base remediation[c]	The migration control and off-base remediation IRA objectives for Subarea LF007C do not appear to be fully achieved. The existing GET system is not fully effective at hydraulically capturing and remediating the TCE plume. TCE continues to migrate off-base at concentrations above the TCE IRG of 5 µg/L. Optimization of the GET IRA is required. A data gaps investigation was performed during 2011 following USFWS approval of the request to reinitiate Section 7 consultation for activities within the vernal pool at the site. Based on the results of the investigation, optimization measures for the GET system will be conducted in 2013-2014. Modeling of optimization measures was used to confirm that the entirety of the on- and off-base portions of the plume will be hydraulically captured when they are completed.	GET optimization: Air stripping discontinued and replaced with LGAC treatment at NGWTP. GET system optimization will be conducted during 2013-2014. These optimization measures include achieving greater groundwater extraction rates and expanded hydraulic capture of the off-base plume by installation of a higher capacity extraction well pump and expansion of the solar panel array that provides electrical power to the pump.	Continuing to comply with seasonal site access and GET system operational constraints imposed by the USFWS. Most of the site is located off-base and is within a large vernal pool. In accordance with USFWS requirements, the site can only be accessed by personnel or vehicles and the GET system operated when the vernal pool is dry (USFWS, 2011, 2002).
LF007D Subarea (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	MNA appears to be a viable remedy at Subarea LF007D. The plume is stable, but concentrations have not decreased significantly during the period of interim remediation. Groundwater contamination is currently limited to a small area in the vicinity of MW261x04. Within this area, PCGs are exceeded for 1,4-DCB (12.6 µg/L vs. PCG of 5 µg/L) and benzene (3 µg/L vs. PCG of 1 µg/L). Concentrations of 1,4-DCB have decreased during the period of interim remediation. However, long-term benzene concentrations have remained relatively stable at about 3 µg/L. Contaminants do not appear to be migrating off-base to the north or east of the site.	None	Monitoring to evaluate natural attenuation processes is continuing.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
LF008 (WABOU)	GET	GET for migration control	The migration control IRA objective at Site LF008 was achieved by the GET system. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved. The distribution of contamination in monitoring wells also indicated hydraulic containment of the plume. The GET system had limited effectiveness at removing the residual organochlorine pesticide contamination. Concentrations are stable and not migrating. The GET system is currently shut down as part of a rebound study for the remainder of the period of interim remediation. No rebound of the pesticide plume has been evident during the rebound study (CH2M HILL, 2012d).The physical properties of pesticides result in a low subsurface mobility because of strong sorption to the soil. The site sediments have a high clay content, which increases sorption and also reduces permeability (CH2M HILL, 2011a). Comparisons of filtered and non-filtered groundwater samples indicated that no detectable concentrations were in the filtered samples. This result indicates that the contamination is not dissolved in the groundwater, but rather sorbed to the fine soil particles suspended in the groundwater.	Rebound study: GET system shut down for a rebound study in 2008.	The preponderance of data obtained at Site LF008 between 4Q08 and 2Q12 indicates that significant rebound of organochlorine pesticide concentrations is not occurring in the absence of GET system operations. Concentrations are decreasing in the absence of active pumping. The data indicate that residual pesticides are almost entirely sorbed to fine soil particles and not dissolved in the groundwater.
SS015 (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Monitoring data indicated that MNA was not successfully addressing Site SS015 contamination. The plume appeared to be migrating, and contaminant concentrations were increasing in some wells. The limited volume of EVO injected during a 2000-2001 vegetable oil injection treatability study was probably exhausted. Optimization of the MNA IRA was required, and supplemental injection of EVO was conducted during 2010 to enhance natural attenuation processes. The performance of the EVO treatment is being evaluated.	Technology demonstration: Data gaps investigation in 2010. Installation of injection wells in 2010. EVO injection in 2010. Installation of additional monitoring wells in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SS015. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing.
SS016 (NEWIOU)	GET	GET for source control[d] GET for migration control[e]	Hydraulic capture of the TARA portion of the Site SS016 plume with the highest concentrations of residual contamination has been achieved. Within the OSA portion of the plume with the highest concentrations of residual contamination, concentrations have decreased, but the extent of hydraulic capture is less certain. Declining TCE concentrations in shallow and deep monitoring wells downgradient of the OSA and TARA portions of the plume with the highest concentrations of residual contamination indicate that the horizontal and vertical extents of the plume were being addressed by the existing GET system. However, even after several years of IRA operation, the highest TCE concentrations at Travis AFB were found in OSA horizontal extraction well EW003x16 (18,000 µg/L). Therefore, IRA optimization actions were taken during 2010. These actions included a data gaps investigation to more fully define the concentrations of residual contamination within the OSA. Based on the results of the data gaps investigation, operation of a 2-Phase® extraction/ThOx treatment was discontinued, and an in situ bioreactor was installed. The performance of the bioreactor is being evaluated. The portion of the commingled Site SS016 plume (OSA/TARA that is not hydraulically captured by the OSA and TARA source control GET systems) is eventually hydraulically captured by the downgradient Site SS029 GET system.	GET optimization: 2-Phase® extraction within OSA discontinued in 2010. UV/Ox and Th/Ox treatment discontinued in 2010. Groundwater treatment replaced by LGAC at CGWTP. Bioreactor demonstration: Data gaps investigation within OSA conducted in 2010. OSA bioreactor installation in 2010.	Analytical and geochemical data collected over 1 year of operation indicate that the Site SS016 bioreactor is performing as designed and has successfully demonstrated the viability of ERD treatment using this process. Performance monitoring and evaluation of the bioreactor is ongoing. Site SS016 access is limited. The site is adjacent to, or within, an active area of military flightline operations (i.e., parking apron, taxiways, and runways).
ST027B (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Site ST027B is located within the NEWIOU but is not included in the NEWIOU Groundwater IROD, and an IRA of MNA Assessment was not formally selected for the site. The entirety of Site ST027 was historically managed under the POCO program at Travis AFB because petroleum hydrocarbons were believed to be the only contaminants present at this site. The presumptive remedy for POCO sites with only petroleum fuel contamination is MNA. However, an investigation conducted in 2007 discovered TCE and several other chlorinated VOCs in groundwater in the southwestern part of the site. Therefore, the site was subsequently subdivided into two (2) portions: Site ST027A (fuels contamination only) and Site ST027B (CERCLA contaminants). Groundwater contamination within Site ST027B has been routinely monitored under the GSAP and natural attenuation processes assessed in the NAAR (CH2M HILL, 2010b) even though these actions were not specified in the NEWIOU Groundwater IROD.	Study: Data gaps investigation within Site ST027B conducted during 2010.	Monitoring to evaluate natural attenuation processes is continuing. Site is bounded by military flightline operations.
SS029 (NEWIOU)	GET	GET for migration control	The migration control IRA objective at Site SS029 has been achieved. The existing GET system has achieved hydraulic capture of the on-base plume and is effectively controlling potential off-base migration of the contaminant plume.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at SBBGWTP. Study: Additional site characterization was conducted during 2012 to assess alternate remediation processes.	Monitoring to evaluate GET system performance is continuing. A large portion of the site is within an area of military flightline operations.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SS030 (NEWIOU)	GET	GET for source control GET for migration control GET for off-base remediation	The source control, migration control, and off-base remediation IRA objectives for the Site SS030 IRA have not been fully achieved. Contaminant concentrations are declining in all of the extraction wells and all but two (2) of the monitoring wells. The off-base plume is being captured on the southern and western sides of the plume. However, increasing TCE concentrations on the eastern side of the off-base plume indicate that contamination may be escaping hydraulic capture. The groundwater elevation contours derived from the 2Q10 GSAP sampling event indicate that the hydraulic capture in this eastern area of the plume has improved after several of the adjacent Site FT005 extraction wells were taken offline for a rebound study. Optimization of the GET IRA is required. Investigations were performed during 2010-2011 to clarify groundwater flow directions and hydraulic capture. Based on the results of the investigation, optimization measures for the current GET system are being conducted as required.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at SBBGWTP. Increased groundwater extraction rates from existing wells to improve hydraulic capture of the off-base plume.	Monitoring to evaluate GET system performance is continuing. Most of the site is located on off-base private property.
SD031 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for source control	The combination of GET in the portion of the Site SD031 plume with the highest concentrations of residual contamination and MNA in the downgradient portions of the plume has been effective. Hydraulic capture of the portion of the plume with the highest concentrations of residual contamination was achieved using GET. The effectiveness of GET is further demonstrated by declining VOC concentrations observed in the majority of site monitoring wells. Declining trends are observed in both shallow and deep monitoring wells, indicating both the horizontal and vertical extent of the target areas are being addressed. The Site SD031 GET system has been shut down for a rebound study for the remaining period of interim remediation, because VOC concentrations have declined. The maximum 1,1-DCE concentrations during the 2010 GSAP were observed within a localized portion of the plume. These included 78.8 µg/L in EW566x31 and 7.4 µg/L in EW567x31. MNA is a viable remedy at Site SD031. Overall, contaminant concentrations are stable or declining in the downgradient MNA assessment monitoring wells. The MNA network includes both shallow and deep monitoring wells. MNA has been shown to be effective throughout the entire thickness of the plume.	GET optimization: Air stripping discontinued and replaced with LGAC groundwater treatment at NGWTP. Rebound study: GET system shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 4Q07 and 2Q11 indicates that significant rebound of chlorinated VOC concentrations is not occurring in the absence of GET system operations.
SD033 (NEWIOU)	MNA Assessment and GET	Assess viability of natural physical, chemical, and biological processes to remediate plume GET for migration control[g]	The GET system for WIOU Site SD033 achieved the migration control IRA objective. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume were addressed by the GET system. In the southern (downgradient) area of the site, MNA appears to be a viable remedy. Groundwater contamination in this area is not migrating.	GET optimization: UV/Ox groundwater treatment discontinued in 2010 and replaced by LGAC at CGWTP. Rebound study: WIOU GET system, including Site SD033, shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD033, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SD034 (NEWIOU)	GET	GET for source control[h] GET for migration control[i]	The GET and passive skimming systems for WIOU Site SD034 are largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L are being captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Floating product removal of Stoddard solvent, containing dissolved COCs, is achieving the source control IRA for the site. The extent of floating product continues to be limited to the original release area and is not migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC at CGWTP. Rebound study: WIOU GET system, including Site SD034, shut down for a rebound study.	Passive skimming operations are continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD034, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SS035 (NEWIOU)	MNA Assessment	Assess viability of natural physical, chemical, and biological processes to remediate plume	Groundwater data obtained during the period of interim remediation within the WIOU plume, including Site SS035, indicate that the plume is not migrating and COC concentrations are stable or decreasing.	Rebound study: WIOU GET system, including Site SS035, shut down for a rebound study.	Monitoring to evaluate natural attenuation processes is continuing. The site is a component of the overall WIOU plume.

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SD036 (NEWIOU)	GET and MNA Assessment	GET for source control GET for migration control	The GET system for WIOU Site SD036 is largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Although IRA objectives are largely being met, even after several years of IRA operation, TCE concentrations greater than 1,000 µg/L continue to be detected within the portion of the Site SD036 plume with the highest concentrations of residual contamination. Optimization of the GET IRA was required. Therefore, data gaps investigations were performed during 2010 to more fully define the extent of residual contamination. Based on the results of the data gaps investigations, optimization measures included discontinuing the GET systems and injection of EVO within the portion of the plume with the highest concentrations of residual contamination. The performance of the EVO treatment is being evaluated. In the downgradient portions of the plume, MNA appears to be a viable remedy. Groundwater contamination in this area does not appear to be migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD036, shut down for a rebound study in 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO injection in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SD036. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD036, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
SD037 (NEWIOU)	MNA Assessment and GET	GET for source control[k] GET for migration control[l]	The GET system for WIOU Site SD037 is largely achieving the source control and migration control IRA objectives. Estimates of the extent of hydraulic capture indicate that VOC concentrations above 100 µg/L were captured by the existing GET system. Decreasing trends of VOC concentrations are observed throughout the commingled WIOU plume. The decreasing trend is observed in both shallow and deep monitoring wells, indicating that the horizontal and the vertical extents of the plume are being addressed by the existing GET system. Although IRA objectives are largely being met, even after several years of IRA operation, TCE concentrations greater than 1,000 µg/L continue to be detected within the portion of the Site SD037 plume with the highest concentrations of residual contamination. Optimization of the GET IRA was required. Therefore, data gaps investigations were performed during 2010 to more fully define the extent of residual contamination. Based on the results of the data gaps investigations, optimization measures included discontinuing the GET systems and injection of EVO within the portion of the plume with the highest concentrations of residual contamination. The performance of the EVO treatment is being evaluated. In the southern (downgradient) area of the WIOU, MNA appears to be a viable remedy. Groundwater contamination in this area does not appear to be migrating.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD037, shut down for a rebound study in 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO injection in 2010.	The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site SD037. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the treatment zone. Performance monitoring and evaluations of the EVO injection are ongoing. Monitoring to evaluate natural attenuation processes is continuing. The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD037, indicates that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.
DP039 (WABOU)	GET and MNA Assessment	GET for migration control GET for source control MNA to assess the viability of natural physical, chemical, and biological processes to remediate plume	The Site DP039 source control IRA objective has been partly achieved. TCE concentrations in the historical contaminant release area (i.e., a former sump) are declining, and a portion of the plume with the highest concentrations of residual contamination was hydraulically contained by a GET system. However, another portion of the plume is not hydraulically captured. This uncaptured portion of the plume, with TCE concentrations exceeding 1,000 µg/L, extends about 800 feet downgradient. This uncaptured portion of the plume with the highest concentrations of residual contamination underlies an ongoing demonstration of phytoremediation. In December 2008, an in situ bioreactor was installed in the former sump area as a technology demonstration. The performance of the bioreactor is being evaluated for the remainder of the period of interim remediation. A data gaps investigation was performed during 2010 to more fully define the extent of downgradient contamination with TCE concentrations greater than 500 µg/L. Based on the results of the data gaps investigations, an in situ PRB of EVO was installed hydraulically downgradient of an existing area of phytoremediation and upgradient of the portion of the plume undergoing MNA. The performance of the EVO PRB is being evaluated. Increasing TCE concentration trends at some monitoring wells in the distal portion of the plume indicate that MNA may not be fully effective if TCE concentrations in the untreated portion of the plume continue to exceed 1,000 µg/L and act as a continuing source of contamination into the downgradient portion of the plume.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at SBBGWTP. Rebound study: GET system shut down in 2008. Bioreactor demonstration: In situ bioreactor installed in 2008. Phytoremediation treatability study: Trees planted in 1998 and evaluated through 2010. EVO demonstration: Data gaps investigation conducted during 2010. EVO PRB installed in 2010.	Analytical and geochemical data collected during 3 years of operation indicate that the Site DP039 bioreactor is performing as designed and has successfully demonstrated the viability of ERD treatment processes. Performance monitoring and evaluations of the bioreactor are ongoing. A phytoremediation treatability study conducted at the site concluded that planted trees can contribute to remediation of the plume. Monitoring within the area of phytoremediation is continuing. The demonstration of in situ ERD treatment via injection of EVO substrate has been successful at Site DP039. Performance monitoring results provide strong indications that the reductive dechlorination process is occurring within the PRB treatment zone. Performance monitoring and evaluations of the EVO PRB are ongoing. Monitoring to evaluate natural attenuation processes is continuing. GET system operations have been discontinued.
SS041 (WABOU)	GET	GET for migration control	Site SS041 has been in NFRAP status. The NFRAP status is documented in a December 14, 2005, consensus statement (Travis AFB, 2005a). The IRA GET system achieved IRGs, and COCs are no longer detected in the site monitoring wells.	None	

TABLE 2.2-2
Summary of Interim Remedial Action Performance and Status
Groundwater Record of Decision, Travis Air Force Base, California

Site	IRA	IRA Objectives	IRA Performance and Status	IRA Optimization Action, Technology Demonstration, or Study	Performance and Status of Optimization Action, Technology Demonstration, or Study
SD043 (WABOU)	GET	GET for migration control	The IRA GET system has effectively reduced plume size and concentrations. No contaminants were detected above IRGs during the 2010 GSAP.	GET optimization: UV/Ox groundwater treatment and VGAC vapor treatment discontinued in 2009-2010 and replaced by LGAC treatment at CGWTP. Rebound study: WIOU GET system, including Site SD043, shut down for a rebound study in 2010.	The preponderance of data obtained between 2Q10 and 4Q11 from the WIOU plume, including Site SD043, indicate that significant rebound is not occurring. Monitoring to evaluate contaminant rebound after discontinuing GET system operation is ongoing. The site is a component of the overall WIOU plume.

[a] On-base portion of plume
[b] Plume at Base boundary
[c] Off-base portion of plume
[d] OSA portion of plume
[e] Southern portion of plume
[f] South Gate Area, Facility 1917, and Facility 810 plumes
[g] Storm sewer
[h] Bioslurp/free product removal
[i] Coordinated with Site SD037
[j] Portions of plume near Facilities 919, 977, 981, and Area G Ramp
[k] Portions of plume near Facilities 837, 838, and Ragsdale/V Area
[l] Remainder of plume

Notes:

NFRAP = No Further Remedial Action Planned
TARA = Tower Area Removal Action
USFWS = U.S. Fish and Wildlife Service
VGAC = vapor-phase granular activated carbon

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade COCs

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
FT004 and SD031 (TCE and 1,1-DCE)	Mann-Kendall trend analysis and chemical time-series plots for most of the downgradient monitoring wells (beyond the influence of the GET system) show decreasing concentrations.	3 (Section 2.3.1)	Geochemical data collected prior to initiation of the GET indicate reducing conditions conducive to biodegradation of chlorinated solvents.	3 (Section 2.3.2)	qPCR demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site FT004.	4
	Downgradient (beyond the influence of the GET system) monitoring and trend analysis indicate plume contraction.	3 (Section 2.3.1)	Geochemical data collected during and following GET operation indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 2.3.2), 4	Enzyme probes demonstrated that the enzymes responsible for aerobic cometabolism are active in samples collected from Site FT004.	4
	The GET system was shut down in 2007. As a whole, the groundwater plume has remained stable as evidenced by stable or continued decreasing TCE concentration trends in 74 percent of the extraction and monitoring wells and the continuing decline in TCE concentrations at downgradient well MW757x04. Similarly, 1,1-DCE concentrations were stable or decreased in 100 percent of the extraction and monitoring wells over the rebound study period.	7 (Section 7.3.1.2)	TCE point attenuation rate constants ranging from 0.058 per year to 0.58 per year were calculated (equivalent to TCE half-lives of 12 and 1 years, respectively).	3 (Section 2.3.1)	The EAP and qPCR results provide evidence of potential for intrinsic aerobic biodegradation at Site FT004. The results of the investigation are indicative of enzymatic cometabolic activity at this site.	4
	Continued decreasing concentrations in the Site FT004 extraction wells and wells within the portion of the plume with the highest concentrations of residual contamination over the course of the rebound study indicate that the portion of the plume with the highest concentrations of residual contamination has been effectively addressed by groundwater extraction and is not continuing to release mass to the groundwater plume.	7 (Section 7.3.1.2)	Numerical modeling estimated an RTF of 15 years (Site SD031) to 35 years (Site FT004) for an MNA remedy.	1 (Section 8.2.2.5)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Most of Sites FT004 and SD031 are unpaved, and it is likely that volatilization also occurs at these sites.	1 (Section C.1.4.1), 5 (Section 4)
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 600 feet. However, the plume receded over the assessment period.	3 (Section 2.3.1)				
FT005 (1,2-DCA)	The GET system was shut down for a rebound study in 2007. Over the course of the rebound study, 1,2-DCA concentrations rebounded in three (3) wells, indicating that GET is reaching its limit of effectiveness.	1 (Section C.1.4.2)	Numerical modeling estimated an RTF of 43 years for an MNA remedy at Site FT005.	1 (Section 8.2.2.5)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. The primary COC at Site FT005 is 1,2-DCA, which is also readily cometabolized. Geochemical conditions and lithology at Site FT005 are similar to Sites DP039 and FT004. Aerobic cometabolism may also be contributing to natural attenuation at Site FT005.	4
	In 2010, groundwater extraction was reinitiated at three (3) extraction wells where rebound was evident. Mann-Kendall trend analysis and chemical time-series plots indicate that over the course of the rebound study, concentrations of 1,2-DCA are stable, or have declined, in 26 of 26 monitoring and extraction wells, including those where ongoing groundwater extraction is occurring.	7 (Section 7.4.1.2)				
	Monitoring and trend analysis indicate plume contraction. In 2011, 1,2-DCA was detected at concentrations exceeding the IRG at only three (3) Site FT005 wells. The maximum concentration detected was 5.8 µg/L.	7 (Section 7.4.1.1)			Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Most of Site FT005 is unpaved, and it is likely that volatilization also occurs at Site FT005.	1 (Section C.1.4.2), 5 (Section 4)

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Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	References	Line 2	References	Line 3	References
LF006 (TCE)	Mann-Kendall analysis and chemical time-series plots indicate that TCE concentrations are decreasing throughout the plume. No monitoring wells have increasing TCE trends.	2 (Section 4.2.6)	TCE point attenuation rate constants ranging from 0.061 per year to 0.035 per year were calculated (equivalent to TCE attenuation half-lives of approximately 11 and 20 years).	3 (Section 3.3.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology at Site LF006 are similar to neighboring Site FT004. Aerobic cometabolism may also be contributing to natural attenuation at Site LF006.	4
	Data from 13 years of groundwater monitoring at Site LF006 indicate that the plume is contained and has decreased in size over time.	2 (Section 4.2.6)	Based on a TCE attenuation half-life of 20 years, an RTF of approximately 5 years was estimated for an MNA remedy.	1 (Section 8.2.2.5)		
	TCE was the only site COC that exceeded IRGs in 2011. The maximum concentration of TCE detected in 2011 was 7.1 J- µg/L.	2 (Section 4.2.6)	A TCE bulk attenuation rate constant of 0.75 per year was calculated for Site LF006. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring.	3 (Section 3.3.1)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB.	1 (Section C.1.4.3), 5 (Section 4)
	In the absence of natural attenuation processes, over the 10-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 800 feet. However, the plume receded over the assessment period.	3 (Section 3.3.1)	Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 3.3.2)		
LF007B Subarea (1,4-DCB)	Groundwater contaminants have not been detected in groundwater at Site LF007B for several years. No groundwater plume currently exists at the site.	1 (Section C.1.4.4), 2 (Section 4.1.5.6)	Because no COCs exceed cleanup goals, the RTF for an MNA remedy is 0 years.	1 (Section 8.2.2.5)		
LF007D Subarea (1,4-DCB and benzene)	Contaminants 1,4-DCB and benzene exceed IRGs at only one (1) well (MW261x07). No other contaminants are detected in groundwater at Subarea LF007D at concentrations exceeding cleanup goals.	1 (Section C.1.4.4), 2 (Section 4.1.5.6)	An attenuation rate constant of 0.054 per year was calculated for 1,4-DCB (equivalent to a 1,4-DCB half-life of approximately 13 years). Based on a half-life of 13 years, the 1,4-DCB RTF for an MNA remedy is approximately 19 years.	1 (Section C.1.4.4), 3 (Section 4.3.1)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. However, volatilization is unlikely to contribute significantly to contaminant reduction at Subarea LF007D. The landfill cap likely reduces volatilization at the site. In addition, while benzene is volatile, 1,4-DCB has a relatively low volatility, and significant volatilization of 1,4-DCB is unlikely.	1 (Section C.1.4.4), 5 (Section 4)
	Mann-Kendall analysis and chemical time-series plots indicate that 1,4-DCB concentrations are declining in all three (3) monitoring wells at which it has historically been detected. In 2011, 1,4-DCB was detected only at monitoring well MW261x07.	2 (Section 4.1.5.6)	In the portion of the plume where contaminants continue to exceed IRGs, analytical and geochemical data indicate anaerobic conditions and that anaerobic biodegradation of 1,4-DCB is occurring. During the 1,4-DCB biodegradation process, 1,4-DCB degrades to chlorobenzene and chlorobenzene degrades to benzene. This degradation pathway is likely contributing to the relatively constant concentrations of benzene observed in the site groundwater. Once the 1,4-DCB source has been depleted, benzene concentrations are expected to decline through either biological or physical attenuation processes, or a combination of both.	3 (Section 4.3.2) 8		
	Plume and downgradient monitoring well data indicate that the benzene plume is stable. Benzene has only been detected in one (1) monitoring well, MW261x07. The Mann-Kendall analysis and chemical time-series plots indicate that the benzene concentrations are stable at this well (ranging between 2 and 3 µg/L).	2 (Section 4.1.5.6)				
	In the absence of natural attenuation processes, over the 10-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 900 feet. However, the plume receded over the assessment period.	3 (Section 4.3.1)	In the portion of the plume where contaminants are below IRGs, geochemical data indicate aerobic conditions, which are conducive to biodegradation of benzene. Once the degradation of 1,4-DCB is complete, conditions near well MW261x07 are expected to gradually become aerobic and more conducive to the aerobic biodegradation of benzene. Under these conditions, the RTF for the MNA remedy is 23 years.	8		
			If conditions near well MW261x07 remain anaerobic, once the degradation of 1,4-DCB is complete, benzene is expected to attenuate through physical processes only. Under these conditions, the RTF for the MNA remedy is 49 years.	8		

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
LF008 (alpha-chlordane)	Stable pesticide concentrations over a period of 7.5 years of groundwater extraction indicate that groundwater extraction is an ineffective remedy for this site. The GET system was consequently shut down in 2008 for a rebound study.	1 (Section C.1.4.5)	The physical properties of pesticides result in very low subsurface mobility because of strong sorption of the chemical to the soil.	1 (Section C.1.4.5)		
	No significant rebound of pesticides is evident during the 3 years since the GET rebound study began. In fact, the alpha-chlordane plume has contracted since GET was taken offline in 2008.	7 (Section 7.2.1.2)	Site sediments have high clay content, which increases sorption and also reduces permeability.	1 (Section C.1.4.5)		
	Mann-Kendall analysis and chemical time-series plots indicate that alpha-chlordane concentrations are stable or have decreased at all seven (7) of the monitoring wells sampled since the initiation of the rebound study. The maximum concentration of alpha-chlordane detected in 2011 was 0.43 J- µg/L; the IRG is 0.1 µg/L.	7 (Section 7.2.1.2)	Because of the high sorption of pesticides, an RTF exceeding 100 years was estimated for both the MNA and the GET remedial alternatives.	1 (Section 8.2.2.5), 8		
SS015 (TCE, cis-1,2-DCE, and vinyl chloride)	ERD treatment of the portion of the plume with the highest concentrations of residual contamination (via EVO injection) began in 2010. Since the EVO injection, the combined mass of TCE, cis-1,2-DCE, and vinyl chloride declined by more than 99 percent in the treatment zone.	7 (Section 6.4.5)	TCE, cis-1,2-DCE, and vinyl chloride bulk attenuation rate constants of 2.3, 6.6, and 9 per year were calculated for Site SS015. The positive bulk attenuation rate constants indicate that attenuation of TCE, cis-1,2-DCE, and vinyl chloride is occurring.	1 (Section C.1.5.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Aerobic cometabolism may also be contributing to natural attenuation at Site SS015.	4
	The downgradient extent of contamination at Site SS015 was defined in 2010; consequently, the monitoring history in the downgradient portion of the plume is too short to identify long-term contaminant trends. However, concentrations of TCE, cis-1,2-DCE, and vinyl chloride have decreased in one (1) or more of the following downgradient wells since they were installed in 2010: MW2103x15, MW2105x15, MW2118x15, and MW2124x15. These wells are located downgradient of the portion of the plume with the highest concentrations of residual contamination and are outside the portion of the plume treated by ERD.	2 (Figures 4.7-8, 4.7-10, 4.7-11)	In the portion of the plume with the highest concentrations of residual contamination, anaerobic biodegradation is the primary mechanism for natural attenuation. Anaerobic biodegradation was enhanced by vegetable oil injection.	3 (Section 5.3.2)	Geochemical conditions at Site SS015 are similar to Sites FT004 and DP039, although the lithology at Site SS015 is different from these two (2) sites. Groundwater contamination at Site SS015 flows through highly weathered shallow sandstone rather than unconsolidated alluvial sediments as at Sites DP039 and FT004.	2 (Section 4.7.3)
			In the portion of the plume beyond the vegetable oil injection area, geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 5.3.2)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Site SS015.	1 (Section C.1.5.1), 5 (Section 4)
	The monitoring well with the most consistent decline in TCE, cis-1,2-DCE, and vinyl chloride concentrations is MW2103x15, located approximately 75 feet downgradient of the ERD treatment area. The decline in contaminant concentrations at this well is likely primarily due to reduction in mass loading from the portion of the plume with the highest concentrations of residual contamination.	7 (Section 6.4.4.2)				
	Since EVO injection, only one (1) Site SS015 monitoring well outside of the injection area, MW625x15, has had increasing TCE, cis-1,2-DCE, and vinyl chloride concentrations. EVO injection was performed at Site SS015 as a response to increasing contaminant concentrations at this monitoring well and at wells located within the portion of the plume with the highest concentrations of residual contamination. Contaminant concentrations have not increased at monitoring wells located downgradient of MW625x15.	2 (Section 4.7.6 and Figures 4.7-8, 4.7-10, 4.7-11)				

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	**References**	**Line 2**	**References**	**Line 3**	**References**
Site ST027B (TCE)	The monitoring history for the TCE plume is shorter than at most of the other sites evaluated for MNA (4 years); however, available plume and downgradient monitoring data indicate that the TCE plume is stable. No plume or downgradient monitoring wells have increasing TCE concentration trends.	1 (Section C.1.4.6), 2 (Section 4.5.6.1)	A TCE bulk attenuation rate constant of 1.1 per year was calculated for Site ST027B. The positive bulk attenuation rate constant indicates that attenuation of TCE is occurring.	1 (Section C.1.4.6)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology at Site ST027B are similar to Sites FT004 and DP039. Aerobic cometabolism may also be contributing to natural attenuation at Site ST027B.	4
	In the absence of natural attenuation processes, over the 28-month MNA assessment period evaluated during the Site ST027B characterization, the TCE plume would have been expected to have migrated approximately 290 feet. However, no appreciable migration occurred over the assessment period.	6	Numerical modeling estimated an RTF of 50 years for an MNA remedy.	1 (Section 8.2.2.5)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Site ST027B.	1 (Section C.1.4.6), 5 (Section 4)
			Geochemical data indicate limited evidence for anaerobic biodegradation of chlorinated VOCs. Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	6		
			Cis-1,2-DCE and vinyl chloride, TCE biodegradation daughter products, are present within the TCE plume.	6		
			Petroleum hydrocarbons, conducive to reductive dechlorination, are present within the TCE plume.	6		
Sites SD033, SD034, SS035, SD036, SD037, and SD043 (TCE)	Trend analysis in downgradient monitoring wells (beyond the influence of the GET system) show stable or decreasing concentrations.	3 (Section 6.5.1)	TCE point attenuation rate constants ranging from 0.019 to 0.058 per year were calculated (equivalent to TCE attenuation half-lives of approximately 36 and 12 years).	3 (Section 6.5.1)	qPCR and enzyme probes at Sites FT004 and DP039 demonstrated that aerobic bacteria that produce TCE cometabolic enzymes are present at similar but geographically distant Travis AFB indicator groundwater sites and that the cometabolic enzymes are active. Geochemical conditions and lithology in the WIOU are similar to neighboring Site DP039. Aerobic cometabolism may also be contributing to natural attenuation at Sites SD033, SD034, SS035, SD036, SD037, and SD043.	4
	Downgradient (beyond the influence of the GET system) monitoring and trend analysis indicate plume contraction.	3 (Section 6.5.1)	Numerical modeling estimated an RTF of 60 years for the portion of the plume beyond the 1,000-µg/L technology demonstration treatment area. This is the amount of time needed for the downgradient portion of the plume to attenuate to cleanup goals.	1 (Section 8.2.2.5)		
	The GET system was shut down in 2010 to support EVO injection within the portions of the plume with the highest concentrations of residual contamination and a rebound study in the distal portions of the plume. As a whole, the distal groundwater plume has remained stable over the rebound study period as evidenced by stable or continued decreasing TCE concentration trends in 85 percent of the extraction and monitoring wells monitored for rebound.	7 (Section 7.1.1.2)	Geochemical data indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 6.5.2)	Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB. Volatilization may occur in the unpaved areas of Sites SD033, SD034, SS035, SD036, SD037, and SD043.	1 (Section C.1.5.3), 5 (Section 4)
	Over the rebound study period, TCE concentrations have not increased in any of the downgradient monitoring wells, which indicates that the plume is not migrating.	7 (Section 7.1.1.2)				
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 560 feet. However, the plume receded over the assessment period.	3 (Section 6.5.1)				

TABLE 2.2-3
Lines of Evidence for Natural Attenuation
Groundwater Record of Decision, Travis Air Force Base, California

Lines of Evidence:

Line 1 = Historical data showing reductions in contaminant mass/concentration over time
Line 2 = Hydrogeologic and geochemical data that provide indirect evidence of the types of natural attenuation processes active at a site and degradation rates
Line 3 = Data from field studies to demonstrate the occurrence of a particular natural attenuation process and its ability to degrade contaminants of concern

Site (Primary COCs)	Line of Evidence					
	Line 1	References	Line 2	References	Line 3	References
DP039 (TCE)	Stable or declining TCE concentrations in five (5) of the nine (9) wells located outside of the area potentially impacted by the technology demonstrations (MW03x39, MW759x39, MW761x39, MW762x39, and MW785x39) indicate that natural attenuation is occurring at Site DP039. However, the recent increases in TCE concentrations in the other four (4) wells (MW04x39, MW758x39, MW760x39, and MW781x39) indicate that mass loading to the aquifer exceeds the aquifer attenuation capacity in portions of the plume.	4	TCE point attenuation rate constants ranging from 0.092 per year to 0.14 per year were calculated (equivalent to TCE attenuation half-lives of approximately 8 and 5 years).	3 (Section 7.3.1)	qPCR demonstrated the presence of bacteria that produce TCE cometabolic enzymes at Site DP039.	4
	The increases in TCE concentrations in portions of the plume led to the conclusion, documented in the NAAR, that natural attenuation alone may be insufficient to prevent plume migration. Consequently, to reduce mass loading on the distal portion of the plume, the EVO PRB was installed in June and July 2010.	3 (Section 7.4), 4	Numerical modeling estimated an RTF of 65 years for the portion of the plume downgradient of the EVO PRB.	1 (Section 8.6.7)	Enzyme probes at Site DP039 demonstrate that the enzymes responsible for aerobic cometabolism are active.	4
	In the absence of natural attenuation processes, over the 8-year MNA assessment period evaluated in the NAAR, the TCE plume would have been expected to have migrated approximately 240 feet. However, the southern (downgradient) edge of the plume remained stable over the assessment period.	3 (Section 7.3.1)	Geochemical data in the downgradient portion of the plume considered for MNA indicate predominantly aerobic and oxidizing conditions, which are conducive to aerobic cometabolism but not to anaerobic degradation.	3 (Section 7.3.2)	The EAP and qPCR results provide evidence of potential for intrinsic aerobic biodegradation at Site DP039. The results of the investigation are indicative of enzymatic cometabolic activity at this site.	4
					Data collected at Site DP039 indicate that volatilization from dissolved to vapor phase occurs at Travis AFB.	5 (Section 4)

References:

1 = FFS (CH2M HILL, 2011a)
2 = GSAP 2010-2011 Annual Report (CH2M HILL, 2012a)
3 = NAAR (CH2M HILL, 2010b)
4 = *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b)
5 = *Technical Report: Phytostabilization at Travis Air Force Base, California* (Parsons, 2010)
6 = *Technical Memorandum Site ST027-Area B Characterization Results* (CH2M HILL, 2010e)
7 = 2011 Annual RPO Report (CH2M HILL, 2012d)
8 = 2012 GSAP Technical Memorandum (CH2M HILL, 2012g)

Notes:

EAP = enzyme activity probe
qPCR = quantitative real-time polymerase chain reaction
RTF = remediation time frame

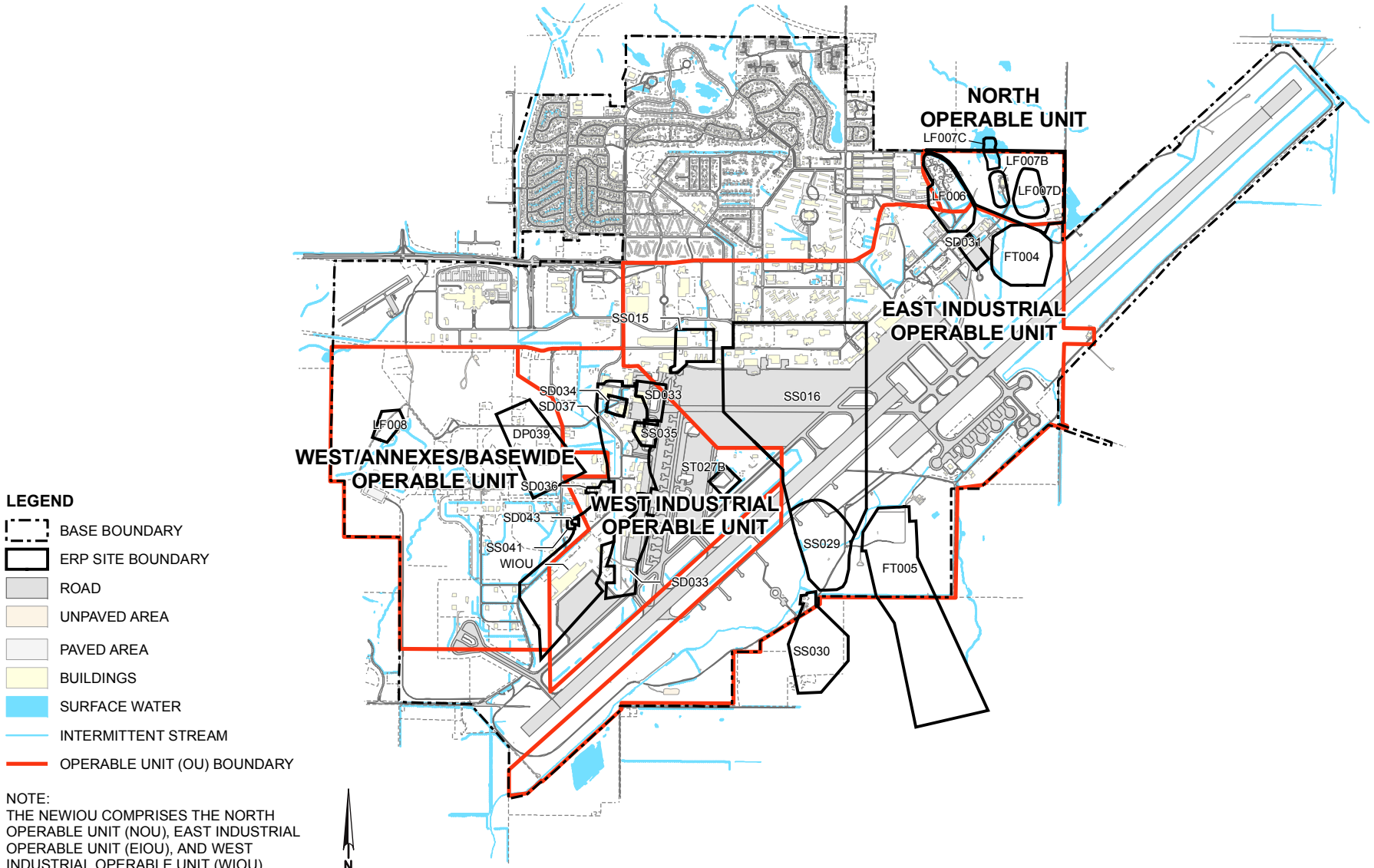


FIGURE 2.2-1
OPERABLE UNITS AND SITES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

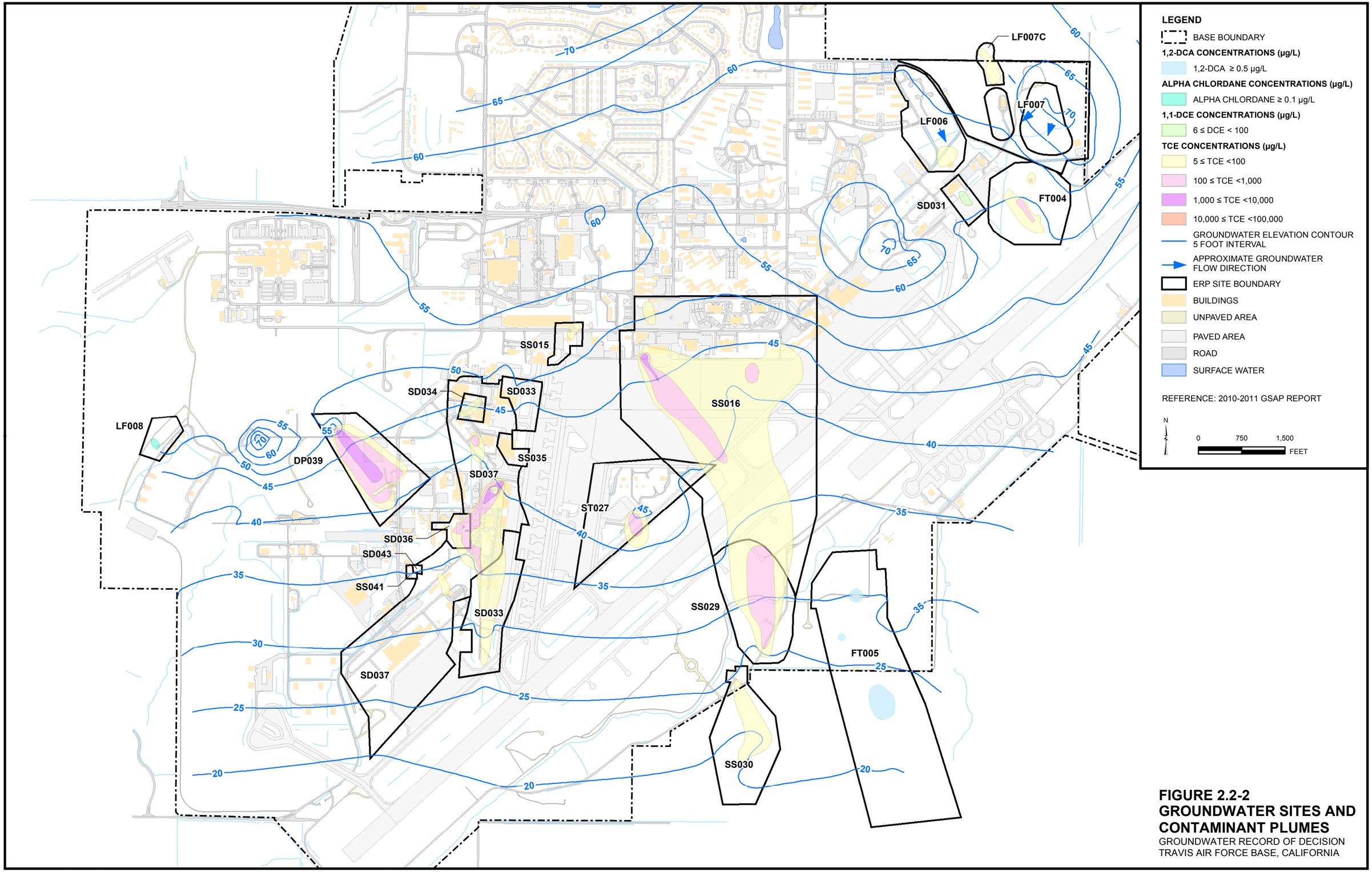
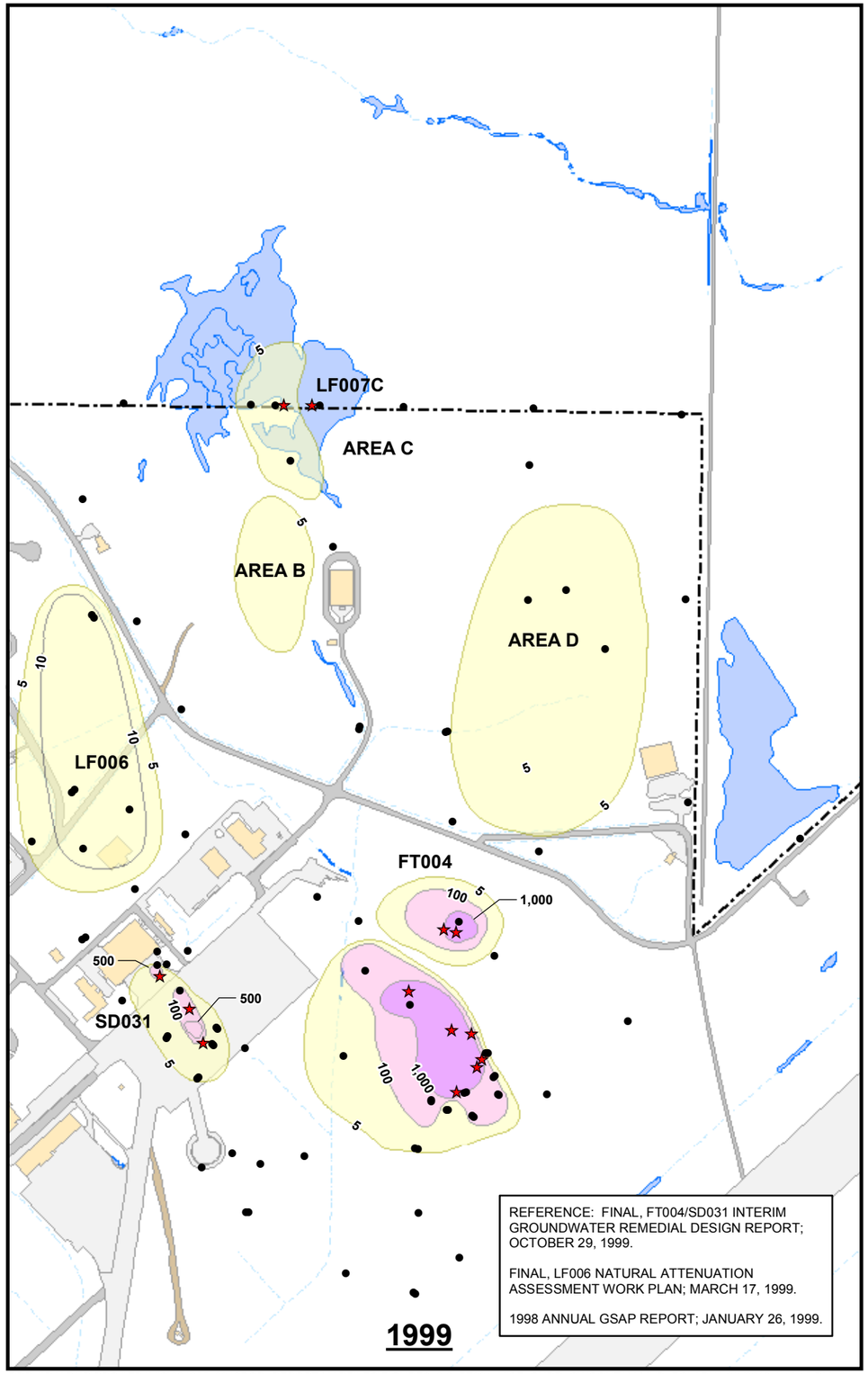
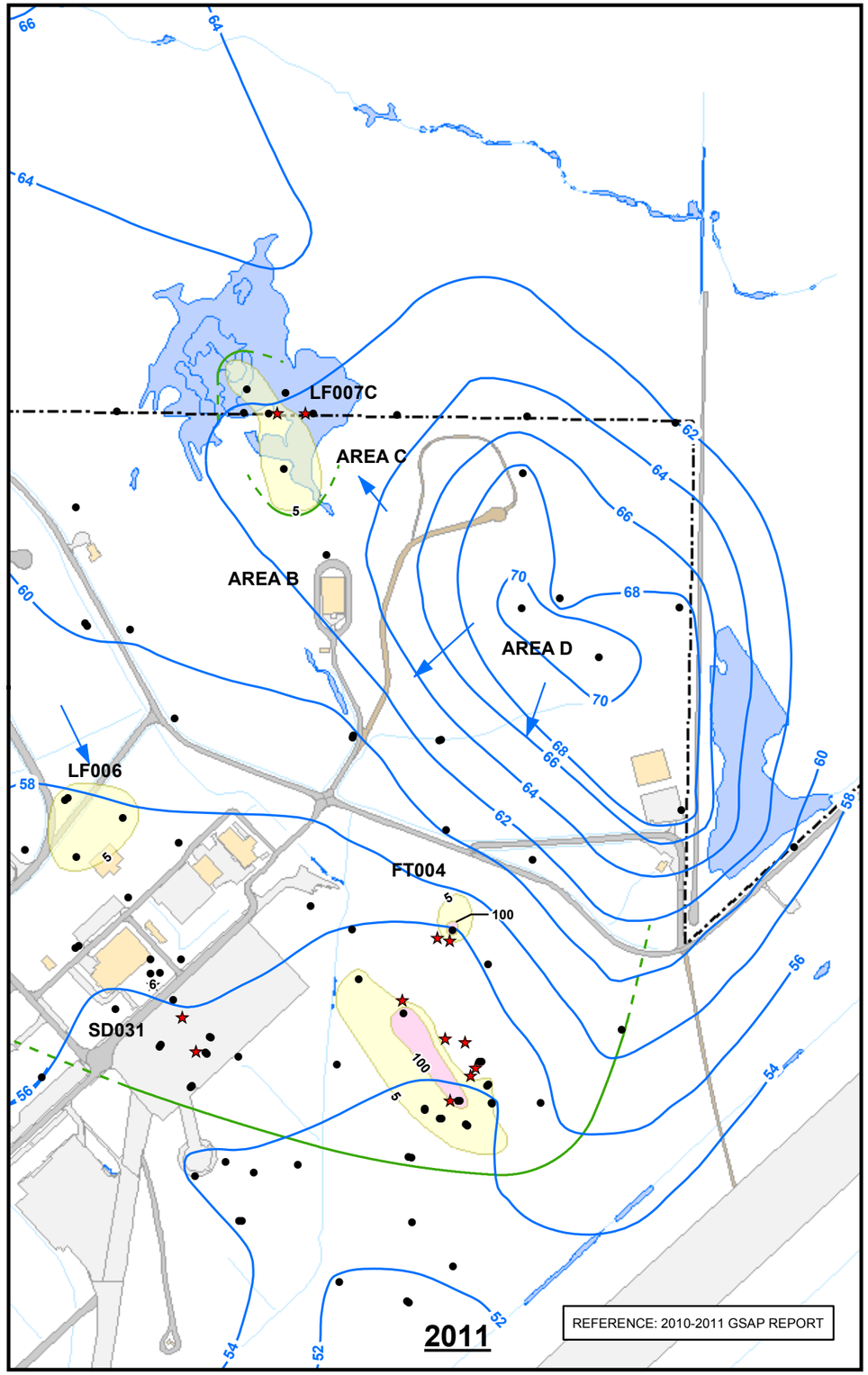
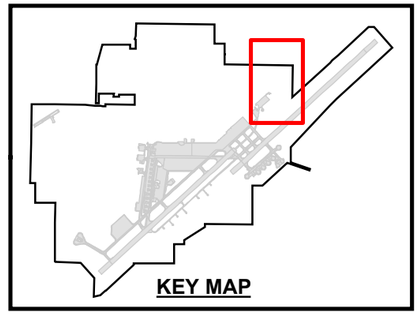


FIGURE 2.2-2
GROUNDWATER SITES AND CONTAMINANT PLUMES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-2_BASEWIDE_PLUME_NETWORK.MXD MSCHROCK 5/29/2013 11:01:09 PM







LEGEND

- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

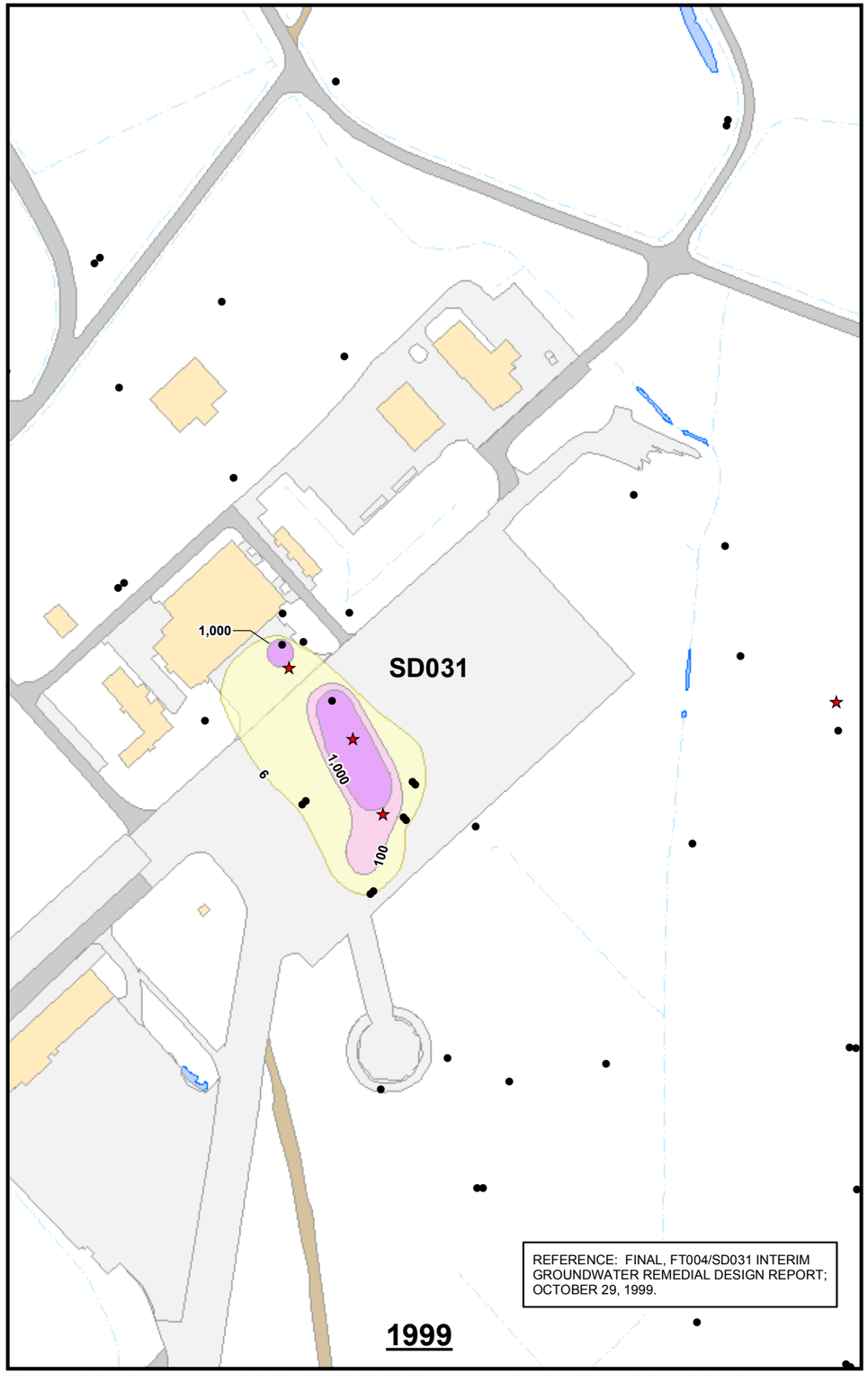
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BASE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

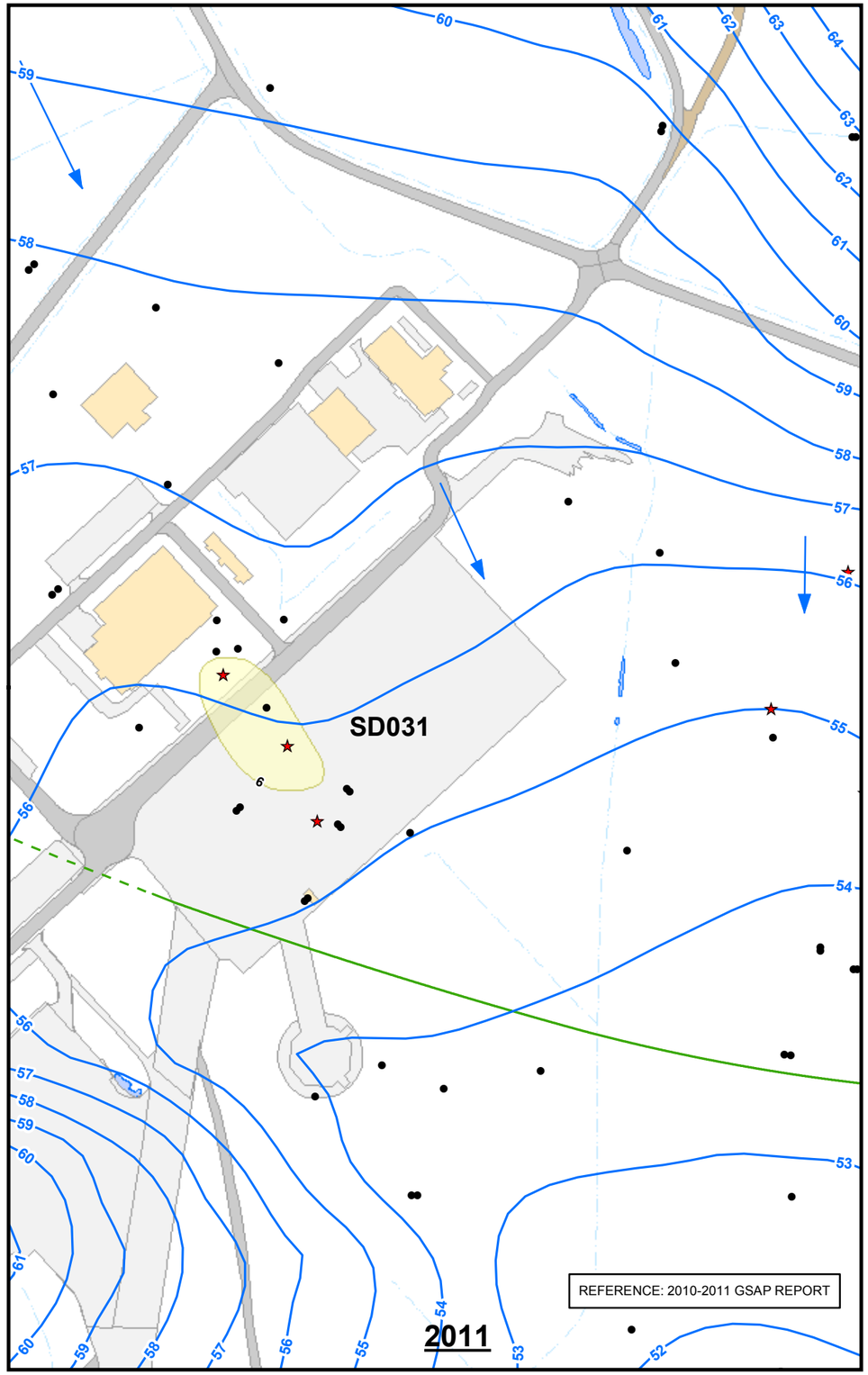
N

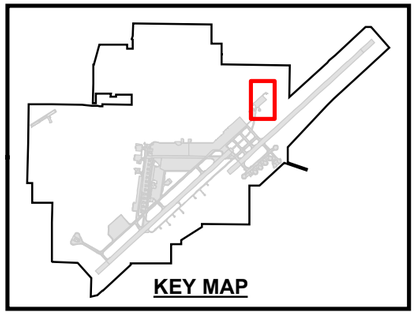
0 275 550 FEET

FIGURE 2.2-3
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITES FT004/SD031/LF006/LF007
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-3_FT004_HIST_CURR_GWCONTAM.MXD ECLARK1 6/4/2013 1:41:45 PM







LEGEND

- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

1,1-DCE CONCENTRATIONS (µg/L)

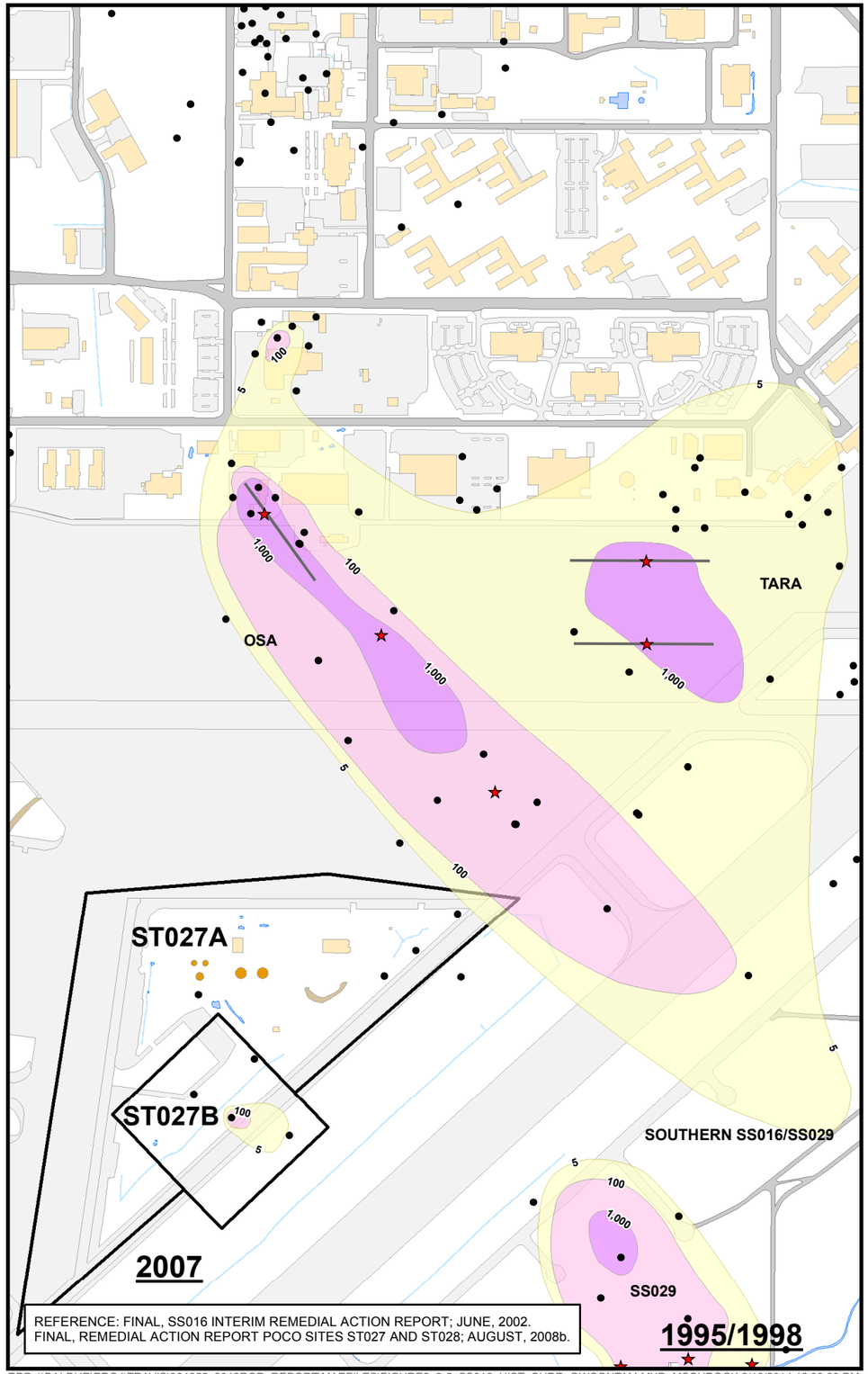
- 6 ≤ DCE < 100
- 100 ≤ DCE < 1,000
- DCE ≤ 1,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 6 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

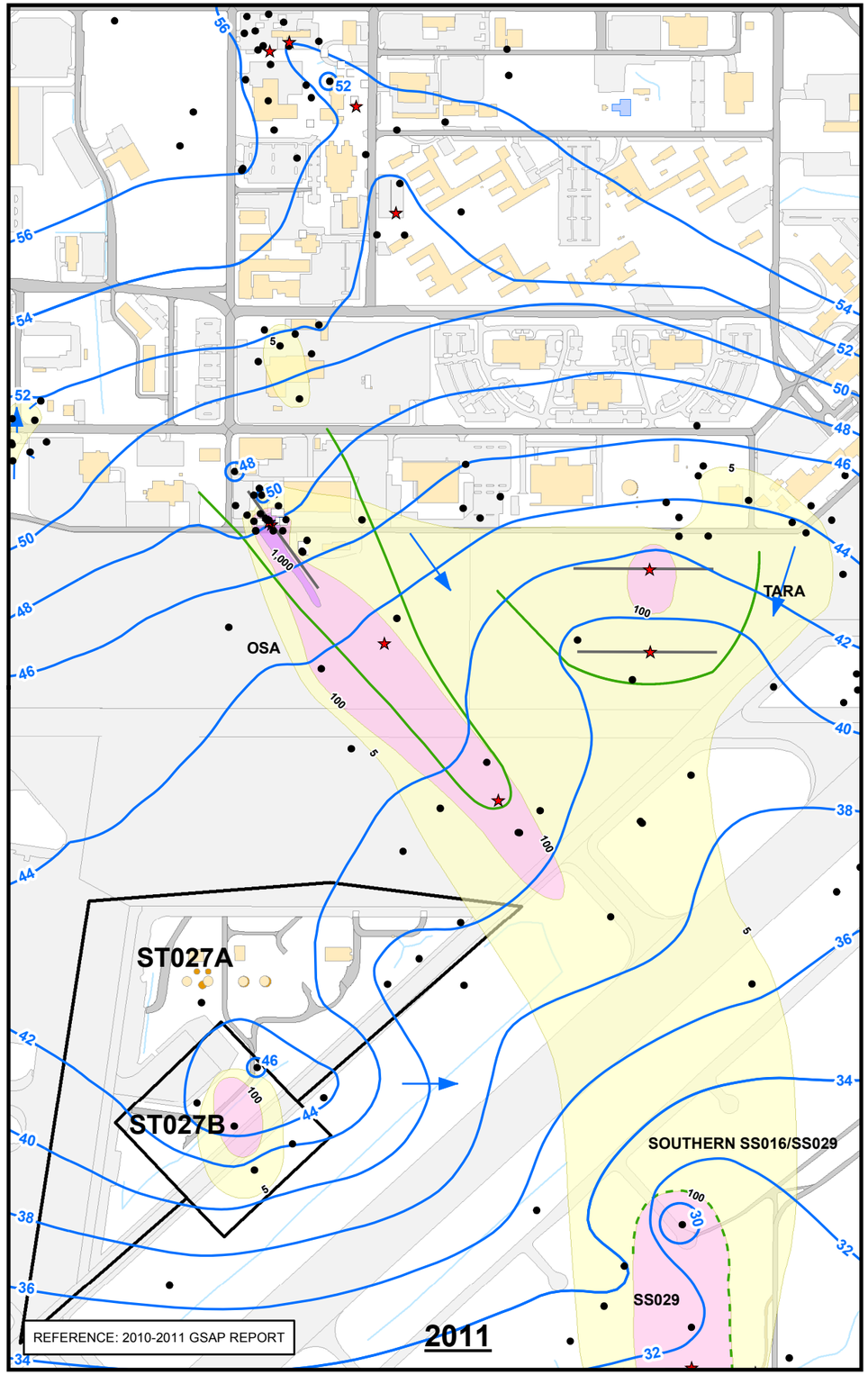
N

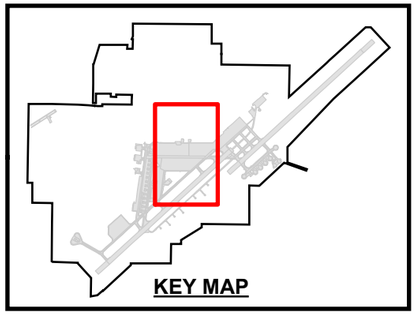
0 125 250 FEET

FIGURE 2.2-4
HISTORICAL AND CURRENT 1,1-DCE GROUNDWATER CONTAMINATION - SITE SD031
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-4_SD031_DCE_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 10:30:18 AM







LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- VERTICAL EXTRACTION WELL
- HORIZONTAL EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- ERP SITE BOUNDARY
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

N

0 275 550 FEET

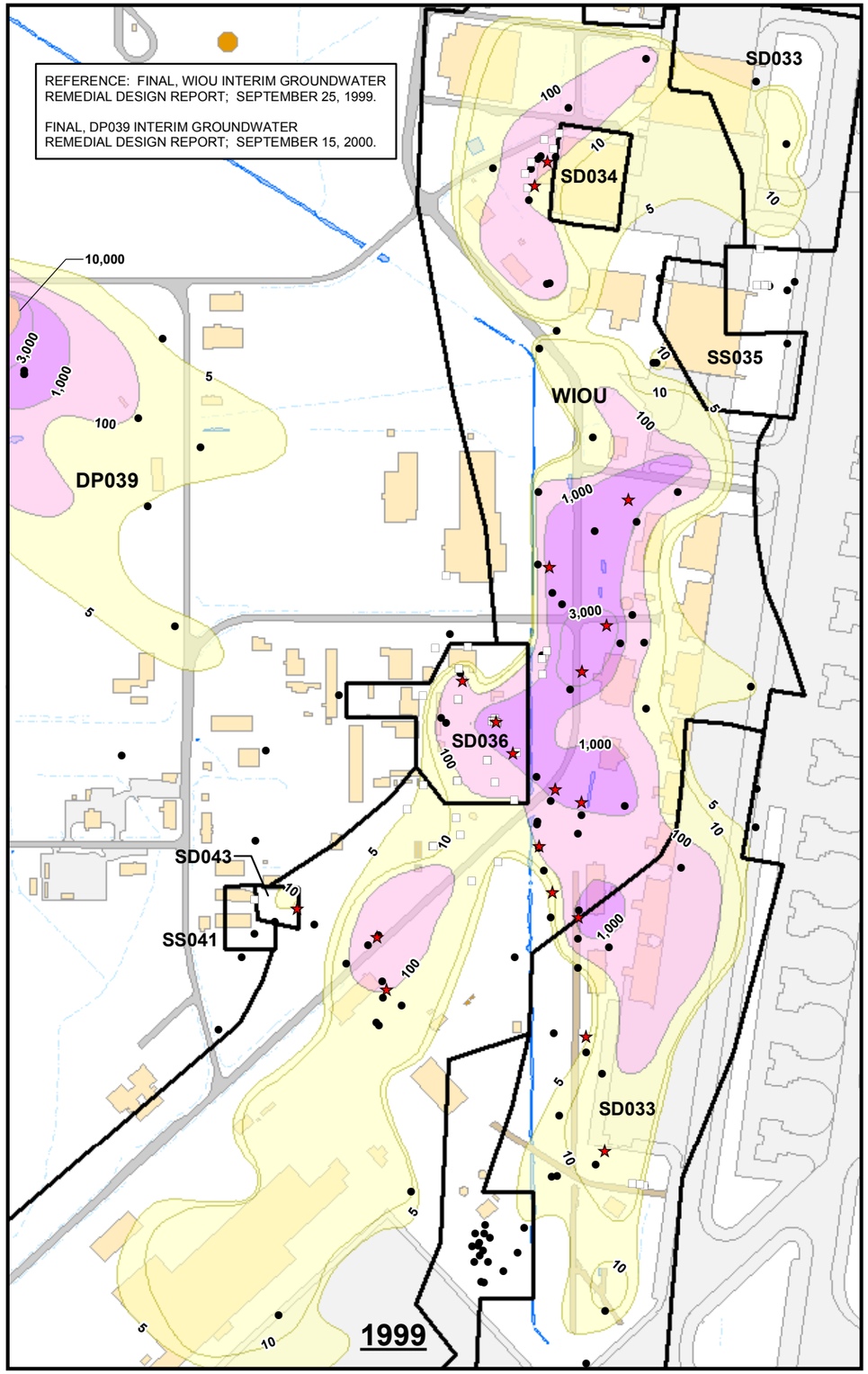
FIGURE 2.2-5
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE SS016 AND SITE ST027B
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

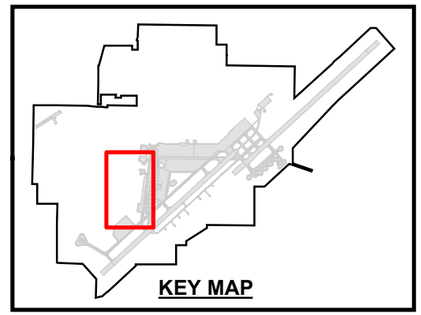
RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-5_SS016_HIST_CURR_GWCONTAM.MXD MSCHROCK 2/10/2014 12:38:30 PM

REFERENCE: FINAL, WIOU INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 25, 1999.

FINAL, DP039 INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 15, 2000.

REFERENCE: 2010-2011 GSAP REPORT





LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- VERTICAL EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

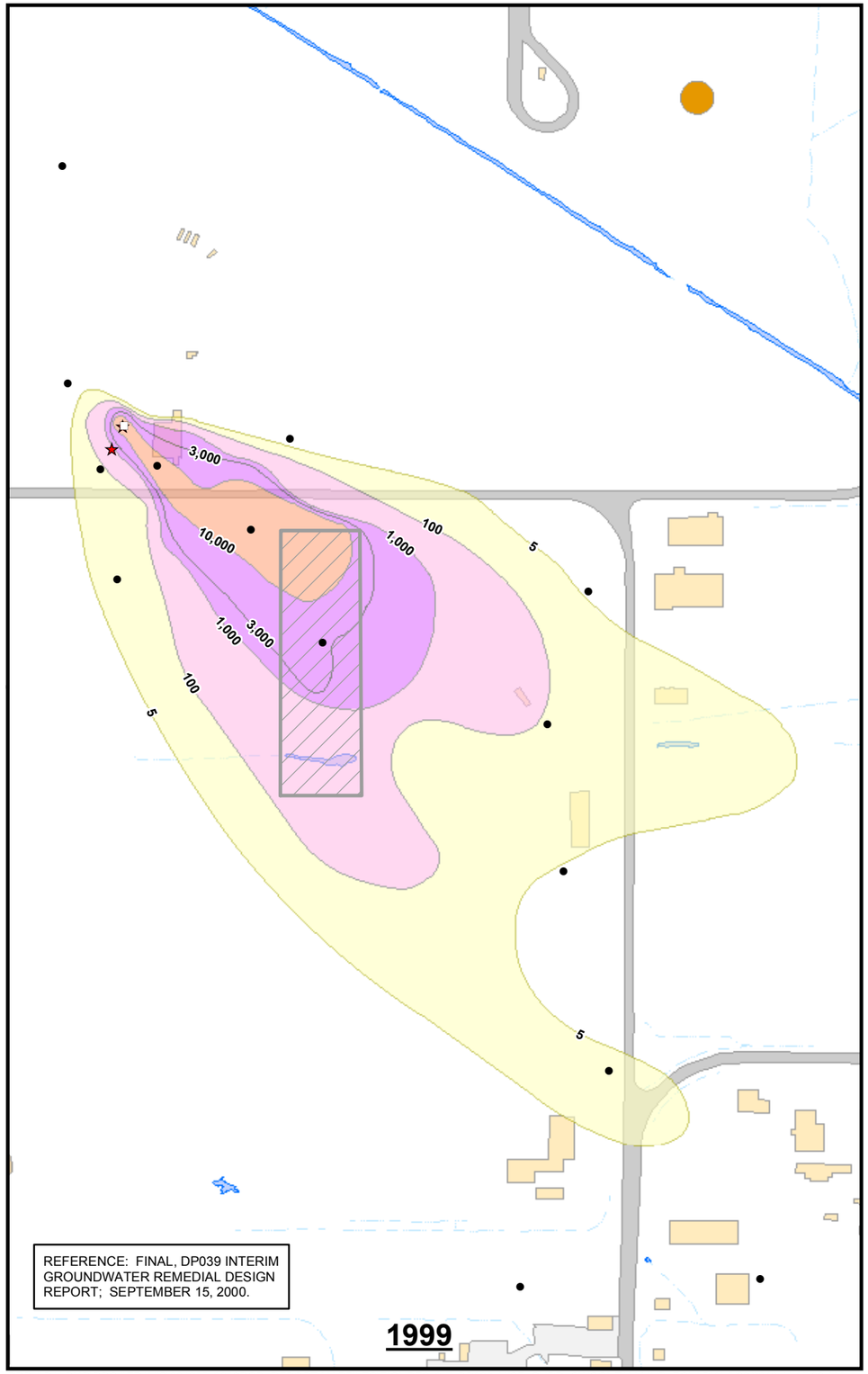
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- ERP SITE BOUNDARY
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

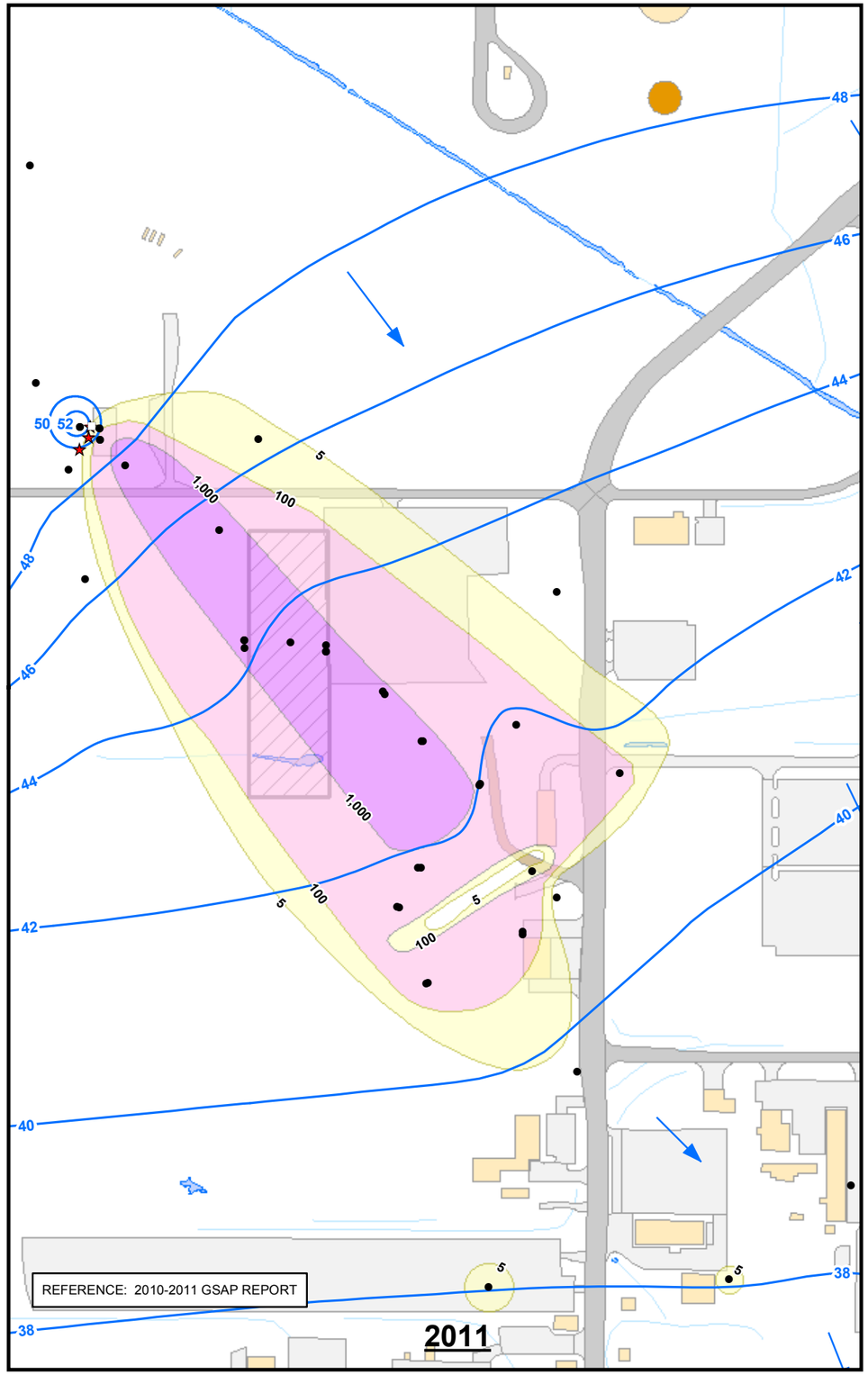
N

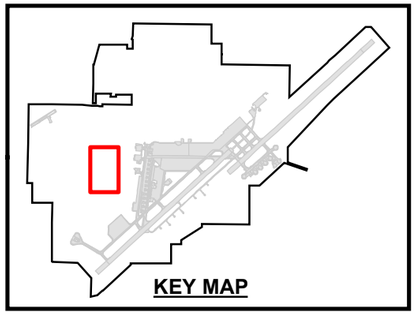
0 250 500 FEET

FIGURE 2.2-6
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - WIOU SITES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-6_WIOU_HIST_CURR_GWCONTAM.MXD ECLARK1 6/4/2013 2:00:45 PM







LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL
- PHYTOREMEDIATION AREA

TCE CONCENTRATIONS (µg/L)

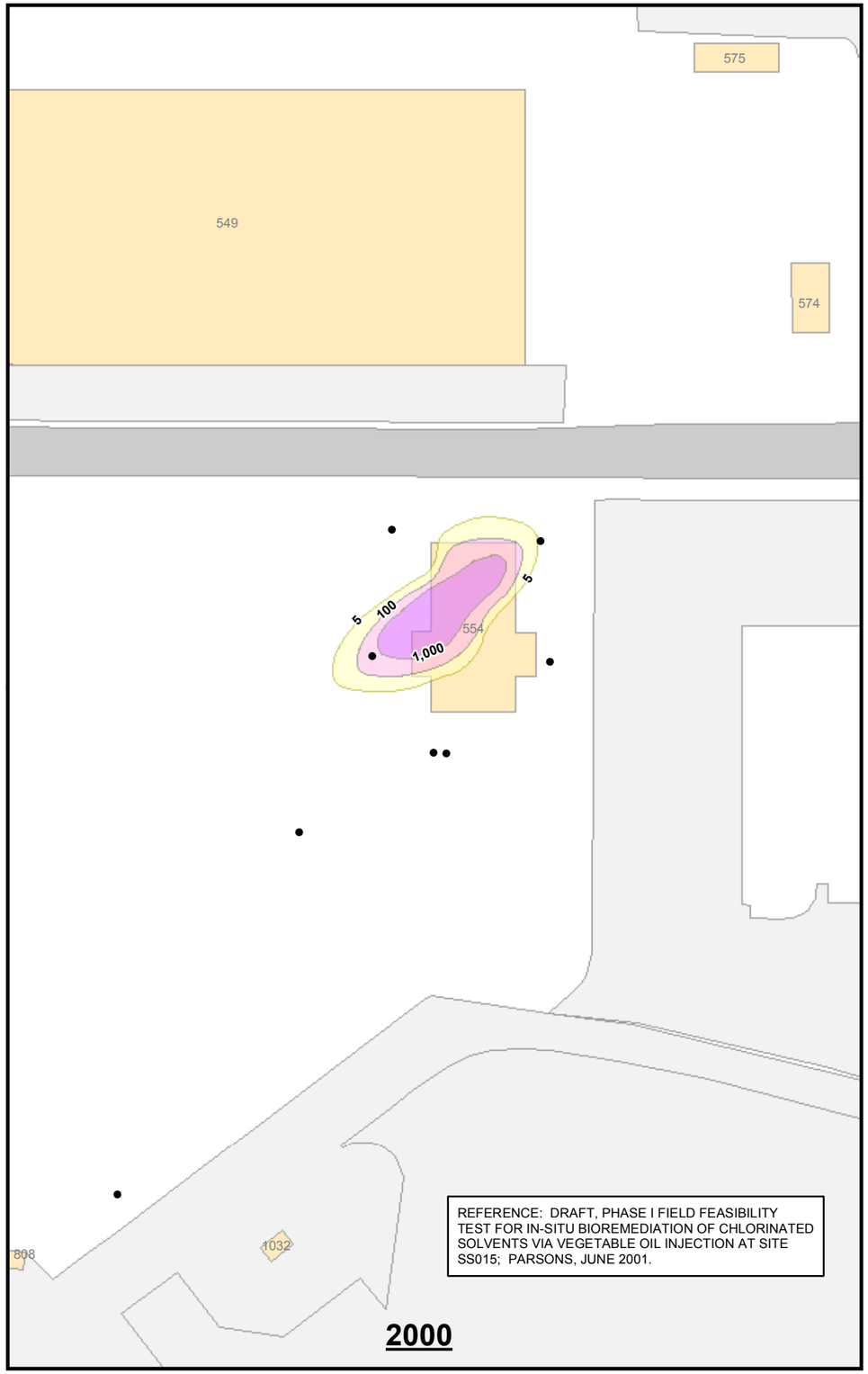
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- 10,000 ≤ TCE <100,000
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

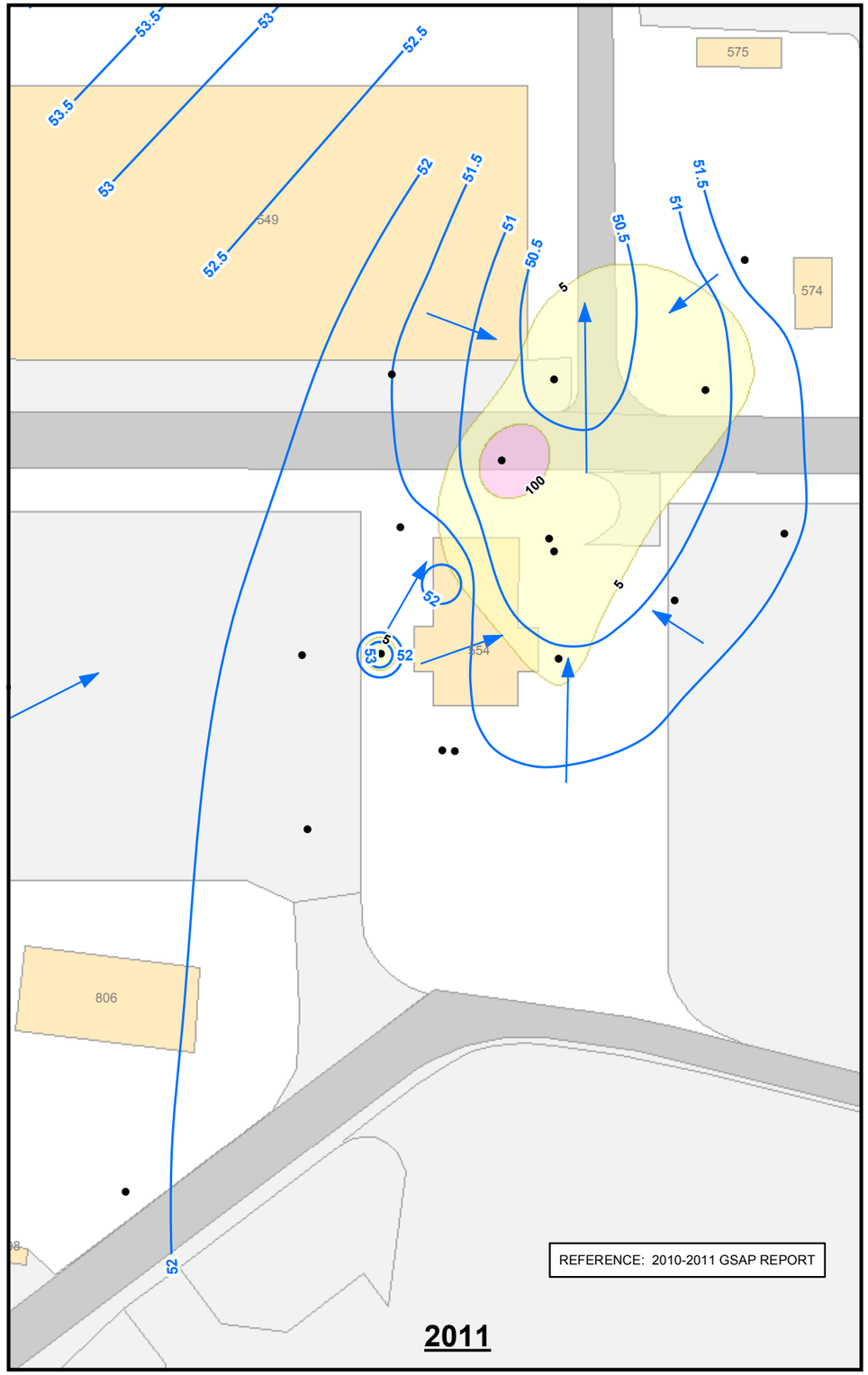
N

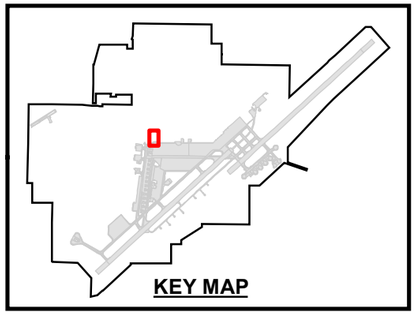
0 150 300 FEET

FIGURE 2.2-7
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE DP039
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-7_DP039_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 11:37:02 AM







LEGEND

- GROUNDWATER MONITORING WELLS

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- 5 — APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 549 — BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD

N

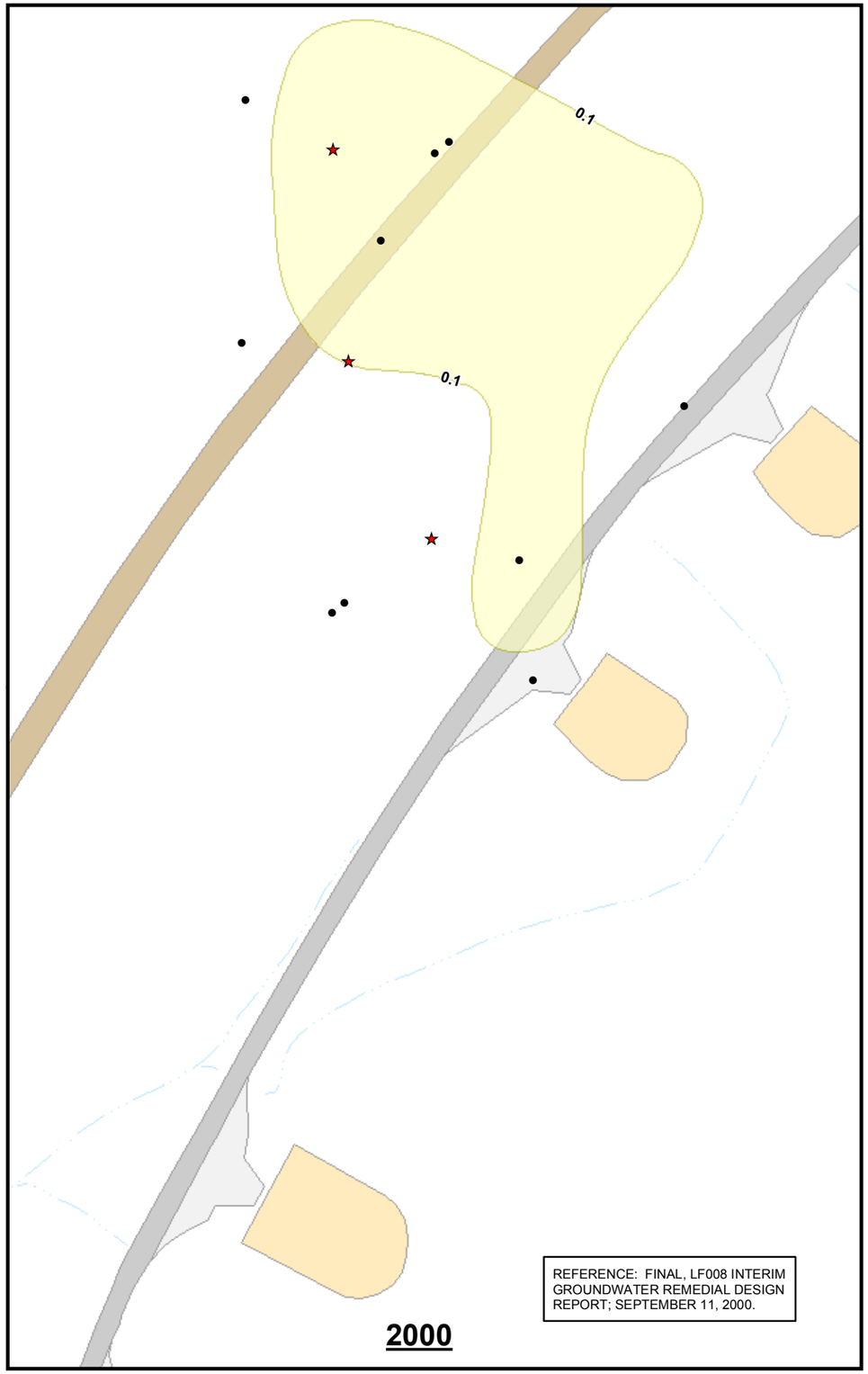
0 50 100 FEET

REFERENCE: DRAFT, PHASE I FIELD FEASIBILITY TEST FOR IN-SITU BIOREMEDIATION OF CHLORINATED SOLVENTS VIA VEGETABLE OIL INJECTION AT SITE SS015; PARSONS, JUNE 2001.

REFERENCE: 2010-2011 GSAP REPORT

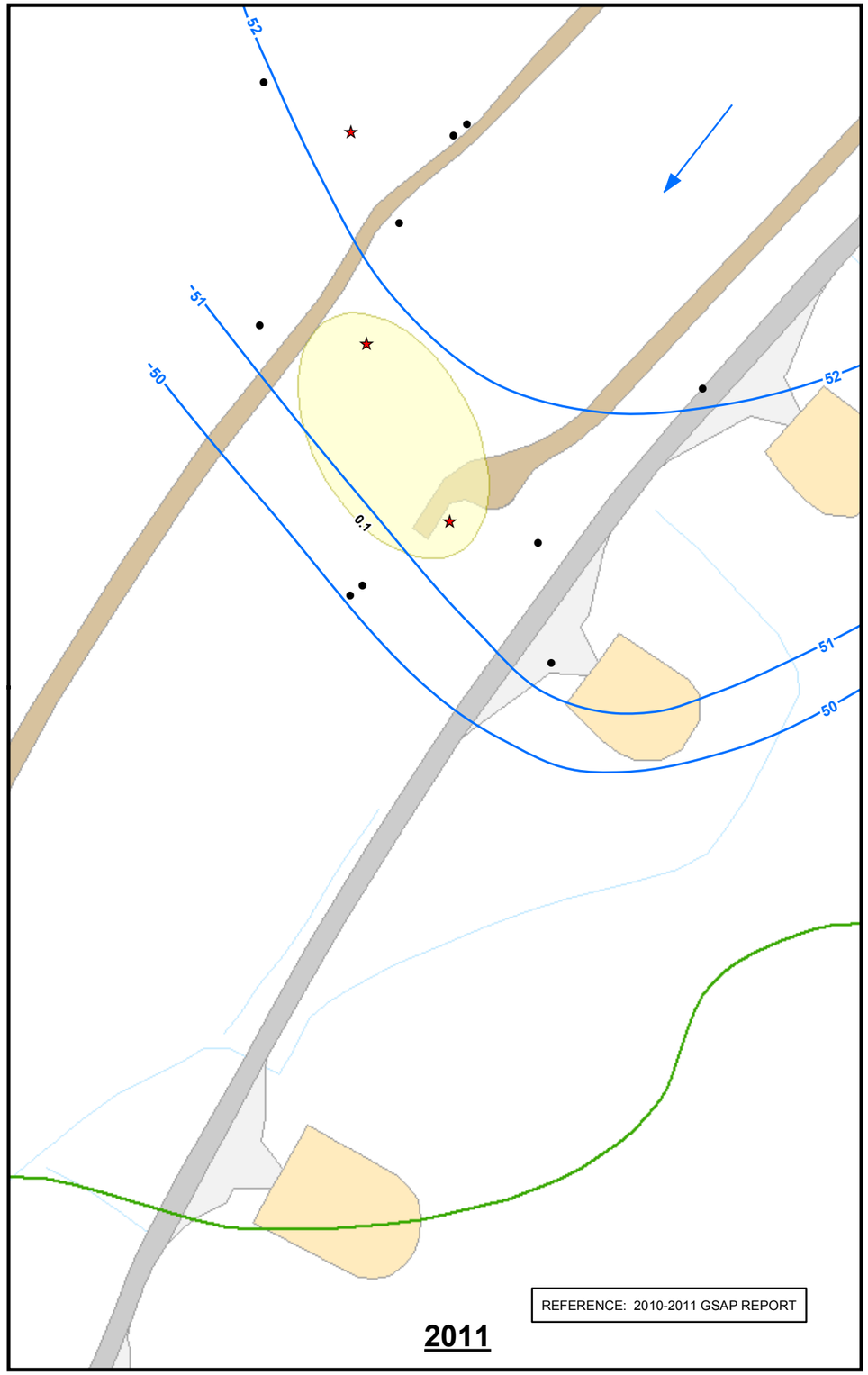
FIGURE 2.2-8
HISTORICAL AND CURRENT TCE GROUNDWATER CONTAMINATION - SITE SS015
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-8_SS015_HIST_CURR_GWCONTAM.MXD SSCOPES 5/30/2013 11:52:14 AM



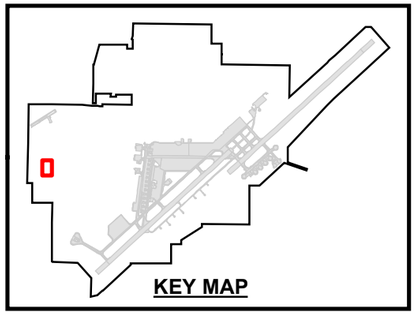
2000

REFERENCE: FINAL, LF008 INTERIM GROUNDWATER REMEDIAL DESIGN REPORT; SEPTEMBER 11, 2000.



2011

REFERENCE: 2010-2011 GSAP REPORT



LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)

ALPHA-CHLORDANE CONCENTRATIONS (µg/L)

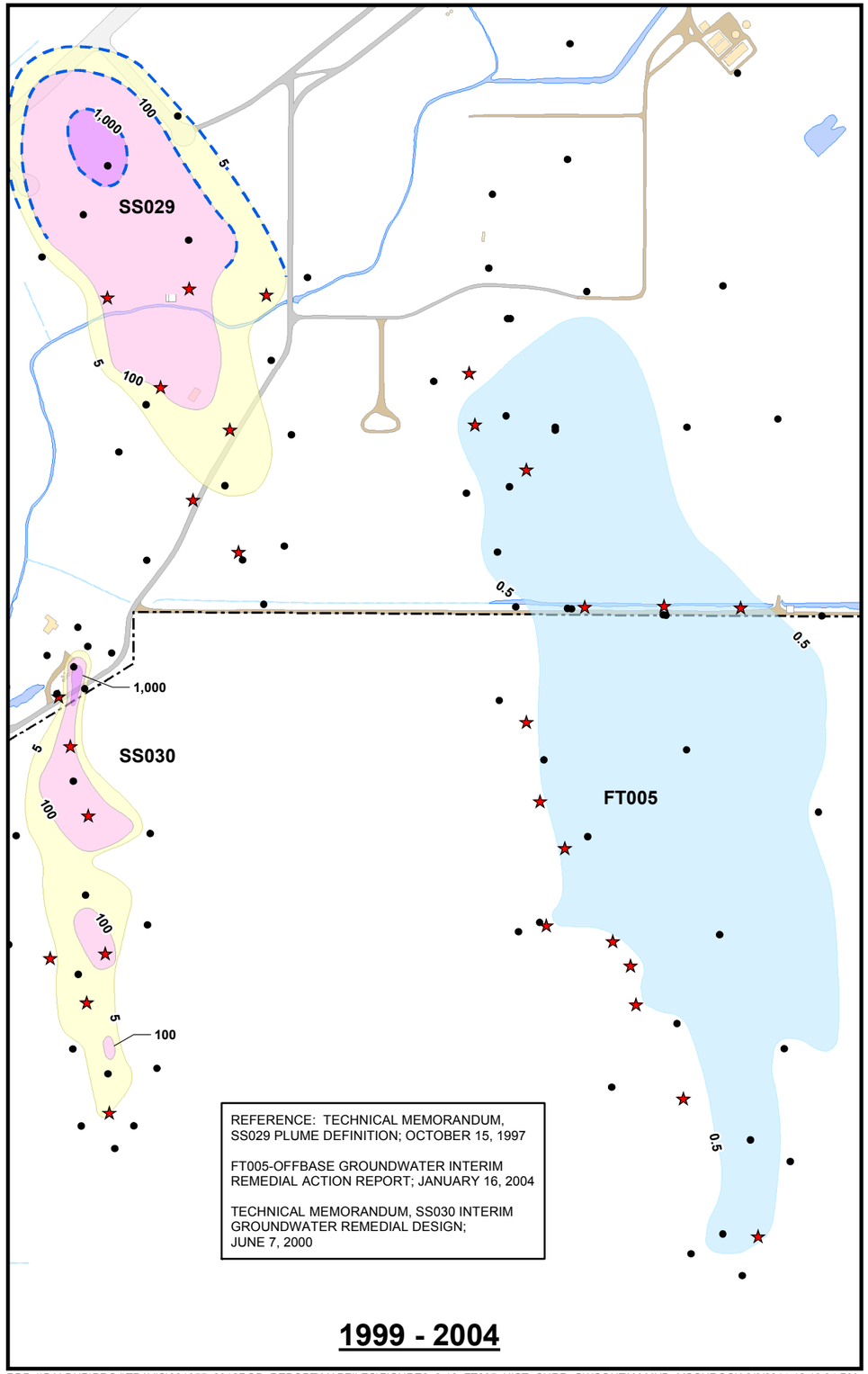
- ALPHA-CHLORDANE ≥ 0.1 µg/L
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 0.1 APPROXIMATE ALPHA CHLORDANE ISOCONCENTRATION CONTOUR (µg/L)
- SURFACE WATER
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD

N

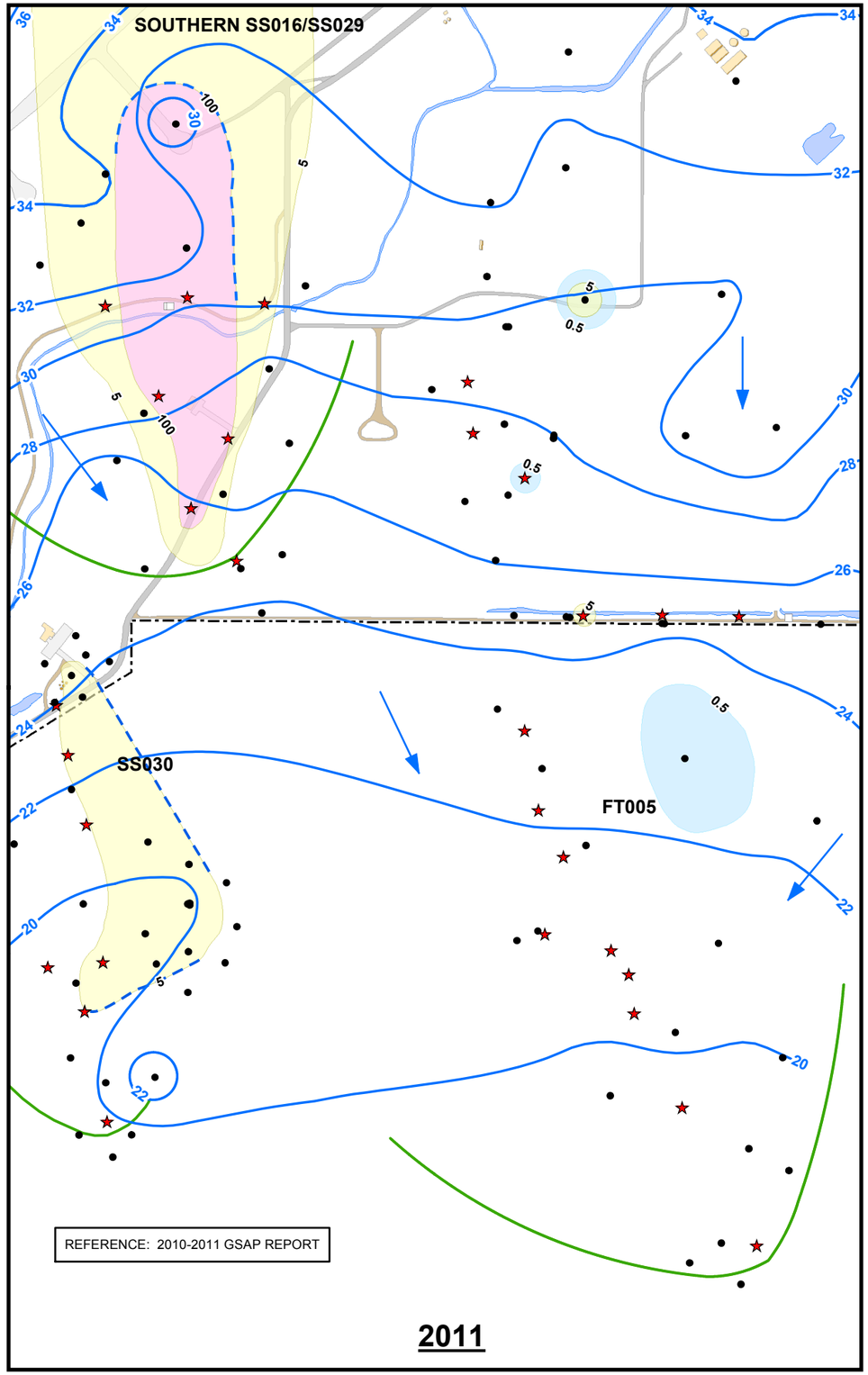
0 50 100 FEET

FIGURE 2.2-9
HISTORICAL AND CURRENT ALPHA-CHLORDANE GROUNDWATER CONTAMINATION - SITE LF008
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

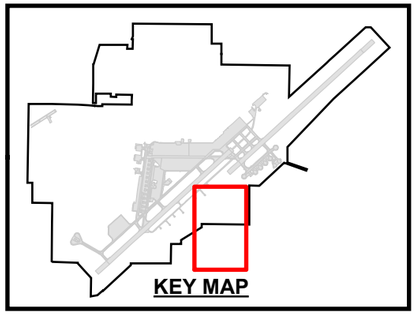
RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-9_LF008_AC_HIST_CURR_GWCONTAM.MXD ECLARK1 5/30/2013 3:03:47 PM



1999 - 2004



2011



LEGEND

- PIEZOMETER
- GROUNDWATER MONITORING WELL
- EXTRACTION WELL

1,2-DCA CONCENTRATIONS (µg/L)

- 1,2-DCA ≥ 0.5 µg/L

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- APPROXIMATE TCE ISOCONCENTRATION CONTOUR (µg/L)
- GROUNDWATER ELEVATION (ft MSL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE (DASHED WHERE LESS CERTAIN)
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- BASE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

N

0 275 550 FEET

FIGURE 2.2-10
HISTORICAL AND CURRENT GROUNDWATER CONTAMINATION - SITES FT005/SS029/SS030
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_2-10_FT005_HIST_CURR_GWCONTAM.MXD MSCHROCK 2/6/2014 12:19:04 PM

2.3 Community Participation

NCP Section 300.430(f)(3) establishes a number of public participation activities that the lead agency must conduct following preparation of the Proposed Plan and review by the support agency. Components of these items and documentation of how each component was satisfied for Travis AFB are described below.

The Proposed Plan was made available to the public on October 10, 2012. The Proposed Plan and other relevant supporting documents, including RI and FS reports, can be found in the Administrative Record file and the Information Repository maintained at the Vacaville Cultural Center Library in Vacaville, California. The Administrative Record file and the Information Repository are updated regularly as documents are finalized so that they are available to the public. The notice of availability for the Proposed Plan was published in the Fairfield *Daily Republic* and Vacaville *Reporter*, newspapers of general circulation on October 12, 2012. Another notice of availability was published in the Travis AFB *Tailwind* on October 12, 2012. Appendix B contains a copy of the notice that was published in all three (3) newspapers.

In addition, the September 2012 edition of the Travis AFB environmental newsletter (the *Guardian*) summarized the purpose of the Proposed Plan, promoted public involvement in the remedy selection process, and advertised the public comment period and public meeting. The *Guardian* was distributed by electronic mail to approximately 50 government and public addresses on October 11, 2012, and by regular mail to approximately 680 government and public addresses in the Travis AFB environmental community involvement mailing list on October 12, 2012.

Finally, the Travis AFB environmental public website advertised the availability of the Proposed Plan, the opportunity to provide public comments on the proposed groundwater remedies, and the invitation to attend the public meeting.

A public comment period was held from October 10 to November 9, 2012. An extension to the public comment period was not requested. In addition, a public meeting was held on October 18, 2012, at the Northern Solano County Association of Realtors building located at 3690 Hilborn Road in Fairfield, California, to present the Proposed Plan to a broader community audience than those who had already been involved at the sites. At this meeting, representatives from the AF answered questions about the sites and the remedial alternatives. A transcript of this meeting has been added to the Administrative Record file and Information Repository.

AF responses to comments received during the public comment period are included in the Responsiveness Summary, which is provided as Section 3 of this ROD.

Other public participation requirements and outreach activities have been performed to maintain and increase public awareness and ensure that there is effective community participation in restoration decisions. Numerous community relations activities have been part of the comprehensive Travis AFB community relations program since 1990 as summarized below:

- **RAB.** In 1994, Travis AFB established a RAB comprising representatives of the community and the regulatory agencies. Through its quarterly meetings and its focus

groups, the RAB has provided valuable input about community concerns regarding the Restoration Program. The Technical Document Review focus group has reviewed and commented on the draft version of every major report. The Relative Risk focus group has provided input on the project prioritization, and the Community Relations focus group is working to reach out to all community members. The RAB replaced the Technical Review Committee, which met periodically to review program progress.

Currently, the RAB meets in April and October of each year. RAB meetings are held at various locations in Fairfield and Vacaville. All meetings are open to the public and are advertised in the Fairfield *Daily Republic,* the Vacaville *Reporter,* and the Travis AFB *Tailwind* at least 1 week in advance. The meeting date and location are also provided on the back cover of the quarterly ERP newsletter, *Guardian*, which is sent to everyone on the mailing list 2 weeks prior to the meeting, and posted on the Travis AFB Environmental Cleanup Program public web site at *http://public.travis.amc.af.mil/enviro.*

- **Administrative Record/Information Repository.** The AF established an Administrative Record to support AF decisions related to the Travis AFB ERP. In addition, the AF established a public information repository for the relevant portion of the Administrative Record at the Vacaville Cultural Center Library. Copies of previously completed RI reports, FS reports, Proposed Plans, IRODs, and RODs are available for public review.

- **CRP.** The AF implemented the first Travis AFB CRP in 1991 as a guideline for conducting community involvement activities associated with the environmental cleanup at Travis AFB. The AF revised the CRP in 1998.

- **CIP.** In August 2001, the CIP replaced the CRP. The AF revised the CIP in 2003 and 2006. The Travis AFB Restoration Program Manager (RPM) maintains the CIP.

- **Mailing List.** Travis AFB maintains a mailing list of all interested government representatives and community members for the distribution of its environmental community involvement products. The mailing list is typically updated after the publication of an environmental quarterly newsletter or on-request. The list was last updated in July 2013 and contains approximately 680 postal addresses and 50 electronic addresses.

- **Fact Sheets and Newsletters.** The AF has been publishing fact sheets describing activities and milestones in the restoration program occasionally since 1993. Since 1995, the AF has published and mailed quarterly newsletters to everyone on the mailing list. The newsletters contain information about public participation, issues of potential concern to the public, and program updates. The RPM writes a Viewpoint article for each newsletter. More information about the Travis AFB Environmental Cleanup Program is available on the public web site at http://www.travis.af.mil/enviro/index.asp.

2.4 Scope and Role of Operable Unit or Response Action

As with many large industrial facilities, the environmental problems at Travis AFB are complex. As a result, in October 1995, the AF, with concurrence from the EPA, the California DTSC, and State Water Board, organized the sites at Travis AFB into two (2) OUs, the NEWIOU and the WABOU. This ROD addresses groundwater contamination at sites within both of these OUs as described below:

- **NEWIOU –** groundwater with chlorinated VOCs, primarily TCE, 1,2-DCE, 1,1-DCE, 1,2-DCA, vinyl chloride, TPH-G, TPH-D, and related compounds originating from Sites FT004, FT005, LF006, LF007, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, and SD037. Site LF007 is divided into three (3) subareas (LF007B, LF007C, and LF007D) to address different COCs.
- **WABOU –** groundwater with chlorinated VOCs (primarily TCE and related compounds) at Sites DP039 and SD043 and organochlorine pesticides (primarily alpha-chlordane) originating from Sites LF008 and SS041.

For more than a decade, Travis AFB has implemented and successfully operated IRAs for groundwater, which were selected in interim RODs (Travis AFB, 1999, 1998). Recent investigations continue to identify chlorinated VOCs and organochlorine pesticides in the groundwater at concentrations above the lowest of either the state or federal primary maximum MCLs. TPH-G and TPH-D also continue to be detected in the groundwater (EPA, 2012). As of 2012, the following contamination was detected:

- Chlorinated VOCs were detected in groundwater at the following concentrations compared with MCLs: TCE at 40,200 µg/L, compared with the MCL of 5 µg/L; 1,1-DCE at 56.7 µg/L, compared with the MCL of 6 µg/L; 1,2-DCA at 5.8 µg/L, compared with the MCL of 0.5 µg/L; cis-1,2-DCE at 8,230 µg/L, compared with the MCL of 6 µg/L; benzene at 7.6 µg/L, compared with the MCL of 1 µg/L; 1,4-DCB at 710 µg/L, compared with the MCL of 5 µg/L; PCE at 212 µg/L, compared with the MCL of 5 µg/L; and vinyl chloride at 1,100 µg/L, compared with the MCL of 0.5 µg/L.
- Organochlorine pesticides were detected in groundwater at the following concentrations compared with MCLs: alpha-chlordane at 0.43 µg/L, compared with the MCL of 0.1 µg/L and heptachlor epoxide at 0.017 J- µg/L, compared with the MCL of 0.01 µg/L.
- TPH-G and TPH-D were detected in groundwater at the following concentrations: TPH-G at 1,200 µg/L and TPH-D at 4,700 µg/L.

On the basis of this groundwater contaminant data, the AF determined that remedial action is necessary to continue to remediate groundwater at Travis AFB and to restore and protect designated beneficial uses (Travis AFB, 2002b). The AF and EPA have jointly evaluated and selected the remedies for groundwater. The California DTSC and San Francisco Bay Regional Water Board concur with the selected remedies.

To address the residual contamination in groundwater that remains after approximately a decade of interim remediation, the overall cleanup strategy for Travis AFB groundwater is to transition from the current interim actions to final remedies. This ROD presents the final response actions for groundwater. Changes, if they occur, to the remedies described in this

ROD will be documented using a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or ROD amendment.

Other environmental media at Travis AFB have previously been addressed in separate decision documents. Final remedies for soil, sediment, and surface water contamination at Travis AFB have been previously selected in the final Soil ROD for the WABOU (Travis AFB, 2002b) and the final NEWIOU Soil, Sediment, and Surface Water ROD (Travis AFB, 2006a).

2.5 Site Characteristics

This section describes the general environmental setting and physical characteristics for Travis AFB, previous site characterization activities, the nature and extent of contamination, and the conceptual exposure model, which are based on information provided in Section 3 of the FFS (CH2M HILL, 2011a), the BIR (CH2M HILL, 2012f), the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a), and four (4) OU-specific RI reports: the WABOU RI Report (CH2M HILL, 1997), the NOU RI Report (Radian, 1995), the EIOU RI Report (Weston, 1995), and the WIOU RI Report (Radian, 1996a).

More complete descriptions of the individual ERP site characteristics are provided in Appendix A. This appendix includes site-specific descriptions of geology, groundwater characteristics, contaminant types and distribution, the nature and status of the IRA, plan view figures, and cross sections.

2.5.1 Physiography and Climate

Travis AFB is located midway between San Francisco and Sacramento, California, on low-lying ground within 1 mile of Suisun Marsh, an estuary of San Francisco Bay. It is located 3 miles east of downtown Fairfield in Solano County. The Base occupies more than 6,000 acres and maintains ownership of, or administrative control over, several properties at off-base locations.

Topography is gently sloping to nearly flat with variations in topographic relief of up to 50 feet. Elevations at Travis AFB range from more than 100 feet above mean sea level (msl), near the northern boundary, to less than 20 feet above msl, near the South Gate. The ground surface generally slopes to the south or southeast at about 30 feet per mile.

Travis AFB has a Mediterranean climate, including wet winters and dry summers, and usually experiences mild temperatures because of its proximity to the Carquinez Straits and the coast. The mean annual temperature is 60 degrees Fahrenheit (°F). The lowest temperatures occur in January, with a mean of 46°F. The highest temperatures occur in July and August, with a mean of 72°F. Monthly mean relative humidity typically ranges from a low of 50 percent in June to a high of 77 percent in January.

Travis AFB averages 17.5 inches of rain annually. Approximately 84 percent of the annual precipitation falls during the winter season of November through March. January is the wettest month, averaging 3.7 inches of precipitation; July is the driest month averaging 0.02 inch of precipitation.

Travis AFB experiences sea breezes during the summer because of its proximity to the Carquinez Straits. The average annual wind speed is 8 knots, with a winter average of 5 to 6 knots and a summer average of 12 knots. The predominant wind directions are from the southwest and west-southwest.

2.5.2 Geology

Travis AFB is characterized by gently sloping alluvial plains and fans overlying undulating bedrock. Older Alluvium makes up most of the sediment found on the Base. Alluvium beneath Travis AFB ranges in thickness from 0 to about 110 feet. The alluvium is underlain

by bedrock consisting of semi-consolidated to consolidated sedimentary units; the alluvium and bedrock are sometimes difficult to distinguish in the field. The alluvium consists primarily of silts and clays that are low in permeability and do not transmit groundwater readily. More permeable units, such as sands and gravels, are geographically restricted and occur as lenses rather than as continuous beds that may be correlated from place to place.

Alluvium was carried in several streams (such as Union Creek) that have migrated laterally across the Base. Coarse sands and gravels are deposited in the streambed and immediately adjacent to the stream levee; finer silts and clays are deposited away from the stream during flood events. Consequently, the discontinuous sand lenses are usually elongated parallel to streams and are contained in an overall matrix of fine-grained silts and clays in the vicinity of Travis AFB. Sand lenses throughout the Base trend south-southeast. These discontinuous permeable zones are preferential pathways that create anisotropic groundwater flow in the horizontal plane.

The bedrock beneath Travis AFB is primarily sandstone and shale. The top of the bedrock unit is weathered to varying degrees and varying thickness. Consequently, bedrock generally becomes increasingly competent with depth. The composition of the most weathered portions reflects the composition of the parent material (sand and silt) and therefore may have similar permeability to the overlying alluvium. No field testing of bedrock permeability has been conducted at the Base, but unweathered bedrock is likely to have much lower permeability than the alluvium.

2.5.3 Hydrogeology

Travis AFB is located along the eastern edge of the Fairfield-Suisun Hydrologic Basin, a hydrologically distinct structural depression adjacent to the Sacramento Valley segment of the Central Valley Province. The primary water-bearing deposits at Travis AFB are the coarse-grained sediments (sand and gravel) within the extremely heterogeneous Older Alluvium and Younger Alluvium. The depth to groundwater at Travis AFB is typically 10 to 15 feet bgs. In general, groundwater elevations have remained relatively constant over time. Groundwater elevations typically fluctuate from 2 to 5 feet between fall and spring, with the maximum elevations in spring and the minimum elevations in fall.

The regional groundwater gradient is generally toward the south or southeast. Groundwater recharge occurs from the direct infiltration of rainfall on the valley surface and from the infiltration of runoff through local streambeds and creek beds. Natural groundwater discharge occurs at the marshlands near Potrero Hills, south of Travis AFB (Thomasson et al., 1960).

The groundwater flow system at Travis AFB is influenced by the configuration of alluvium and bedrock at the Base. Groundwater flow within the alluvium is typically to the south, but there are relatively small and localized variations in the flow direction because of permeability differences between the alluvium and underlying bedrock.

In accordance with the *Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy*), the groundwater at Travis AFB is appropriately categorized as Class IIB – groundwater that is potentially a source for drinking water (EPA, 1986). However, Travis AFB does not currently use the groundwater and has no plans to do so in the future because of the low groundwater quality and low aquifer yields.

2.5.3.1 Aquifer Stratigraphy

The aquifer system underlying Travis AFB should be viewed as a single leaky and heterogeneous aquifer system of unconsolidated alluvium, as opposed to one (1) with multiple and distinct aquifers. The depth to bedrock ranges from a few feet to tens of feet; thus, the saturated thickness of the aquifer is small compared with the length of the groundwater contaminant plumes. It is not usually possible to predict with confidence where the more permeable sand lenses may be encountered or interconnected.

The saturated alluvium thickness at Travis AFB averages approximately 28 feet. However, localized thicknesses of up to about 100 feet are found in the vicinity of Site SD036.

2.5.3.2 Groundwater Flow Velocity

Groundwater at Travis AFB is found under unconfined or semi-confined conditions and flows in a predominantly horizontal direction. Typical groundwater flow rates in the alluvium in the Base area are on the order of 100 to 200 feet per year (ft/year), assuming an effective porosity of 20 percent, which is typical for the fine-grained sediments encountered at the Base.

2.5.3.3 Horizontal and Vertical Gradients

The following subsections briefly describe the groundwater horizontal and vertical gradients at Travis AFB. More complete information is provided in annual GSAP reports and GRISRs.

Groundwater at Travis AFB flows primarily south, except where groundwater mounds or depressions exist. Local variations in flow direction are the result of the subsurface geology and groundwater pumping. Typically, the horizontal gradients in the alluvium at Travis AFB range from 0.004 to 0.008 feet per foot (ft/ft). Where groundwater mounds exist, the localized horizontal gradients are relatively steep (approximately 0.02 ft/ft) when compared with the horizontal gradients in the alluvial basins away from the mounds. The horizontal gradients typically observed in bedrock are approximately 0.01 ft/ft. In general, the magnitudes of vertical gradients in the alluvium at Travis AFB are less than 0.1 ft/ft. Few data are available regarding the vertical gradient between bedrock and alluvium. Almost all of the monitoring wells at Travis AFB are screened within the permeable zones of the alluvium. In one (1) well pair, the vertical gradient was approximately 0.00 ft/ft.

2.5.3.4 Current and Anticipated Future Groundwater Use

Travis AFB overlies the Suisun-Fairfield Valley groundwater basin. According to the Basin Plan (San Francisco Bay Regional Water Board, 2011), beneficial uses for groundwater in the Suisun-Fairfield Valley groundwater basin are municipal and domestic water supply, industrial process and industrial service water supply, and agricultural water supply.

Approximately 3,562 acre-feet per year of groundwater are pumped for agricultural use from the Suisun-Fairfield Valley groundwater basin. Although there are 15 public water supply wells within the Suisun-Fairfield Valley groundwater basin, they do not serve a municipal population. The nearest city to Travis AFB is Fairfield, California, which uses surface water rather than groundwater for their municipal water supply. Downtown Fairfield is located west of Travis AFB. Downgradient of Travis AFB is the brackish water of Suisun Marsh.

No on-base wells are currently used for potable water production at Travis AFB, and none are planned for the future. Currently, one (1) privately owned domestic water well (DWSET1x30) is located at the southern extent of Site SS030. No COCs originating from Travis AFB have been detected in this well. It has been sampled semiannually for VOCs under the Travis AFB GSAP (now GRIP). The amount and rate of groundwater production from this privately owned well is unknown, because no flow meter is installed.

Approximately 90 percent of the water used at Travis AFB is surface water originating from Lake Berryessa and Lake Oroville. This water is conveyed to a water treatment facility managed by the City of Vallejo, which provides potable water to the Base. Three (3) groundwater production wells located at the Cypress Lakes Golf Course Annex provide the remaining 10 percent of the Base water supply. These production wells are located approximately 3 miles north of Travis AFB and are hydraulically separate from the Base.

In the future, it is anticipated that the Base water will be entirely supplied by production wells located at the Cypress Lakes Golf Course Annex, and the current service from the City of Vallejo will be discontinued (Weston, 2011).

2.5.4 Surface Water

Surface water features at Travis AFB include Union Creek and a network of underground pipes, culverts, and open drainage ditches. This surface water collection system divides the Base into eight (8) independent drainage areas. The head-waters of Union Creek are located approximately 1 mile north of the Base, near the Vaca Mountains, where the creek is an intermittent stream. Union Creek splits into two (2) branches north of the Base (the Main Branch and the West Branch). As it enters Travis AFB, the Main (eastern) Branch is impounded into a recreational pond designated as the Duck Pond. At the exit from the Duck Pond, the creek is routed through an underground storm drain pipe to the southeastern area of the Base, where it empties into an open channel.

The West Branch of Union Creek flows south and enters the northwestern border of Travis AFB east of the David Grant Medical Center in an excavated channel. This channel flows south to the northeastern corner of the WABOU. The channel forms the boundary between the WIOU and the WABOU and parallels Ragsdale Street for about 4,000 feet. Flow in the channel is then directed to a culvert under the runway and discharges to the main channel of Union Creek at Outfall II. From Outfall II, Union Creek flows southwest and discharges into Hill Slough, a wetland located 1.6 miles from the Base boundary. Surface water from Hill Slough flows into Suisun Marsh.

Local drainage patterns have been substantially altered within the Base by the rerouting of Union Creek, the construction of the aircraft runway and apron, the installation of storm drain pipes and ditches, and general development (e.g., the Base Exchange, industrial shops, maintenance yards, roads, housing, and other facilities).

The eastern portion of the Base is served by one (1) of the drainage systems that collects runoff from along the runway and the inactive sewage treatment plant area and directs it to Denverton Creek and Denverton Slough. Denverton Creek is an intermittent stream near the Base. The northwestern portion of the WABOU drains to the west toward the McCoy Creek drainage area. McCoy Creek is also an intermittent stream near the Base. With the exception of these drainages, the remaining six (6) drainage areas at the Base empty into Union Creek.

2.5.5 Ecology

Travis AFB has a variety of terrestrial and aquatic/wetland habitats and wildlife that are typical of the region.

2.5.5.1 Vegetation

The terrestrial habitats at Travis AFB and adjacent areas consist of herbaceous-dominated habitats (annual grassland, pasture, and early ruderal habitat) and urban habitat (industrial areas, lawns, and ornamental plants) (Mayer and Laudenslayer, 1988).

In general, annual grassland habitat is dominated by non-native plant species. Some native plants may also be found, usually associated with undisturbed areas.

Aquatic/wetland habitats at Travis AFB include riverine (Union Creek) and riparian habitat, lacustrine (Duck Pond), and herbaceous-dominated wetlands, marshes, and vernal pools. Herbaceous wetland vegetation is found along the permanent (natural or artificial) drainages on-base and can also occur seasonally within vernal pools, swales, and ditches.

The vernal wetlands are concentrated along the western, southern, and southeastern boundaries of the Base.

Vernal pools at Travis AFB contain indicator species such as goldfields, coyote thistle, dwarf woolly-heads, water pygmy-weed, and one (1) or more species of downingia and popcornflower.

2.5.5.2 Wildlife

Terrestrial vertebrates associated with non-native annual grasslands are commonly found on Travis AFB. Typical avian species include ring-necked pheasant, American kestrel, American robin, and the western meadowlark. Reptiles observed, or potentially occurring, at the Base include the western fence lizard, gopher snake, and California red-sided garter snake. Common mammals identified include deer mouse, California ground squirrel, Botta's pocket gopher, black-tailed hare, and red fox.

Permanent wetlands and seasonally wet areas support aquatic invertebrates, fish, amphibians, reptiles, birds, and mammals. Some aquatic invertebrate species observed in herbaceous wetlands and vernal pools at Travis AFB include vernal pool fairy shrimp, damselflies, crayfish, and aquatic snails. Amphibian species identified include bullfrog, Pacific tree frog, and California tiger salamander. Aquatic birds observed on or near the Base include mallard, great egret, and great blue heron.

Many aquatic invertebrates and amphibians also use riverine and riparian habitats. These include damselflies, crayfish, aquatic snail, bullfrog, Pacific tree frog, and California tiger salamander. Fish species include mosquitofish, fathead minnow, threespine stickleback, and bluegill. Riverine/riparian habitats are also used extensively by birds and terrestrial mammals for forage, shelter, and as a source of water. These include red-winged blackbird, raccoon, muskrat, and beaver.

Habitats that support special-status species are considered sensitive habitats. Sensitive aquatic/wetland areas include vernal pools, swales, and ditches that can support special-status plants and animals. Urban environments, scattered throughout the Base, can

also support special-status species. Burrowing owls may use man-made culverts, perches, and bare earth areas that contain burrows provided by ground squirrels. Loggerhead shrikes may nest on antenna wires and forage in grasslands. Also, vernal pool fairy shrimp have been found in artificially created depressions that seasonally fill with water.

2.5.6 Previous Site Characterization Activities

Data characterizing groundwater at Travis AFB have been collected during previous site activities from 1983 to the present. These include a PA/SI, RIs completed in the mid-1990s to support development of interim remedial alternatives in two (2) FSs, IRAs initiated in 1998 and 1999, subsequent measures implemented to optimize the IRAs, technology studies and demonstrations, MNA assessments, and a vapor intrusion assessment (see Section 2.2). Groundwater sampling is also conducted under the Travis AFB GSAP and GRIP. This additional information was used to support development of remedial alternatives for groundwater in the FFS (CH2M HILL, 2011a).

A summary of these investigations is provided in Table 2.5-1, and a detailed history is included in the following reports:

- WIOU RI Report (Radian, 1996a)
- NOU RI Report (Radian, 1995)
- EIOU RI Report (Weston, 1995)
- WABOU RI Report (CH2M HILL, 1997)
- NEWIOU Groundwater IROD (Travis AFB, 1998)
- WABOU Groundwater IROD (Travis AFB, 1999)
- NAAR (CH2M HILL, 2010b)
- *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)
- *Technical Report: Phytostabilization at Travis Air Force Base, California* (Parsons, 2010)
- Section 3 of the FFS (CH2M HILL, 2011a)
- GSAP 2010-2011 Annual Report (CH2M HILL, 2012a)
- BIR (CH2M HILL, 2012f)
- 2011 Annual RPO Report (CH2M HILL, 2012d)
- *Site LF007C Data Gaps Results Technical Memorandum* (CH2M HILL, 2012e)
- *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b)
- *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a)
- *2012 Groundwater Sampling and Analysis Program Technical Memorandum* (CH2M HILL, 2012g)

2.5.7 Nature and Extent of Contamination

COCs in groundwater at Travis AFB have resulted from releases of liquid solvents from past waste management and disposal practices (see Figure 2.2-2). The most significant contaminant release mechanism to groundwater is deep percolation of the liquid solvents downward, and laterally along preferential pathways, through the vadose zone and into the saturated zone. The depth to groundwater at Travis AFB is relatively shallow at approximately 10 to 15 feet bgs. Contaminants released at the ground surface have readily migrated through this shallow vadose zone and into the groundwater.

Potential secondary sources of groundwater contamination at Travis AFB include DNAPLs and a LNAPL. Relatively high dissolved-phase contaminant concentrations indicate that DNAPLs are probably present in portions of the plumes at Sites SS015, SS016, SD036, SD037, and DP039. Free-phase Stoddard solvent, an LNAPL containing dissolved COCs, is intermittently observed floating on the groundwater table at Site SD034. Additional information on the distribution of groundwater contamination at each site is provided in Appendix A – Conceptual Site Models.

It is difficult to verify the presence of DNAPLs through direct observation. Generally, their presence is indirectly estimated. One (1) approach to evaluating the possible presence of DNAPL is based on groundwater concentration data and the "1 percent of solubility" rule-of-thumb (EPA, 1992). Under this approach, DNAPL is suspected to be present when the concentration of a chemical in groundwater is greater than 1 percent of its pure-phase solubility. For example, if the concentration of TCE is greater than 14,720 µg/L in the dissolved phase (i.e., 1 percent of its pure-phase solubility of 1,472,000 µg/L), then TCE is inferred to be present as a DNAPL (EPA, 2004b). Another rule-of-thumb proposes a value of 10 percent of pure-phase solubility (Feenstra and Cherry, 1988). Taking these rules-of-thumb together, the likelihood of DNAPL contributing to the dissolved-phase plume can be summarized as follows: In cases where the maximum concentration of a COC exceeds 10 percent of its solubility, then DNAPL may be assumed to be contributing to the plume. If the maximum concentrations fall between 1 and 10 percent, then DNAPL may possibly be contributing to the plume. But, if the maximum concentration is less than 1 percent of solubility, then DNAPL can be assumed not to be present or not contributing to the plume.

However, in addition to these rules-of-thumb, it must be considered that DNAPL can remain as a residual liquid within the aquifer's soil pore spaces or it can diffuse into low permeability clays and silts. This diffused DNAPL can then act as a residual source of contamination to groundwater, even though the resultant groundwater concentrations may be lower than typically expected near the source (Cherry, 1996). These aqueous concentrations may be from 1,000 µg/L or greater. At Travis AFB, the aquifer is dominated by fine-grained silts and clays, and DNAPL has likely diffused into the finer-grained soils (Travis AFB, 1998). Therefore, a more appropriate and conservative rule-of-thumb under the conditions that exist at Travis AFB is to assume DNAPLs are contributing to a plume when the concentration of a COC is 1,000 µg/L or greater. During the period of interim remediation, these concentrations existed at Sites SS015, SS016, SD036, SD037, and DP039. Long-term operation of interim GET systems and/or the ERD treatment demonstrations implemented since 2008 using bioreactors and/or EVO injections at these sites have already reduced the highest concentrations of contaminants. Summaries of the historical and current maximum concentrations of COCs at each site are provided in Table 2.5-2 and in Appendix A.

Groundwater, soil, and soil gas sampling results from four (4) OU-specific RIs (Weston, 1995; Radian 1995, 1996a; CH2M HILL, 1997) indicate relatively low levels of VOC contamination in the soil and soil gas at the ERP sites, while the groundwater has significantly higher concentrations of contamination. No significant VOC soil contamination was found during the RI sampling, and the low levels detected are not expected to adversely impact the groundwater. Concentrations of VOCs in soil and soil gas are consistent with models of diffusion and adsorption from associated groundwater plumes, indicating that the VOC contamination in the soil and soil gas is a result of the underlying contaminated groundwater plume (Travis AFB, 2006a).

Groundwater plumes are typically characterized by chlorinated VOCs (primarily dissolved-phase TCE and related VOCs, including breakdown products) and organochlorine pesticides. The highest concentration of TCE detected in groundwater during 2010-2011 was 182,000 µg/L at Site SS016. Concentrations of TCE exceeding 10,000 µg/L were detected at Site SD036. TCE was detected at concentrations greater than ten (10) times the MCL of 5 µg/L at Sites FT004, SS015, SS016, ST027B, SS029, SS030, SD033, SD036, SD037, and DP039. Site-specific lists of COCs and summaries of the nature and extent of COCs for each of the groundwater plumes are provided in Table 2.5-2. More detailed descriptions of the nature and extent of groundwater contamination at each site are provided in the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a) and in Section 3 of the FFS (CH2M HILL, 2011a).

2.5.7.1 High-concentration Portion of Plumes

DNAPL is likely present within the higher concentration portions of the Site SS015, SS016, SD036, SD037, and DP039 contaminant plumes, where relatively large-volume releases of TCE may have infiltrated through soils following the path of largest pore size or fracture aperture and affected groundwater. This typically results in sparse horizontal pools and vertical fingers of DNAPL (Kueper et al., 1989; Cohen et al., 1994). Generally, the volume of DNAPL pools and fingers near the release site is approximately 0.01 to 0.0001 of the overall source zone volume (Sale, 1998).

While DNAPL is present, groundwater moving under the hydraulic gradient will slowly erode the DNAPL pool and carry high-concentration, dissolved-phase contaminants into the hydraulically downgradient portions of the aquifer. Some DNAPLs are probably still present within the higher concentration portions of the Site SS015, SS016, SD036, SD037, and DP039 plumes even after approximately a decade of interim remediation and implementation of treatment demonstrations.

The dissolved high-concentration plume originating from a DNAPL source initially moves through the higher permeability sand seams within the overall silt and clay soil matrix. As the plume expands and eventually stabilizes, the high contaminant concentrations found within the sand seams move into the lower permeability silts and clays. After the entire DNAPL source zone has dissolved into the groundwater (typically decades), the dissolved contaminant concentrations will decline rapidly within the permeable sand seams. However, the contamination residing in the low-permeability silts and clays is then released into the sand seams. This process is driven strictly by contaminant concentration differences between the silts/clays and the sand. The process is both slow and occurs at an ever-decreasing rate. Even after apparent "remediation" of the groundwater contained within the permeable sand seams, contamination is still present within the low-permeability

silt/clay. This contamination will slowly emerge from the silt/clay and be a long-term source of contamination into the sand seams.

There are a number of challenges associated with the treatment of DNAPLs. These include the effectiveness of partial source removal, uncertainties in the location and quantity of DNAPL in the subsurface, limited availability of performance and cost data for using innovative technologies to treat DNAPLs, and uncertainties about the long-term effectiveness of DNAPL source reduction. There is an ongoing debate within the remediation community regarding the utility of partial source removal or reduction, where some but not all of the DNAPL source is removed or destroyed. Although EPA policy generally supports active attention to sources (EPA, 1993, 1999, 2002), the published results of modeling and/or laboratory-scale column studies suggest that almost all DNAPL must be removed before site risks are significantly reduced, at least in the short term (Freeze and McWhorter, 1997; Sale and McWhorter, 2001; EPA, 2004b).

LNAPL is present within the higher concentration portion of Site SD034. Stoddard solvent free product is intermittently detected floating on the groundwater table in one (1) site monitoring well. During the second quarter of 2011, Stoddard solvent was measured in only one (1) well at a thickness of 0.44 foot (CH2M HILL, 2012a).

Stoddard solvent (aka PD-680) is a petroleum distillate mixture (i.e., a mineral spirit) of 15 percent trimethylbenzene and 85 percent n-nonane with boiling point characteristics between those of common gasoline and common diesel fuels (CH2M HILL, 1999). Neither of the main constituent compounds of pure Stoddard solvent have a primary State of California or federal MCL. However, the Stoddard solvent at Site SD034 is a non-aqueous medium also containing dissolved-phase COCs at concentrations above MCLs. Previous characterization of the floating Stoddard solvent detected a cis-1,2-DCE concentration of 7,200 µg/L (CH2M HILL, 1999). The chlorinated VOCs, such as cis-1,2-DCE, and other chemicals contained in the free product matrix will dissolve into the surrounding groundwater over time and pose a continuing source of dissolved-phase groundwater contamination.

2.5.7.2 Downgradient Plumes

The dominant loss and transport mechanisms that govern downgradient, aqueous-phase dissolved plumes differ from those discussed above for the higher concentration portions of the plumes with DNAPL.

In downgradient plumes, no steep concentration gradient as described above for higher concentration portions of the plumes occurs. Instead, a combination of physical, chemical, and biological contaminant-loss mechanisms, also referred to as natural attenuation processes, begin to dominate contaminant fate and transport and lead to the eventual stabilization of the plume. The ultimate configuration of the dissolved plume downgradient of the higher concentration portions of the plume is dependent on the collective influences of the processes of adsorption, diffusion, dispersion, biodegradation, and heterogeneity of aquifer properties. These processes are described briefly in this section. For additional information, refer to the *Natural Attenuation Assessment Plan* (NAAP) (CH2M HILL, 1998b). Most of the plumes at Travis AFB are best described as downgradient, dissolved-phase plumes, including those at Sites FT004, FT005, and LF006; Subareas LF007B, LF007C, and LF007D; and Sites LF008, ST027B, SS029, SS030, SD031, SD033, SS035, SS041, and SD043.

The remaining sites have a high concentration plume component associated with a lower concentration downgradient plume component, including those at Sites SS015, SS016, SD034, SD036, SD037, and DP039.

As dissolved solvents migrate with the groundwater, a portion of the contaminants may adsorb to organic materials in the soil matrix, and thus become fixed to the soil particle surface. Adsorption is not an irreversible process; as groundwater moves through the aquifer matrix, contaminants may desorb back into groundwater.

The portion of the contaminant that is sorbed to soil and not migrating is said to be "retarded." The extent of retardation is a function of the properties of both the chemical contaminant and the soil. While this process does not actively destroy contaminant mass, if the rate of migration is retarded to a significant degree, biodegradation processes will have more time to act on the contaminant plume and degrade the contaminant of interest.

Molecular diffusion attempts to equalize solute concentrations by moving solute from high concentration zones to low concentration zones. The driving force for diffusion is differential concentrations, and the effect of diffusion is to increase the volume of contaminated groundwater, while decreasing the concentration. Diffusion is generally a slow process but may be significant in systems where the groundwater velocity is low, as is the case at many sites at Travis AFB.

Hydrodynamic dispersion tends to spread, or disperse, the solute front as it moves through the aquifer. Spreading in the direction of flow is referred to as longitudinal dispersion, which usually has a much stronger influence than spreading perpendicular to the direction of flow, or transverse dispersion (Freeze and Cherry, 1979). Dispersion also occurs because of variability in the hydraulic properties of the saturated soil present at a particular site (Gelhar et al., 1992). At Travis AFB, the complex geometry of the more permeable sand lenses occurring within the lower-permeability silt and clay alluvial matrix almost certainly results in additional spreading of migrating contaminant plumes.

Biodegradation of chlorinated compounds typically proceeds through reductive dehalogenation, but may also occur through electron donor reactions and cometabolism. Reductive dehalogenation occurs anaerobically and results in the degradation of the chlorinated compounds found in Travis AFB groundwater such as PCE, TCE, 1,2-DCE, and vinyl chloride. These processes are described in detail in the NAAP (CH2M HILL, 1998b) and NAAR (CH2M HILL, 2010b). More detailed discussions on the processes of aerobic cometabolism are provided in the *Work Plan for the Assessment of Aerobic Chlorinated Cometabolism Enzymes* (CH2M HILL, 2012c) and in the *Technical Memorandum for Assessment of Aerobic Chlorinated Cometabolism Enzymes at Travis Air Force Base, California* (CH2M HILL, 2012b).

If biodegradation is occurring at rates that are significant with respect to the movement of contamination through the aquifer, then this process can ultimately balance with the migration of the plume and lead to a plume that is stable in configuration over time. In the absence of significant degradation rates, dispersion and dilution will ultimately lead to a stable plume. However, the influence of these processes is limited, and plumes stabilized by these processes will likely have a much greater areal extent than those limited by biodegradation processes. If the aquifer downgradient of the DNAPL source has large differences in permeability, such as high-permeability sand layers acting as preferential

pathways for contaminant movement within a low permeability silt/clay matrix, then this characteristic may significantly influence the distribution of contamination in the downgradient plume.

Three (3)-dimensional, finite element computer modeling of contaminant transport was conducted using MicroFEM® software during development of the site-specific interim GET systems designs. After implementation of the IRAs, an empirical approach was taken for evaluating the long-term performance of the interim GET systems and MNA assessments. For over a decade, groundwater performance monitoring data was collected and evaluated under the GSAP in lieu of specific fate and transport modeling.

2.5.8 Conceptual Site Model

Conceptual site models were developed during the RI/FS to depict the potential relationship or exposure pathway between chemical sources and receptors. The relationships and pathways are shown on Figure 2.5-1. More complete descriptions are provided in the following reports:

- NOU RI Report (Radian, 1995) – Site LF006 and Subareas LF007B, LF007C, and LF007D
- EIOU RI Report (Weston, 1995) – Sites FT004, FT005, SS015, SS016, SS029, SS030, and SD031
- WIOU RI Report (Radian, 1996a) – Sites SD033, SD034, SS035, SD036, and SD037
- WABOU RI Report (CH2M HILL, 1997) – Sites LF008, DP039, SS041, and SD043
- *Site ST027-Area B Human Health Risk Assessment* (CH2M HILL, 2011c) – Site ST027B

An exposure pathway describes the means by which a receptor can be exposed to contaminants in environmental media. These pathways are based on current and potential future land uses and potential beneficial uses of groundwater at Travis AFB. Based on currently available information, the most plausible current or future human receptor populations that may contact COCs in groundwater consist of an on-base or hypothetical off-base industrial worker and a hypothetical on-base or off-base resident. Although future residential land use at Travis AFB is unlikely, a hypothetical future residential land use was also evaluated to support risk management decisions. Contaminated groundwater does not currently underlie any on-base residential areas. Based on current and potential future land uses at Travis AFB and in the area immediately surrounding it, the following potentially complete human exposure pathways and routes were considered for characterizing human health risks from groundwater on- and off-base:

- **Future Industrial Worker:** Inhalation of volatiles migrating from groundwater into ambient and indoor air.
- **Hypothetical Future Resident:** Ingestion of groundwater, dermal contact with groundwater, inhalation of volatiles during showering or other household activities, and inhalation of volatiles migrating from groundwater into indoor air.

No ecological receptors of concern were identified for groundwater.

No water supply wells are, nor are projected to be, threatened. Data indicate that the plumes are stable. The Site FT005, Subarea LF007C, and Site SS030 plumes extend off-base, but are not threatening water supply wells. No other plumes are migrating off-base.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
PA/SI	1983-1986, AF	Records search and interviews with past and present Base employees who were familiar with past disposal practices. Additional interviews were conducted with local, state, and other federal agency personnel. Included field and helicopter reconnaissance.
RCRA Facilities Assessment	1991, AF	Environmental inspections at current and active facilities to identify manufacturing processes and potential avenues for contaminant releases to the environment.
PA/SI	1993-1994, Jacobs	A secondary PA/SI focused on the former Fairfield Air Station within the boundaries of Travis AFB. Also included annexes not adequately evaluated during previous investigations and more recently identified areas of concern. Sites were subsequently grouped into four (4) OUs (NOU, EIOU, WIOU, and WABOU), based on the geographic location within the Base and the source and nature of the suspected contaminants.
NOU RI	1995, Radian	Soil, sediment, soil vapor, and groundwater investigations within the NOU component of the NEWIOU. Included investigations at Sites FT004, LF006, and LF007. The main finding of the NOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
EIOU RI	1995, Weston	Soil, sediment, soil vapor, and groundwater investigations within the EIOU component of the NEWIOU. Included investigations at Sites FT004, FT005, SS015, SS016, SS029, SS030, and SD031. The main finding of the EIOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
WIOU RI	1995, Radian	Soil, sediment, soil vapor, and groundwater investigations within the WIOU component of the NEWIOU. Included investigations at Sites SD033, SD034, SS035, SD036, and SD037. The main finding of the WIOU RI was that groundwater was contaminated with chlorinated VOCs and petroleum-fuel constituents.
WABOU RI	1997, CH2M HILL	Soil, sediment, soil vapor, and groundwater investigations at WABOU Sites LF008, DP039, SS041, and SD043. The main finding of the WABOU RI was that groundwater was contaminated with chlorinated VOCs and organochlorine pesticides.
Groundwater IRAs	1998-present; CH2M HILL, GTI, OHM, URS	Groundwater IRAs at all ERP sites conducted in accordance with the NEWIOU and WABOU Groundwater IRODs. Included installation and long-term O&M of site-specific GET systems, MNA assessments, and GET systems combined with MNA assessments.
Phytostabilization Treatability Study	1998-2005, Parsons	Soil, soil vapor, and groundwater characterization conducted as part of a study of biological remediation using planted trees at Site DP039. Although the treatability study has concluded, the trees remain at the site and groundwater contamination continues to be monitored as part of an ongoing demonstration of phytoremediation processes.
Site SS015 Vegetable Oil Injection Field Treatability Study	2000-2001, Parsons	Groundwater characterization conducted as part of a limited treatability study to evaluate the feasibility of ERD facilitated by injection of soybean oil within a high concentration portion of the Site SS015 contaminant plume. The study was terminated early because of a military construction project at the site, but the findings indicated that bioremediation was taking place.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
Vapor Intrusion Assessment	2008-2009, CH2M HILL	Characterization of soil vapor and air conducted as part of assessments of potential human health risks posed by soil vapors emanating from contaminated groundwater into building interiors. Included monitoring of shallow soil gas, soil vapor under building floor subslabs, building indoor air, and outdoor air.
Vapor Intrusion Assessment Update	2013, CH2M HILL	Provides an update to the *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a). Addresses changes to the toxicity values for several chemicals, including TCE.
Site DP039 Data Gaps Investigation and ERD Treatment Demonstrations via Bioreactor EVO Injection	2008-2010, CH2M HILL	Groundwater investigation to support a demonstration of ERD treatment via an in situ bioreactor and EVO injection. Included installation of a demonstration bioreactor and modifying the existing GET system with a solar-powered groundwater circulation system to irrigate the bioreactor. Also included installation of injection wells and injection of EVO in a linear configuration to create a PRB. Performance monitoring of the bioreactor and EVO PRB is ongoing.
Site ST027B Data Gaps Investigation	2009, CH2M HILL	Groundwater and soil vapor characterization to further clarify the nature and extent of chlorinated VOC contamination and support development of human health and ecological risk assessments. Additional characterization was needed because previous investigations had identified only petroleum-fuel constituents and the entirety of the site was managed under the Travis AFB POCO program. No risk assessments were required under the POCO program. In 2007-2008, TCE was detected in a portion of plume. This portion of the plume was subsequently designated as Site ST027B and is now managed as an ERP site.
Site SD036 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater and soil characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SD036 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SD037 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SD037 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SS015 Data Gaps Investigation and ERD Treatment Demonstration via EVO Injection	2010, CH2M HILL	Groundwater and soil characterization to support a demonstration of ERD treatment via injection of EVO. Included installation of groundwater monitoring wells, EVO injection wells, and injection of EVO within a high concentration portion of the Site SS015 contaminant plume. Performance monitoring of the ERD treatment demonstration is ongoing.
Site SS016 Data Gaps Investigation, GET System RPO, and ERD Treatment Demonstration via Bioreactor	2010, CH2M HILL	Groundwater characterization to support a demonstration of ERD treatment via an in situ bioreactor. Included installation of a demonstration bioreactor, modifying the existing GET system with a solar-powered groundwater circulation system to irrigate the bioreactor, and installation of groundwater monitoring wells. Performance monitoring of the ERD treatment demonstration is ongoing.

TABLE 2.5-1
Previous Site Investigation and Remediation Activities
Groundwater Record of Decision, Travis Air Force Base, California

Investigation or Remediation Activity	Year, Contractor	Summary
Site SS030 Data Gaps Investigation and GET System RPO	2010-2013, CH2M HILL	Groundwater characterization conducted to support improved hydraulic capture of the Site SS030 plume using the existing GET system. Included collection of in situ groundwater samples and installation of groundwater monitoring wells.
Subarea LF007C Data Gaps Investigation and GET System RPO	2011-2013 (ongoing), CH2M HILL	Groundwater characterization conducted to support optimization of the existing GET system. Included installation of groundwater monitoring wells, installation of solar-powered groundwater extraction wells, and modifications to the solar power supply.
Aerobic Chlorinated Cometabolism Enzyme Study	2012, CH2M HILL	Groundwater characterization conducted to assess the biological component of MNA contributed by aerobic chlorinated cometabolism.
Travis AFB GSAP/GRIP	Ongoing, CH2M HILL	Long-term collection of groundwater monitoring well samples and groundwater elevations. Includes off-base laboratory analyses, data validation, and reporting. Beginning in 2013, the Travis AFB GSAP transitioned to the GRIP. The findings of the groundwater monitoring program are now documented in an annual GRISR. The GRISR also documents the findings of the LTO&M program.
2012 GSAP Technical Memorandum	2012, CH2M HILL	Provides the analytical data collected during the second quarter 2012 GSAP monitoring event in the absence of a 2011-2012 Annual GSAP Report. Also, documents the results of a study of the nature of pesticide contamination at Site LF008 and provides an updated estimate of the RTF for groundwater contamination at Subarea LF007D.
LTO&M	Ongoing, CH2M HILL	LTO&M of interim remediation system infrastructure, including groundwater monitoring wells, extraction wells, injection wells, bioreactors, conveyance systems, and treatment plants. Includes collection of treatment process flow samples, off-base laboratory analyses, data validation, and reporting. Beginning in 2013, the Travis AFB LTO&M program transitioned to the GRIP. The findings of the LTO&M program are documented in an annual GRISR. The GRISR also documents the findings of the LTO&M program.

Notes:

LTO&M = long-term operations and maintenance
RCRA = Resource Conservation and Recovery Act

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L) Historical Maximum[a,b] (pre-IRA)	Concentration (µg/L) Current Maximum[c] (2010 to 2011)	Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
FT004	Historical practices during fire training exercises conducted between approximately 1953 and 1962. During this period, waste fuels, oils, and solvents were burned on open ground.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**5,200**	**204 J-**	TCE plume approximate dimensions: Length: 950 feet Width: 250 feet Thickness: 30 feet	250,893 ft^2 1,455,170 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. A rebound study began in December 2007 and included select extraction wells. In February 2009, the remaining extraction wells were taken offline. Data obtained during the study did not indicate significant plume migration when GET system operations were discontinued.
			cis-1,2-DCE	**60.5**	**12.6 J+**			
			1,2-DCA	**5.12**	ND			
			Chloroform	15	3.8			
			Bromodichloromethane	5.7	0.73 J-			
			1,1-DCE	**42**	0.77			
			Vinyl chloride	**43.7**	**14.8**			
			1,4-DCB	3.8	ND			
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**21**	-[e]			
		Metals	Nickel[f]	**6,270**	-[f]			
					Results during shutdown of IRA GET system for rebound study.			
FT005	Historical practices during fire training exercises conducted between approximately 1962 and 1987. During this period, waste fuels, oils, and solvents were burned on open ground.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**160**	**5.6 J-**	1,2-DCA plume approximate dimensions: Length: 600 feet Width: 400 feet Thickness: 25 to 30 feet The majority of the contaminant plume extends to off-base privately owned property.	1,258,142 ft^2 11,323,278 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. A recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2007. Recently observed increases in the concentrations of COCs at some wells indicate that continuation of GET system operation within those portions of the plumes with increasing concentrations is warranted to prevent possible future migration. Therefore, selected extraction wells continue to operate on an as-warranted basis.
			1,2-DCA	**14.2**	**5.8**			
			cis-1,2-DCE	**19**	0.48 J-			
			Chloroform	10	0.29 J-			
			Bromodichloromethane	2.0	ND			
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**50.3**	-[e]			
		Metals	Nickel[f]	**4,270**	-[f]			
					Results during shutdown of IRA GET system for rebound study.			
LF006	A historical general refuse landfill that used trench and cover methods from approximately 1943 through 1950.	Chlorinated VOCs. Primarily carcinogenic, toxic, and mobile.	TCE	**30**	**6.9**	TCE plume approximate dimensions: Length: 400 feet Width: 350 feet Thickness: 25 to 30 feet	110,447 ft^2 662,680 ft^3	Plume is stable. Monitoring data over approximately 10 years of MNA assessment did not indicate significant plume migration.
			1,1-DCE	0.64	ND			
					Results after approximately a decade of MNA assessment.			
LF007B Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs, SVOCs, pesticides/ PCBs, and dioxins. Primarily carcinogenic, toxic, low mobility.	Benzene	**59.3**	ND	No plume dimensions. Contaminant concentrations already less than IRGs.	0 ft^2 0 ft^3	Plume is stable. Monitoring data over approximately 10 years of interim MNA assessment did not indicate significant plume migration.
			1,4-DCB	**43.8**	ND			
			Chlorobenzene	**161**	ND			
			bis(2-Ethylhexyl)phthalate[e]	**66.1**	-[f]			
			Aroclors 1242 and 1248	**14.1**	ND			
			2,3,7,8-TCDDeq	**0.55 pg/L**	ND			
					Results after approximately a decade of MNA assessment.			

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
LF007C Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs. Carcinogenic, toxic, low mobility.	TCE Vinyl chloride 1,1-DCE 1,2-DCA 1,2-Dichloropropane	**49.1** 0.198 0.297 0.314 3.38	**10.3** ND ND ND 0.3 J Results after approximately a decade of IRA GET system operation. Optimization pending.	TCE plume approximate dimensions: Length: 620 feet Width: 220 feet Thickness: 25 feet The majority of the contaminant plume extends to off-base privately owned property.	110,330 ft^2 485,452 ft^3	Plume is stable. Monitoring data over approximately 10 years of interim GET system operation did not indicate significant plume migration.
LF007D Subarea	Portion of a historical general refuse landfill that used trench and cover methods from approximately 1950 through 1970.	Chlorinated VOCs, SVOCs, PCBs, and dioxins. Primarily carcinogenic, toxic, low mobility.	Benzene Vinyl chloride 1,4-DCB 1,1-DCE Chlorobenzene 2,3,7,8-TCDDeq Aroclors 1242 and 1248 bis(2-Ethylhexyl)phthalate[e]	**25.8** **1.78** **43.8** 0.96 **282** **16.99 pg/L** 14.1 124	**2.2** ND **12.6** ND 30.2 ND ND -[e] Results after approximately a decade of MNA assessment.	Plume is limited to a small area in the vicinity of MW261x07.	31,000 ft^{2g} 248,000 ft^{3g}	Plume is stable. Monitoring data over approximately 10 years of interim MNA assessment did not indicate significant plume migration.
LF008	Historical disposal practices at an inactive landfill. Pesticide containers were disposed of in a series of small, unlined trenches.	Organochlorine pesticides. Carcinogenic, toxic, relatively immobile.	Alpha-chlordane Heptachlor Heptachlor epoxide	**1.7** **0.29** **0.63**	**0.43** ND **0.017 J-** Results during shutdown of IRA GET system for rebound study.	Alpha-chlordane plume approximate dimensions: Length: 195 feet Width: 112 feet Thickness: 35 feet	33,368 ft^2 233,576 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. A recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2008.
SS015	Historical practices at facilities used between approximately 1964 and 1980 for solvent stripping of aircraft parts, aircraft maintenance and repair, OWS activities, and hazardous waste accumulation.	Chlorinated VOCs. Probable DNAPL within the high concentration portion of the plume. Carcinogenic, toxic, and mobile. SVOCs Metals	TCE cis-1,2-DCE Vinyl chloride 1,2-DCA PCE bis(2-Ethylhexyl)phthalate[e] Nickel[f]	**563** **7,680** **3,220** 0.45 **105** **260** **2,210**	**226** **598** **70.6** 0.3 J **3.1** -[e] -[f] Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume.	cis-1,2-DCE plume approximate dimensions: Length: 360 feet Width: 160 feet Thickness:10 to 15 feet	55,994 ft^2 78,392 ft^3	Monitoring data over approximately 10 years of MNA assessment indicated some local plume migration in the direction of local groundwater flow toward the northeast. Trends indicate increasing TCE concentration at MW625x15 and decreasing TCE concentration at MW216x15 as discussed in the GSAP 2010-2011 Annual Report (CH2M HILL, 2012a). The plume has moved and increased in size primarily along the northeast-southwest axis as seen on Figure 2.2-8.

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SS016/ SS029	Site SS016: Historical practices within flight line support areas subject to oil spills, degreasing operations, leaking OWS, equipment maintenance and repair, aircraft and vehicle maintenance, hazardous materials storage, aircraft and vehicle washing, and stormwater runoff. Most of the areas have been used from the 1940s through the present day. Site SS029: Undeveloped land near the southern Base boundary. The historical practices resulting in groundwater contamination are unknown.	Chlorinated VOCs. Probable DNAPL within the high concentration portion of the Site SS016 OSA plume. Carcinogenic, toxic, and mobile.	TCE cis-1,2-DCE Vinyl chloride Benzene Chloroform 1,4-DCB Bromodichloromethane 1,2-DCA 1,1-DCE PCE	**210,000** **19,100** **1,530** **550** 13 **315** 1.3 **9.16** **84** **105**	**40,200** **8,230** **812** ND 0.42 J **710** ND **13.4 J** **50.2 J** **108**	Site SS016 and SS029 TCE plume approximate dimensions: Length: 5,700 feet Width: 1,400 feet Thickness: 25 to 40 feet	7,112,191 ft^2 41,250,708 ft^3	Plume is stable. Plumes were hydraulically captured by the combined site-specific IRA GET systems over approximately 10 years of interim remediation. Monitoring data indicated that some migration of the Site SS016 plume into the hydraulically downgradient Site SS029 plume was occurring. However, combined IRA GET system operations are continuing to maintain hydraulic capture of the overall plume. In October 2010, a maximum 1,4-DCB concentration of 710 µg/L was detected in MW2020Ax16. This concentration exceeded the historical maximum concentration of 1,4-DCB at the site. Monitoring well MW2020Ax16 was installed in 2010 within the higher concentration portion of the plume to support monitoring of the bioreactor. After initiation of the bioreactor, 1,4-DCB concentrations declined from 710 to 57.6 µg/L by May 2011. In October 2010, the maximum 1,2-DCA (13.4 J µg/L) concentration detected at Site SS016 slightly exceeded the historical maximum detection at source area extraction well TPE-Wx16. However, after initiation of the source area bioreactor, 1,2-DCA concentrations at this well decreased to nondetect by May 2011. In February 2011, the maximum PCE concentration detected at Site SS016 slightly exceeded the historical maximum detection at new source area well MW2112Ax16. After initiation of the source area bioreactor, PCE concentrations at this well declined to 97.8 J µg/L by May 2011 (the historical maximum concentration was 105 µg/L).
		SVOCs	bis(2-Ethylhexyl)phthalate[e]	**67.3**	-[e]			
		Metals	Nickel[f]	**6,560**	-[f]			
					Results following demonstration of ERD treatment via bioreactor within a high concentration portion of the plume. Portion of GET system shut down to support installation of bioreactor. Remainder of GET system remains in operation.			
ST027B	Historical practices at a former aircraft engine test stand area. The historical activities resulting in groundwater contamination are unknown. Historically managed under the POCO program and not included in any of the four (4) OU-specific RIs, two (2) OU-specific FSs, or two (2) groundwater IRODs. In 2007-2008, POCO investigations discovered a small, previously unknown TCE plume at concentrations greater than the IRG in the southwestern part of Site ST027. This area of TCE contamination has been designated Site ST027B.	Chlorinated VOCs. Primarily carcinogenic, toxic, and mobile.	TCE[h] Vinyl chloride[h] cis-1,2-DCE[h] Benzene Toluene	ND[h] ND[h] ND[h] 0.44 0.1	**435** **7.1** **338** 0.32 J ND	TCE plume approximate dimensions: Length: 650 feet Width: 400 feet Thickness: 30 to 35 feet Formerly managed under POCO program. Chlorinated VOCs were detected after the IROD was finalized and IRAs implemented.	183,134 ft^{2h} 1,281,938 ft^{3h}	Plume is stable. Monitoring data obtained during period of POCO and ERP program management did not indicate significant plume migration.
					Results following periods of MNA under POCO and ERP.			

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SS030	Undeveloped land near the southern Base boundary. Historical practices associated with Building 1125 are believed to have resulted in groundwater contamination.	Chlorinated VOCs. Carcinogenic, toxic, and mobile. Metals	TCE Chloroform Bromodichloromethane 1,2-DCA Nickel[f]	**3,860** 9.3 2 0.34 **1,850**	48.8 7.4 ND ND -[f] Results during IRA GET system operation.	TCE plume approximate dimensions: Length: 1,400 feet Width: 400 feet Thickness: 20 to 40 feet The majority of the contaminant plume extends onto off-base privately owned property.	455,647 ft^2 1,822,588 ft^3	Plume is stable. Plume was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. IRA GET system operations are continuing to maintain hydraulic capture of the plume.
SD031	Historical practices in an area used for maintenance and repair of diesel generators, wash rack activities, OWS activities, and aircraft maintenance from approximately 1957 through the present day.	Chlorinated VOCs. Carcinogenic, toxic, and mobile. Metals	TCE Benzene 1,1-DCE cis-1,2-DCE Carbon tetrachloride Chloroform 1,2-DCA Vinyl chloride Nickel[f]	**8,100** **28** **7,300** **3,600** **11** 11 **5** **1.2** **6,780**	7.1 J- ND 56.7 0.78 J- ND 0.17 J ND ND -[f] Results during shutdown of IRA GET system for rebound study.	1,1-DCE plume approximate dimensions: Length: 300 feet Width: 150 feet Thickness: 25 to 30 feet	54,255 ft^2 260,424 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in December 2007.
SD033 (component of WIOU)	Historical practices within support areas used for management of stormwater runoff, fuel transport, aircraft maintenance, and aircraft washing, including the use of wash racks and OWS.	Primarily chlorinated VOCs. Some commingled SVOCs. Primarily carcinogenic, toxic, and mobile.	TCE 1,1-DCE 1,2-DCA cis-1,2-DCE	**200** 1.9 **1.52** **75.9**	**99.2** ND ND **50** Results during shutdown of IRA GET system for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SD034 (component of WIOU)	Historical practices at an aircraft wash rack facility with OWS and overflow pond. Leaks from the OWS resulted in a layer of Stoddard solvent, containing dissolved COCs, floating on the groundwater table. The leaking OWS was replaced in 1994.	Primarily chlorinated VOCs. Free-phase Stoddard solvent (PD-680) LNAPL consisting of 15 percent trimethyl benzene and 85 percent n-nonane floating on groundwater table. The Stoddard solvent non-aqueous medium also contains dissolved COCs. Primarily carcinogenic, toxic, and mobile.	TCE Vinyl chloride 1,1-DCE Benzene cis-1,2-DCE PCE bis(2-Ethylhexyl)phthalate[e]	**456** **11** 3.2 **1.34** **391** **41.4** **3,350**	**5.8** **2.1** ND 0.21 J 5.7 ND -[e] Results during shutdown of IRA GET system for rebound study.	-i Free-phase Stoddard solvent, containing dissolved COCs, intermittently measured floating on groundwater table. Site contamination is within the overall WIOU plume.	-i	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SS035 (component of WIOU)	Historical practices during aircraft repair, painting, and washing. A wash rack with OWS was constructed in 1970.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**5.3**	ND	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
SD036 (component of WIOU)	Historical practices at Facilities 872/873/876. The facilities were constructed in 1953 and consist of multiple-use shops, including a wash rack and OWS. A leaking segment of an underground sanitary sewer may have released contamination. This segment of the sewer was repaired.	Primarily chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Primarily carcinogenic, toxic, and mobile.	Vinyl chloride TCE 1,1-DCE cis-1,2-DCE 1,2-DCA Benzene Bromodichloromethane PCE	**360** **18,500** 3.71 **3,870** **7.9** **3.87** 2.26 **512**	**1,100** **14,400** **12.5 J-** **6,710** **1.2** 0.59 ND **13.3 J** Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume. IRA GET system component shut down for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010. In June 2011, the maximum vinyl chloride concentration detected at Site SD036 (1,100 µg/L) exceeded the historical maximum detection at ERD performance monitoring well EW594x36. The reason for this increase in vinyl chloride concentrations is that vinyl chloride is a daughter product of ERD. Elevated vinyl chloride concentrations are restricted to the EVO treatment area. The presence of ethane, ethene, and methane within the treatment area indicates ERD is going to completion and vinyl chloride is being destroyed. The maximum 1,1-DCE concentration detected at Site SD036 (12.5 J- µg/L) also exceeded the historical maximum detection at ERD performance monitoring well MW2033Ax36. The reason for this increase in 1,1-DCE concentrations within Site SD036 is that 1,1-DCE is also a daughter product of ERD. Elevated 1,1-DCE concentrations are also restricted to the EVO treatment area. The presence of ethane, ethene, and methane within the treatment area indicates ERD is going to completion and 1,1-DCE is being destroyed.
SD037 (component of WIOU)	Historical practices within support areas used for management of domestic and industrial wastewater, aircraft maintenance, heavy equipment maintenance, air cargo handling, vehicle washing, fuel transport, and waste accumulation. These operations began in the 1940s.	Primarily chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Primarily carcinogenic, toxic, and mobile.	1,1-DCE 1,2-DCA Benzene Bromodichloromethane Carbon tetrachloride PCE TCE Vinyl chloride cis-1,2-DCE bis(2-Ethylhexyl)phthalate[e]	**8.2** **1.68** **4,240** 3 **40.4** **900** **5,800** **430** **381** **91**	4.6 ND **7.6** ND **7.6** **212** **1,720** **26.3** **749** -[e] Results following demonstration of ERD treatment via injection of EVO within a high concentration portion of the plume. IRA GET system component shut down for rebound study.	TCE plume approximate dimensions: Length: 4,650 feet Width: 750 feet Thickness: 20 to 90 feet Site SD037 plume dimensions represent the overall WIOU plume.	1,626,667 ft^2 13,664,003 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

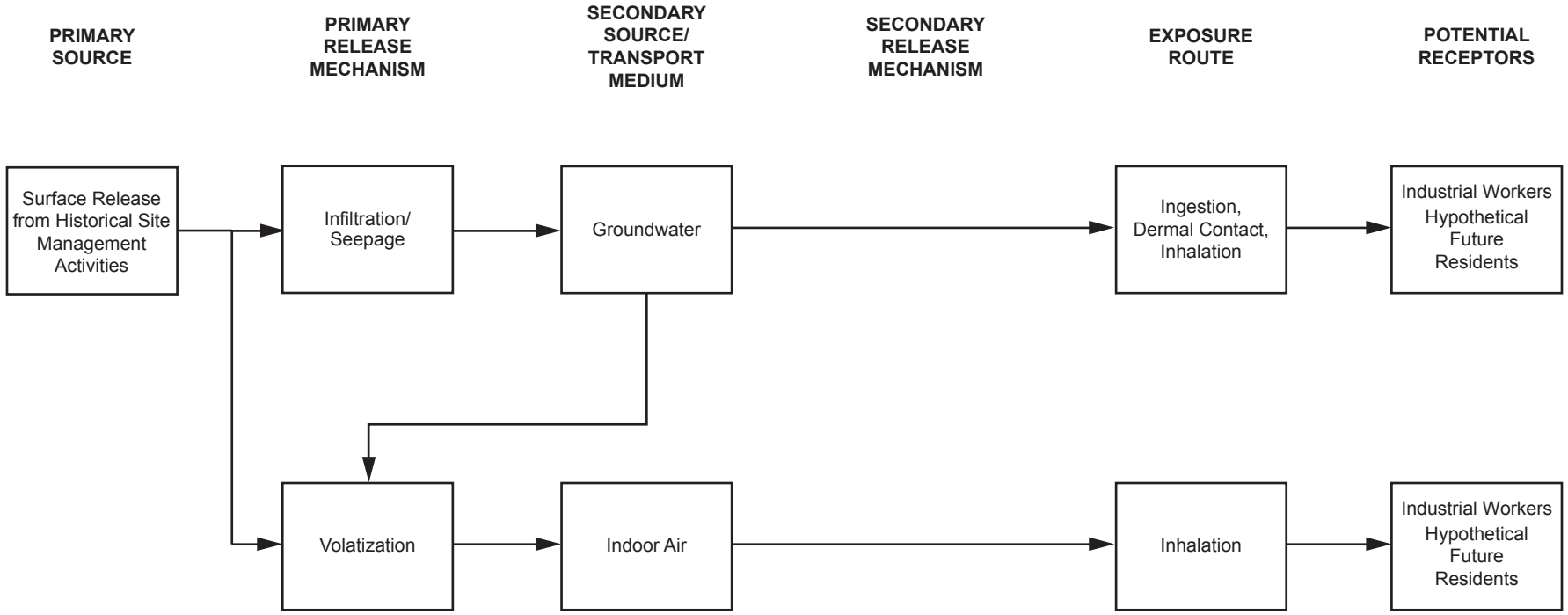
TABLE 2.5-2
Summary of Nature and Extent of Contamination
Groundwater Record of Decision, Travis Air Force Base, California

Site	Source of Contamination	Types and Characteristics of Contamination	COCs	Concentration (µg/L)		Current Lateral and Vertical Extent of Contamination	Current Area and Volume of Contamination[d]	Comments
				Historical Maximum[a,b] (pre-IRA)	Current Maximum[c] (2010 to 2011)			
DP039	Historical practice conducted prior to 1978 at Building 755. Battery acid solutions and solvents were discharged from the building into an exterior sump.	Chlorinated VOCs. Probable DNAPL within a high concentration portion of the plume. Carcinogenic, toxic, and mobile.	1,1-DCE 1,2-DCA 1,1,1-TCA 1,1,2-TCA Bromodichloromethane Methylene chloride PCE TCE	**7,900** **440** **26,000** **240** 10 **3,500** **20** **230,000**	**2,210** **5.2** ND ND ND **24** ND **1,740** Results following demonstration of ERD treatment via bioreactor and injection of EVO PRB within higher concentration portions of the plume. IRA GET system component shut down to support installation of bioreactor.	TCE plume approximate dimensions: Length: 1,720 feet Width: 820 feet Thickness: approx. 20 to 45 feet	1,144,580 ft^2 9,614,472 ft^3	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.
SS041	Historical activities at the Base Entomology Shop (Building 905) from 1983 to 1992 to prepare pesticides and herbicides for on-base use. A concrete wash rack in the back of the building was used to clean pesticide applicator vehicles. Overspray from the washing resulted in pesticide contamination of the groundwater.	Organochlorine pesticides. Carcinogenic, toxic, relatively immobile.	Heptachlor epoxide	**0.023 J**	ND	No plume dimensions. Contaminant concentrations already less than IRGs.	0 $ft^{2[j]}$ 0 $ft^{3[j]}$	The IRA achieved cleanup of groundwater to concentrations below detection levels. The site has been in NFRAP status since 2005.
SD043 (component of WIOU)	Historical disposal practices from maintenance activities at an emergency electric power facility.	Chlorinated VOCs. Carcinogenic, toxic, and mobile.	TCE	**38**	0.7 IRA GET system component shut down for rebound study.	-[i] Site contamination is within the overall WIOU plume.	-[i]	Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation (combined GET and MNA assessment) did not indicate significant plume migration. Data obtained during a recent rebound study did not indicate significant plume migration when GET system operations were discontinued in April 2010.

[a] Maximum historical concentration prior to implementation and long-term operation of the groundwater IRA at the site. Source: GSAP 2010-2011 Annual Report (CH2M HILL, 2012a).
[b] **Bolded** concentrations are above the contaminant-specific IRG established in the NEWIOU or WABOU Groundwater IROD.
[c] Current concentration after approximately a decade of IRA operation. Source: GSAP 2010-2011 Annual Report (CH2M HILL, 2012a).
[d] Estimated based on the groundwater COC with greatest areal extent. Groundwater pore volume estimated from the plume area, saturated thickness, and a porosity of 20 percent.
[e] Bis(2-Ethylhexyl)phthalate was initially identified as a COC, but in 2002 was recognized as a field and/or laboratory artifact and not representative of groundwater contamination.
[f] Nickel was initially identified as a COC, but in 2002 it was demonstrated as leaching from the stainless steel well casings used in monitoring well construction and not representative of groundwater contamination.
[g] Contamination is limited to a small area in the vicinity of MW261x07. Plume areas and volumes are based on an approximate 100-foot plume radius around this well.
[h] Portion of Site ST027 formerly managed under the Travis AFB POCO program. Chlorinated VOCs regulated under CERCLA were not detected in the Area B portion of plume (i.e., Site ST027B) until after the NEWIOU Groundwater IROD was finalized.
[i] Included in Site SD037 estimates. The plume areas and volumes for Sites SD033, SD034, SS035, SD036, SD037, and SD043 comprise the overall WIOU plume. These site contaminant plumes are inseparably commingled and are addressed as a single WIOU plume. Site SD037 is selected as representative of the WIOU plume because the ERP site boundary has the greatest geographic extent of the component sites.

Notes:

ft^2 = square feet
ft^3 = cubic feet
ND = not detected
SVOC = semivolatile organic compound
TCDDeq = tetrachlordibenzo-p-dioxin equivalent



LEGEND

→ Potentially Complete Exposure Pathway

FIGURE 2.5-1
CONCEPTUAL EXPOSURE MODEL
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

2.6 Current and Potential Future Land Use and Resource Uses

This section provides descriptions of the current and potential future uses of land and resources at Travis AFB.

2.6.1 Current and Potential Land Use

Travis AFB is a secured, active military facility. Access to the Base is generally limited to military members, their dependents, and civilian government employees. The Travis AFB General Plan (Travis AFB, 2002b) designates existing and planned future land use for Travis AFB into the following eight (8) functional categories:

- **Mission –** Uses are closely associated with the airfield and include facilities such as maintenance hangars and docks, avionics facilities, and other maintenance facilities. Aircraft operations facilities include control towers, Base operations, flight simulators, and other instructional facilities.
- **Administrative –** Uses include personnel, headquarters, legal, and other support functions.
- **Community –** Uses include both commercial and service activities. Examples of commercial uses include the Base Exchange, dining halls, service station, and clubs; service uses include the schools, chapel, library, and the family support center.
- **Housing –** Uses include both accompanied housing for families and unaccompanied housing for singles, temporary personnel, and visitors.
- **Base Support/Industrial –** Uses are for the storage of supplies and maintenance of Base facilities and utility systems.
- **Medical –** Uses include facilities for medical support, including the David Grant Medical Center.
- **Outdoor Recreation –** Uses include ball fields, golf course, equestrian center, swimming pools, and other recreational activities.
- **Open Space –** Used as buffers between Base facilities and to preserve environmentally sensitive areas.

Land overlying the groundwater plumes is under four (4) of these functional categories, including mission, administrative, Base support/industrial, and open space areas. Contaminated groundwater does not currently underlie any of the community, housing, medical, and outdoor recreation areas. These areas are hydraulically upgradient of the groundwater plumes.

As the lead agency, the AF has the authority to determine the future anticipated land use of Travis AFB. The AF has determined that Travis AFB is reasonably anticipated to continue as an active military facility, and current land uses are reasonably anticipated to continue indefinitely to support the mission of the facility.

The current land use of adjacent/surrounding land, including that land contiguous to the boundary of Travis AFB, is primarily livestock grazing and pasture land accompanied by low-density rural residential homes. The current use of adjacent/surrounding land is expected to remain the same over the foreseeable future. The lands surrounding Travis AFB on the northeast and east are primarily used for ranching and grazing. Areas to the south are a combination of agricultural and marshland. A few commercial/light industrial areas are present to the north of the Base. The area west of Travis AFB is predominantly residential.

2.6.2 Groundwater Beneficial Uses

Designated beneficial uses of the affected aquifer include domestic, municipal, agricultural, and industrial supply (San Francisco Bay Regional Water Board, 2011). Groundwater at Travis AFB is not currently used as a drinking water source or as a water supply for any purpose, and it is not reasonably anticipated to be used for any purpose in the future.

There is one (1) known off-base domestic water supply well located hydraulically downgradient of Travis AFB. This privately owned domestic water supply well is downgradient of the Site SS030 TCE plume. No contaminants related to the Site SS030 plume have been detected in this well.

Approximately 90 percent of the water currently used at Travis AFB is provided by the City of Vallejo and is surface water originating from Lake Berryessa and Lake Oroville. Groundwater production wells located at the Cypress Lakes Golf Course Annex provide the remaining 10 percent of the Base water supply. These production wells are located approximately 3 miles north of Travis AFB and are hydraulically separate from the Base.

Along with the industrial contaminants listed in Table 2.5-2, groundwater quality at Travis AFB is impacted by the following naturally occurring constituents at concentrations exceeding primary MCLs. Section 3.6 of the TEFA presents the groundwater quality data that is summarized in the following list (CH2M HILL, 2012h):

- Dissolved metals at concentrations exceeding the primary MCLs.
- Fluoride, sulfate, nitrate, nitrite, and turbidity at concentrations that exceed the primary MCL.
- Total dissolved solids (TDS) at concentrations that exceed 3,000 milligrams per liter (mg/L). A provision in State Water Board Resolution 88-63 – Sources of Drinking Water, Item 1a states that such concentrations are "not reasonably expected by Regional Boards to supply a public water system."

In comparison with water quality parameters measured at the City of Vacaville production wells, groundwater at Travis AFB is of lower quality. Concentrations of alkalinity, fluoride, hardness, nitrate, pH, sulfate, total organic carbon (TOC), and turbidity measured at Travis AFB are all greater than those measured in the City of Vacaville wells.

2.7 Summary of Site Risks

This section summarizes the human health risk assessments (HHRAs) for groundwater, which were performed at Travis AFB as part of the OU-specific RIs (Radian, 1995; Weston, 1995; Radian, 1996a; CH2M HILL, 1997) prior to implementation of the IRAs, and a vapor intrusion assessment for groundwater at Sites FT004, FT005, LF006, LF007, LF008, SS015, SS029, SS030, SD031, SD033, SD034, SS035, SD036, SD037, DP039, and SD043 (CH2M HILL, 2010a). The HHRAs also identified COCs associated with unacceptable risks from groundwater, as well as the potentially exposed populations and exposure pathways of primary concern. Based on the presence of unacceptable risks to a hypothetical future resident and considering that groundwater is not safe for drinking water because it remains contaminated with chlorinated VOCs and organochlorine pesticides at concentrations above MCLs, remedial action is being recommended in this ROD to further reduce risks from groundwater.

After more than a decade of interim remediation, the concentrations of COCs in groundwater and corresponding levels of potential risk have decreased or remained stable. Historical maximum concentrations of COCs at each site compared with the current maximum concentrations are provided in Table 2.5-1.

Groundwater is located below the depth at which ecological receptors are present. Therefore, there are no chemicals posing risks to environmental receptors at any of the sites.

The groundwater to surface water pathway is addressed in Section 5.1 of the final NEWIOU Soil, Sediment, and Surface Water ROD. This section of the NEWIOU Soil, Sediment, and Surface Water ROD states that extraction of groundwater has reduced levels of TCE in surface water to levels that do not pose risks to human health or the environment. Accordingly, NEWIOU Soil, Sediment, and Surface Water ROD Alternative 10 – No Action for Surface Water was the selected remedial action at all sites with surface water features (Travis AFB, 2006a).

2.7.1 Human Health Risk Assessment

The baseline HHRA estimates the potential risks a site poses to human health if no actions had been taken and identifies the COCs and exposure pathways that needed to be addressed by the remedial action. Potential human health risks from exposure to contaminated groundwater at Travis AFB calculated prior to implementation of the IRAs in the mid-1990s, and providing the basis for interim actions, and the vapor intrusion assessment are documented in the following reports:

- Appendix C of the NOU RI Report (Radian, 1995)
- Appendix K.6 of the EIOU RI Report (Weston, 1995)
- Appendix H of the WIOU RI Report (Radian, 1996a)
- Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
- *Site ST027-Area B Human Health Risk Assessment* (CH2M HILL, 2011c)
- *Vapor Intrusion Assessment Report* (CH2M HILL, 2010a)
- *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a)

2.7.1.1 Approach

The HHRA consists of the following components:

- **Selection of Chemicals of Potential Concern (COPC) –** Identifies the constituents considered to be most important to the human health risk estimation process.
- **Exposure Assessment –** Identifies the pathways by which potential human exposures could occur, describes how they are evaluated, and evaluates the magnitude, frequency, and duration of these potential exposures. See Section 2.5.8 for further discussion of potential exposure scenarios.
- **Toxicity Assessment –** Summarizes the toxicity of the selected chemicals and the relationship between magnitude of exposure and the occurrence of adverse health effects.
- **Risk Characterization –** Integrates information from the exposure and toxicity assessments to characterize the risks to human health from potential exposure to chemicals in environmental media. Numerical estimates of potential carcinogenic (cancer) risks and noncarcinogenic (non-cancer) health effects are calculated.
- **Uncertainties Analysis –** Summarizes the basic assumptions used in the HHRA, as well as limitations of data and methodology.

COPCs were divided into two (2) broad groups (noncarcinogens and carcinogens) on the basis of their tendency to cause adverse non-cancer health effects, such as liver toxicity or developmental effects, or cancer. Estimates of potential non-cancer health effects and cancer risks for each COPC are calculated for each exposure scenario and media of interest. Cumulative risks, including risk from all COPCs for each exposure scenario and media of interest, are also calculated.

In the HHRA, potential cancer risk is referred to as the potential excess lifetime cancer risk (ELCR) because it would be in addition to the risk of cancer from other sources, such as exposure to too much sun. An ELCR of one-in-one-million means that there is a one-in-one-million probability that exposure to the constituent will cause cancer. For convenience, ELCR values are usually expressed using scientific notation, where one-in-one-million is expressed as 1×10^{-6} or 1.0E-06. The higher the ELCR value, the greater the probability that exposure to the contaminant will cause cancer. For a cumulative ELCR for site-related contaminants, risks are interpreted within the context of the CERCLA acceptable risk management range of 10^{-6} to 10^{-4}.

For non-cancer health effects, the body's protective mechanisms must be overcome before an adverse effect is manifested. If exposure is high enough and these protective mechanisms (or thresholds) are exceeded, adverse health effects can occur. The dose-response relationship for non-cancer effects is expressed as a reference dose (RfD). An RfD represents a level that an individual may be exposed to a constituent that is not expected to cause any harmful effects. The ratio of the chronic daily intake divided by the RfD is expressed as a hazard quotient (HQ). A hazard index (HI) is generated by adding the HQs for all COPCs and pathways that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium to which an individual may reasonably be exposed. An HI less than or equal to 1 indicates that adverse effects are unlikely from additive exposure to constituents (i.e., exposure is less than the RfD). An HI greater than 1 indicates that adverse non-cancer health effects may occur from exposures.

2.7.1.2 Summary of Risk Estimates

See Table 2.7-1 for a summary of human health risks. These were the potential risks posed by the COCs identified during risk assessments conducted as part of the four (4) OU-specific RIs. The full list of COCs and their concentrations prior to implementation of the IRAs is provided in Table 2.5-2.

For direct contact with groundwater prior to implementation of the IRAs based on the hypothetical future residential scenario, the cumulative ELCR estimates ranged from 7.0×10^{-6} to 2.0×10^{-1}, and the cumulative HIs ranged from less than 1 to above 3,000.

For direct contact with groundwater prior to implementation of the IRAs based on the on-base industrial scenario, the cumulative ELCR estimates ranged from 2.0×10^{-6} to 3.0×10^{-2}, and the cumulative HIs ranged from less than 1 to 460.

2.7.2 Vapor Intrusion Assessments

The vapor intrusion assessments evaluated whether inhalation of volatiles migrating from groundwater into indoor air poses a risk to human health based on current and future site conditions. These assessments are documented in the *Vapor Intrusion Assessment Report* and the *Vapor Intrusion Assessment Update* (CH2M HILL, 2010a, 2013a).

2.7.2.1 Vapor Intrusion Assessment

During 2008-2009, Travis AFB conducted a vapor intrusion assessment to evaluate whether inhalation of VOCs migrating from groundwater into indoor air pose a risk to human health based on current and future site conditions at Sites FT004, FT005, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS016, SS029, SS030, SD031, ST032 (now a POCO site), SD033, SD034, SS035, SD036, SD037, DP039, and SD043. This assessment was conducted in accordance with the final *Vapor Intrusion Assessment Work Plan* (CH2M HILL, 2008c). Potential preferential pathways under current (commercial/industrial land use) and potential future (hypothetical residential use) conditions were evaluated. Sufficient historical data were available for Sites FT005, LF007 (inclusive of Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS030, SD031, ST032 (now a POCO site), and SD043 to perform a vapor intrusion assessment. However, the need for additional data to support the assessment was identified at Sites FT004, SS016, SS029, SD033, SD034, SS035, SD036, SD037, and DP039. Therefore, additional investigation was performed at these sites in the following three (3) phases:

- **Phase 1 –** During Phase 1 of the vapor intrusion assessment, shallow soil vapor sampling, building subslab soil vapor sampling, indoor air sampling, and outdoor air sampling was conducted at Sites FT004, SS029, SD033, SD034, SS035, SD036, SD037, and DP039.
- **Phase 2 –** Phase 2 consisted of building surveys in areas where the soil gas or groundwater data indicated a potential for vapor intrusion. The building surveys were conducted at Facilities 16 (Site SS016), 18 (Site SS016), 22 (Site SS016), 755 (Site DP039), 811 (Site SD034), 836 (Site SD037), 864 (Site SD037), and 919 (Site SD037) to confirm the current building usage; identify potential soil vapor migration routes; confirm building heating, ventilation, and air conditioning operation; and identify potential sources of other chemicals within the buildings.
- **Phase 3 –** Following the completion of Phase 2, Phase 3 consisted of collecting building subslab soil vapor samples, indoor air samples, and outdoor air samples at buildings

within Sites SS016, SD033, SD034, SS035, SD036, and SD037. Data evaluations and assessment of risks were included in this phase.

2.7.2.2 Vapor Intrusion Assessment Update

During 2012-2013, an update to the *Vapor Intrusion Assessment Report* was developed because toxicity values for several of the chemicals originally evaluated had changed. This update is provided in the final *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a). The results of the updated assessment were used to develop revised risk-based groundwater concentrations for residential and industrial vapor intrusion exposure scenarios and revised residential and industrial groundwater-to-indoor-air LUC boundaries.

2.7.2.3 Summary of Risk Estimates

The vapor intrusion assessments did not identify unacceptable risk from vapor intrusion into indoor air based on current site use. However, potential future vapor intrusion risks were identified at some sites if site conditions change (such as construction of new facility overlying a groundwater plume or change in facility use). See Table 2.7-2 for a summary of potential future vapor intrusion risks based on shallow soil gas data.

For an industrial exposure scenario, potential future vapor intrusion risk is posed by VOCs in groundwater at Sites FT004, SS015, SS016, SS029, and DP039. The cumulative ELCR estimates for Sites FT004, SS029, and DP039 range from 6.2×10^{-6} to 1.9×10^{-5}, and the cumulative HIs range from 2 to 7. For Sites SS015 and SS016 (where shallow soil gas samples were not collected), concentrations of COCs in groundwater are greater than risk-based concentrations (RBCs).

For a residential exposure scenario, potential future vapor intrusion risk is posed by VOCs in groundwater at Site FT004, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD033, SS035, SD036, SD037, and DP039. Under this hypothetical future residential scenario, the cumulative ELCR estimates for Sites FT004, SS029, SD033, SS035, SD036, SD037, and DP039 range from 1.5×10^{-5} to 6.7×10^{-4}. The cumulative HIs for Sites FT004, SS029, SS035, SD036, SD037, and DP039 range from 1.4 to 140. For Sites LF007, SS015, SS016, and SS030 (where shallow soil gas samples were not collected), concentrations of COCs in groundwater are greater than RBCs.

The vapor intrusion pathway is not a potential future concern under either a residential or industrial exposure scenario at Sites FT005, LF006, LF008, ST027B, SD031, SD034, SS041, and SD043 based on the following:

- Groundwater contaminant concentrations at Sites FT005, LF006, LF008, SD031, SS041, and SD043 were below groundwater-to-indoor-air RBCs, and no additional investigation of the vapor intrusion pathway was warranted.
- Shallow soil gas concentrations detected at Site ST027B were below shallow-soil-gas-to-indoor-air RBCs.
- Shallow soil gas cumulative ELCR estimates were below (industrial exposure) or within (residential exposure) the risk management range, and cumulative HIs for Site SD034 were less than 1 for both industrial and residential exposure.

2.7.3 Basis for Action

The response actions selected in this ROD are necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. The response actions are also necessary to protect the public health or welfare or the environment from actual or threatened releases of pollutants or contaminants at the sites, which may present an imminent and substantial endangerment to the public health or welfare. Groundwater at Travis AFB is not safe for use as drinking water because it is contaminated with chlorinated VOCs (primarily TCE) and organochlorine pesticides (primarily alpha-chlordane) at concentrations above MCLs. Potential risks are also posed by the slow movement of contaminated groundwater toward an off-base location where groundwater is used as drinking water. Travis AFB does not use groundwater underlying its geographic footprint and does not plan to do so in the future.

Stoddard solvent free product (LNAPL) is floating on the groundwater table at Site SD034 and potentially impacts designated beneficial uses. Stoddard solvent (aka PD-680) is a petroleum distillate mixture of 15 percent trimethylbenzene and 85 percent n-nonane. Neither of these constituent compounds have a primary State of California or federal MCL. However, the Stoddard solvent is a non-aqueous medium also containing dissolved-phase COCs (primarily cis-1,2-DCE) at concentrations above MCLs. The COCs contained in the free product will dissolve into the surrounding groundwater over time. Therefore, action is warranted to remove the free product that acts as a source of contamination to the groundwater. The free product will be removed to the maximum extent practicable, in a manner that minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site.

Migration of VOC vapors from groundwater to indoor air does not present an imminent and substantial endangerment to the public health or welfare based on current and anticipated site use. Potential future vapor intrusion risks are posed from exposure to VOCs (TCE, PCE, vinyl chloride, and benzene) migrating from onsite groundwater to indoor air if, in the future, buildings are constructed overlying some of the groundwater VOC plumes. Travis AFB's current indoor air vapor intrusion mitigation policy, which restricts new residential/industrial construction at portions of these sites unless vapor barriers and passive ventilation systems are installed, will be incorporated into land use restrictions as part of this response action. Residential and industrial land uses at Sites FT004, SS015, SS016, SS029, and DP039 and residential land uses at Site FT004, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD033, SS035, SD036, SD037, and DP039 will not be allowed without prior approval from the AF and appropriate regulatory agencies until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.

TABLE 2.7-1
Summary of Human Health Risks for Direct Contact with Groundwater
Groundwater Record of Decision, Travis Air Force Base, California

Site	Pre-IRA Carcinogens – ELCR Estimate		Pre-IRA Noncarcinogens – Hazard Index		Reference
	Hypothetical Future Residential	Future Industrial	Hypothetical Future Residential	Future Industrial	
FT004	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
FT005	1.76 E-03	5.76 E-03	1.16 E+02	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
LF006	3.30 E-04	5.10 E-05	5.89 E+01	1.22 E+01	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007B	7.80 E-04	2.70 E-04	7.00 E+01	<1 E+00	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007C	3.60 E-05	4.70 E-06	3.10 E+01	4.60 E+01	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF007D	1.00 E-03	3.70 E-04	5.10 E+01	6.00 E+00	Tables 6-11 and 6-12 of the NOU RI Report (Radian, 1995)
LF008	3.00 E-05	2.00 E-05	<1 E+01	<1 E+00	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SS015	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SS016	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
ST027B	2.40 E-04	1.40 E-04	2.63 E+01	1.15 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SS029	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SS030	1.76 E-03	5.76 E-03	1.16 E+02	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SD031	NA*	5.76 E-03	NA*	3.17 E+01	Appendix K.6 of the EIOU RI Report (Weston, 1995)
SD033	8.90 E-05	1.10 E-04	2.32 E+01	8.20 E+00	Appendix H of the WIOU RI Report (Radian, 1996a)
SD034	2.40 E-03	1.20 E-03	2.18 E+02	6.10 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SS035	8.60 E-05	5.00 E-05	3.5 E+00	1.50 E+00	Appendix H of the WIOU RI Report (Radian, 1996a)
SD036	6.80 E-03	2.50 E-03	1.79 E+02	2.30 E+01	Appendix H of the WIOU RI Report (Radian, 1996a)
SD037	9.60 E-04	5.70 E-04	2.44 E+02	1.02 E+02	Appendix H of the WIOU RI Report (Radian, 1996a)
DP039	2.00 E-01	3.00 E-02	>3 E+03	4.60 E+02	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SS041	7.00 E-06	2.00 E-06	<1 E+00	<1 E+00	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)
SD043	1.00 E-04	5.00 E-05	3.50 E+01	2.20 E+01	Appendix G1 of the WABOU RI Report (CH2M HILL, 1997)

*The EIOU RI determined that future residential land use at this site was unlikely; therefore, this exposure route was not included in the risk assessment (Weston, 1995).

TABLE 2.7-2
Summary of Human Health Risks for Indoor Air Vapor Intrusion
Groundwater Record of Decision, Travis Air Force Base, California

Site[b]	ELCR Estimate[a]		Hazard Index[a]	
	Hypothetical Future Residential	On-base Industrial	Hypothetical Future Residential	On-base Industrial
FT004	2.2 E-04	6.2 E-06	46	2
ST027B	2.0 E-06	7.0 E-08	0.1	0.005
SS029	6.7 E-04	1.9 E-05	140	7
SD033	1.5 E-05	6.1 E-07	0.51	0.024
SD034	7.4 E-06	3.0 E-07	0.18	0.01
SS035	3.5 E-05	1.3 E-06	1.4	0.066
SD036	6.4 E-05	1.7 E-06	12	0.56
SD037	8.1 E-05	3.2 E-06	3.3	0.16
DP039	3.6 E-04	7.5 E-06	54	3

[a] Reflects range of estimates for multiple exposure areas.
[b] Potential future risk from vapor intrusion if site conditions change (such as construction of new facility overlying a groundwater plume or change in facility use).

Source: *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a).

2.8 Remedial Action Objectives

Remedial action objectives (RAOs) provide a general description of what the cleanup will accomplish. These goals typically serve as the design basis for the remedial alternatives, which are presented in the next section.

The RAOs for groundwater at Travis AFB provide for protection of human health and include the following:

- Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses. Refer to Table 2.8-1.
- Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health. Refer to Table 2.8-2.
- Prevent or minimize further migration of the contaminant plume that is above the cleanup levels referenced in Table 2.8-1.
- Prevent or minimize further migration of contaminants from the portions of the plumes with the highest concentrations of dissolved groundwater contaminants resulting from the dissolution of residual DNAPLs to hydraulically downgradient portions of plumes. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the Site SS015, SS016, SD036, SD037, and DP039 contaminant plumes followed by natural attenuation at Sites SS015, SD036, SD037, and DP039; and hydraulic control and removal at Site SS016.
- Remove Stoddard solvent, containing dissolved COCs, floating on the groundwater table at Site SD034 and potentially impacting designated beneficial uses to the maximum extent practicable.

Cleanup levels to achieve the RAOs of restoring designated beneficial uses of groundwater are provided in Table 2.8-1. Groundwater concentrations that will trigger implementation of LUCs and mitigation measures for vapor intrusion are provided in Table 2.8-2.

TABLE 2.8-1
Groundwater Cleanup Levels for Direct Contact
Groundwater Record of Decision, Travis Air Force Base, California

Chemical of Concern[a]	Direct Contact Cleanup Level[b] (µg/L)	Basis for Groundwater Cleanup Level[c,d]
TCE	5	Federal Primary MCL
cis-1,2-DCE	6	California Primary MCL
Vinyl chloride	0.5	California Primary MCL
1,2-DCA	0.5	Federal Primary MCL
Chloroform	100	Federal Primary MCL
Bromodichloromethane	100	Federal Primary MCL
1,1-DCE	6	California Primary MCL
1,4-DCB	5	California Primary MCL
Benzene	1	California Primary MCL
Chlorobenzene	70	California Primary MCL
1,2-Dichloropropane	5	Federal Primary MCL
Alpha-chlordane	0.1	California Primary MCL
Heptachlor	0.01	California Primary MCL
Heptachlor epoxide	0.01	California Primary MCL
PCE	5	Federal Primary MCL
Toluene	150	California Primary MCL
Carbon tetrachloride	0.5	California Primary MCL
Methylene chloride	5	Federal Primary MCL
1,1,1-TCA	200	California Primary MCL
1,1,2-TCA	5	California Primary MCL
MTBE	13	California Primary MCL
TPH-D	NA[e]	NA[e]
TPH-G	NA[e]	NA[e]
Aldrin	0.004	EPA Risk-based RSL[f]
Acetone	12,000	EPA Risk-based RSL[f]
Naphthalene	0.14	EPA Risk-based RSL[f]
Chloromethane	190	EPA Risk-based RSL[f]

[a] COCs listed in the NEWIOU and WABOU Groundwater IRODs prior to implementing IRAs. Nickel was initially identified as a COC, but in 2002 was demonstrated as leaching from the stainless steel well casings used in some monitoring well construction and not representative of groundwater contamination. Similarly, bis(2-ethylhexyl)phthalate was initially identified as a COC, but in 2002 was recognized as a field and/or laboratory artifact and not representative of groundwater contamination. Accordingly, nickel and bis(2-ethylhexyl)phthalate are not listed as COCs.

[b] Groundwater cleanup level is the lesser of the federal MCL or State of California MCL.

[c] EPA Federal Primary MCL. Source: EPA, 2012.

[d] State of California Primary MCL. Source: State Water Board, 2011.

[e] If residual TPH is present after RAOs are achieved, then those sites will be transferred from the CERCLA program to the POCO program.

[f] EPA Region 9 Tapwater Regional Screening Level. Source: EPA, 2012.

TABLE 2.8-2
Groundwater Concentrations Requiring Vapor Intrusion Land Use Controls and Mitigation Measures
Groundwater Record of Decision, Travis Air Force Base, California

Chemical of Concern	Groundwater Concentrations Requiring Vapor Intrusion Land Use Controls and Mitigation Measures (µg/L)[a]	
	Industrial Exposure	Residential Exposure
TCE	57	26
cis-1,2-DCE	6,800	4,800
Vinyl chloride	14	4.1
1,2-DCA	57	34
Chloroform	20	12
Bromodichloromethane	51	30
1,1-DCE	5,500	3,900
1,4-DCB	95	56
Benzene	48	29
Chlorobenzene	12,000	8,600
1,2-Dichloropropane	75	45
PCE	490	350
Toluene	600,000	430,000
Carbon tetrachloride	13	7.9
Methylene chloride	72,000	43,000
1,1,1-TCA	250,000	180,000
Aldrin	NA[b]	NA[b]
Acetone	16,000,000	12,000,000
Naphthalene	120	69
Chloromethane	5,020	3,600

[a] Risk-based groundwater concentration protective of the indoor air pathway for industrial use and hypothetical residential land use exposure scenarios. Source: *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a). Risk-based groundwater concentrations were calculated using a target ELCR of 1×10^{-6} and unit risk factors and reference concentrations based on the EPA hierarchy for human health toxicity values for Superfund risk assessments and AF guidance on selection of toxicity values for risk. Sources: *Vapor Intrusion Assessment Update* (CH2M HILL, 2013a) and *Vapor Intrusion Assessment Work Plan* (CH2M HILL, 2008c). The vapor intrusion assessment developed indoor air cleanup levels for all VOCs detected in groundwater at Travis AFB from August 2006 through June 2007. The groundwater COC 1,1,2-TCA was not detected in groundwater at Travis AFB over this time period; therefore, no groundwater cleanup level protective of the indoor air pathway was developed for 1,1,2-TCA (CH2M HILL, 2008c).

[b] NA = not applicable. Aldrin is a nonvolatile pesticide. Vapor intrusion is not an exposure pathway for this COC.

2.9 Description of Alternatives

A total of seven (7) groundwater remedial alternatives for groundwater at Travis AFB were developed in the final FFS (CH2M HILL, 2011a). As technologies or remedy components may not be appropriate for each site, only applicable alternatives were developed and evaluated for each site. For example, at Site LF004, the following three (3) alternatives were developed and evaluated: Alternative 1 – No Further Action, Alternative 2 – MNA, and Alternative 3 – GET (continuing the IRA). The alternatives are summarized in Table 2.9-1 (by alternative) and Table 2.9-2 (by site).

The overall cleanup strategy described in the ROD for Travis AFB groundwater is to transition from the current interim actions to final remedies. This transition includes incorporating successfully performing components of the existing interim actions, incorporation of successful treatment demonstrations, actions based on the results of supporting studies, and actions following GSR practices. Summaries of the Travis AFB groundwater sites, interim remedies, remedial alternatives, and the rationale for the transition from the interim remedies are provided in Tables 2.9-1 and 2.9-2.

Following placement on the NPL in 1989, Travis AFB followed the requirements of CERCLA to investigate site contamination and design and implement appropriate measures. Travis AFB successfully implemented the six (6)-step CERCLA process of (1) PA/SI, (2) RI, (3) FS, (4) remedy selection, (5) RD/RA, and (6) performance monitoring and five-year reviews. The process was modified at the remedy selection step to take an interim approach to groundwater remediation, but otherwise all the requirements of CERCLA were followed throughout the process.

Travis AFB began evaluations of potential groundwater remedial technologies with the development of two (2) CERCLA FSs, including the final NEWIOU FS Report (Radian, 1996b) and the final WABOU FS Report (CH2M HILL, 1998a). Two (2) basic approaches to Travis AFB groundwater remediation resulted from the evaluations conducted in these feasibility studies: GET and MNA assessments. These interim remediation technologies were then implemented at each site, either singly or in combination, in accordance with the NEWIOU Groundwater IROD (Travis AFB, 1998) and the WABOU Groundwater IROD (Travis AFB, 1999). The performance of the interim remedy selected for each site has been monitored and evaluated during the period of interim remediation since the late 1990s.

As the period of interim remediation using GET and MNA assessment concluded, Travis AFB developed the FFS to re-evaluate remediation technologies that had matured since the initial FSs were finalized in 1996 and 1998 (CH2M HILL, 2011a). Three (3) basic remedy transitions resulted from the evaluations conducted in the FFS:

1. Continue the interim remedy.
2. Modify the interim remedy.
3. Discontinue the interim remedy and implement one (1) or more different technologies.

Included in the CERCLA FS criteria evaluations, the FFS re-evaluations included consideration of the following factors:

- Past completion of the CERCLA process at Travis AFB
- The long-term performance of GET systems implemented under the IRODs

- The results of long-term MNA assessments implemented under the IRODs
- Ongoing optimizations of GET systems
- The performance of in situ treatment demonstrations began in 2008 (i.e., ERD treatment using bioreactors and EVO injections)
- The results of supplemental studies (e.g., phytoremediation treatability study, aerobic chlorinated cometabolism enzymes study)
- Preference for GSR practices (e.g., using solar-powered GET systems)

Accordingly, the FFS assembled seven (7) remedial alternatives from technology processes that best satisfied the CERCLA FS threshold and primary balancing evaluation criteria and represented the most reasonable value for the money.

2.9.1 Description of Remedy Components

Summary descriptions of the main components of each remedial alternative are provided in Table 2.9-1. Site-specific listings of IRAs, remedial alternatives, and the remedy transition rationale are provided in Table 2.9-2. Each alternative is described in more detail, including common elements and distinguishing features and expected outcomes, in the following sections.

TABLE 2.9-1
Summary of Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Remedial Alternative	Alternative Description	Sites Evaluated
1. No Further Action	The No Further Action alternative serves as a baseline for comparison with the other remedial alternatives. No further actions, including no LUC provisions, will occur to remediate or manage COCs in groundwater.	All sites
2. MNA	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of existing IRA GET systems is discontinued. LUCs will restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs will be enforced in areas overlying plumes that exceed groundwater-to-indoor-air RBCs.	FT004, FT005, LF006, Subarea LF007B, Subarea LF007D, LF008, SS015, ST027B, SS029, SS030, SD031, SD033, SS035, SD043
3. GET	Extraction and ex situ treatment of COCs in groundwater with LGAC and hydraulic containment of plumes using GET systems. Water will be discharged to the stormwater drainage system. LUCs will restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs will be enforced in areas overlying plumes that exceed groundwater-to-indoor-air RBCs.	FT004, FT005, Subarea LF007C, LF008, SS016, SS029, SS030, SD031, SD033, SD034, SD036, SD037, DP039, SD043
4. Bioreactor and GET	Treatment of COCs in groundwater with an in situ bioreactor and extraction and ex situ treatment with a GET system. An in situ bioreactor installed within a source zone will facilitate ERD treatment processes to anaerobically degrade chlorinated VOCs. Groundwater within the hydraulically downgradient portions of the plume will be extracted and treated ex situ with LGAC. Treated water will be discharged to the stormwater drainage system. LUCs will restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs will be enforced in areas overlying plumes that exceed groundwater-to-indoor-air RBCs.	SS016

TABLE 2.9-1
Summary of Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Remedial Alternative	Alternative Description	Sites Evaluated
5. EVO and EA	In situ source zone treatment with EVO and EA within the hydraulically downgradient portion of the plume. An edible oil substrate (i.e., EVO) will be injected into the higher concentration source zone of the plume to facilitate ERD treatment processes to anaerobically degrade chlorinated VOCs. Naturally occurring physical, chemical, and biological processes will remediate COCs in downgradient groundwater, which will be enhanced by the reduced influx of contaminants from the treated source zone. LUCs will restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs will be enforced in areas overlying plumes that exceed groundwater-to-indoor-air RBCs.	SS015, SD036, SD037
6. Bioreactor, Phytoremediation, EVO PRB, and EA	In situ treatment of COCs in the higher concentration source zone of groundwater with a bioreactor, phytoremediation, and an injected EVO PRB to facilitate biological processes and EA within the remainder of the downgradient plume. A grove of engineer-planted eucalyptus trees will supplement source zone treatment by the hydraulically upgradient bioreactor as the plume flows beneath the trees. A PRB of injected edible vegetable oil across the leading edge of the source area (i.e., a biobarrier) will continue to treat the portion of the aquifer downgradient of the bioreactor and zone of phytoremediation. Naturally occurring physical, chemical, and biological processes will remediate COCs in downgradient groundwater, which will be enhanced by the reduced influx of contaminants from the treated source zone. LUCs will restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs will be enforced in areas overlying plumes that exceed groundwater-to-indoor-air RBCs.	DP039
7. Passive Skimming and EA	Passive skimming to remove the continuing source of groundwater contamination and EA. Stoddard solvent, containing dissolved COCs, floating on the groundwater table will be physically removed using passive skimmers and recycled. Removal of the continuing source and naturally occurring physical, chemical, and biological processes will remediate COCs in groundwater. LUCs will restrict groundwater access and use and residential and industrial land uses.	SD034

Note:

For each of the listed remedies, except Alternative 1 – No Further Action, O&M groundwater monitoring will be conducted during the period of LTO to assess whether the remedy is performing as intended. The O&M monitoring will be conducted until groundwater cleanup levels have been achieved. After the O&M data indicate that groundwater cleanup levels have been achieved, then LTM will be conducted for an additional 2 years to verify that the concentrations of contaminants have been permanently reduced to cleanup levels or below.

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
FT004	GET and MNA Assessment	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (35 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the plume (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediation of the entire plume under the site conditions (refer to Section 2.2.5.1).
FT005	GET	3 – GET	Alternative 3 – GET best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (10 years). The main factors considered in the FFS criteria evaluations included the following: the GET remedy components have already been implemented, GET has been demonstrated to be effective at remediating the site plume, and the GET system capital costs have already been incurred. Off-base EPA-approved vendor treatment of contaminant-laden LGAC will also satisfy the statutory preference for treatment. Implementation of ROD Alternative 3 – GET at Site FT005 represents a continuation of approximately a decade of successful interim GET system operation (refer to Section 2.2.5.2).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
LF006	MNA	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (5 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site LF006 is a continuation of approximately a decade of successful MNA during the period of interim remediation (refer to Section 2.2.5.3).
Subarea LF007B	MNA Assessment	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (0 years). Cleanup levels were achieved during the period of interim remediation. The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the subarea plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site LF007B represents a transition from approximately a decade of successful MNA Assessment (CH2M HILL, 2010b) (refer to Section 2.2.5.4).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
Subarea LF007C	GET	3 – GET	Alternative 3 – GET best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (26 years). The main factor considered in the FFS criteria evaluations is that GET system remedy components have already been mostly implemented. Interim GET system optimization will be conducted during 2013 to increase groundwater pumping rates, improve hydraulic capture, and achieve a higher rate of contaminant mass removal. Following the completion of optimization activities, the GET system capital costs will be largely incurred. Off-base EPA-approved vendor treatment of contaminant-laden LGAC will also satisfy the statutory preference for treatment. The use of solar-powered groundwater extraction pumps and beneficial reuse of treated groundwater in the on-base Duck Pond provides aspects of GSR. Implementation of ROD Alternative 3 – GET at Subarea LF007C represents a continuation of approximately a decade of interim GET system operation (refer to Section 2.2.2.1).
Subarea LF007D	MNA Assessment	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (23 to 49 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Subarea LF007D represents a transition from approximately a decade of successful MNA Assessment (refer to Section 2.2.5.5).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
LF008	GET	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (100 to 110 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of MNA will be effective because the site plume has been demonstrated to be stable or contracting, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site LF008 represents a transition from approximately a decade of partially effective interim GET system operation. Pesticide contaminant concentrations were stable over the period of active GET. Therefore, the interim GET system was shut down for a contaminant rebound study in 2008. After approximately 7.5 years following shutdown of the GET system, no significant change in contaminant concentrations was observed. Filtered and non-filtered sample data indicated that residual pesticide contaminants are strongly sorbed to soil particles and not dissolved in the groundwater. Therefore, MNA is a viable remedy for the entirety of the site under these conditions (refer to Section 2.2.5.6).
SS015	MNA Assessment	5 – EVO and EA	Alternative 5 – EVO and EA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (70 years). The main factors considered in the FFS criteria evaluations included the following: the EVO injection well components of the remedy have already been mostly implemented during the ERD treatment demonstration, and the EA monitoring well components have already been implemented; the effectiveness of ERD treatment via EVO injection to address residual DNAPL principal threat wastes and the higher concentration portion of the plume have been successfully demonstrated; the processes of natural attenuation are assessed as likely to be effective at remediating the lower concentration portion of the plume when combined with the EVO injection component (refer to Section 2.2.5.7); and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR.

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
			Implementation of ROD Alternative 5 – EVO and EA at Site SS015 represents a transition from approximately a decade of an ultimately unsuccessful MNA Assessment for the entirety of the site plume (refer to Section 2.2.5.7) to a more effective strategy of active ERD treatment within the highest concentration portion of the plume taken in combination with natural attenuation processes in the lower concentration portion of the plume. ERD treatment using EVO injection has been demonstrated to be effective at remediating the highest concentration portion of the plume (refer to Section 2.2.3.2). Natural attenuation processes within the lower concentration portion of the plume will be more effective after the ongoing source of contamination is greatly reduced by the ERD treatment component of the remedy (refer to Section 2.2.5.7).
SS016	GET	4 – Bioreactor and GET	Alternative 4 – Bioreactor and GET at Site SS016 best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (62 years). The main factors considered in the FFS criteria evaluations included the following: the bioreactor and GET system components of the Site SS016 remedy have already been implemented within an area of restricted access and ongoing military flightline operations, ERD treatment via a bioreactor was successfully demonstrated as being effective for addressing the residual DNAPL principal threat wastes and the highest concentration portions of the Site SS016 plume, GET system operation has been demonstrated to be effective at remediating the remainder of the higher concentration plume, and the capital costs for both the bioreactor and GET system components of the remedy have already been largely incurred. Use of an in situ bioreactor under Alternative 4 will satisfy the statutory preference for treatment. Off-base EPA-approved vendor treatment of contaminant-laden LGAC will also satisfy the statutory preference for treatment. Use of organic mulch to facilitate in situ ERD treatment processes in the bioreactor provides an aspect of GSR. Implementation of ROD Alternative 4 at Site SS016 follows approximately a decade of interim GET system operation. Operation of the GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system within this portion of the plume was shut down in 2010 for a successful ERD treatment demonstration via the bioreactor (refer to Section 2.2.3.1). The remainder of the GET system remained in operation and continues to operate successfully (refer to Section 2.2.2.2).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
ST027B	MNA[c]	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (50 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site ST027B represents a transition from MNA as the POCO program presumptive remedy for the site and a period of MNA assessment after CERCLA contaminants were detected in 1999. Site ST027B was not included in the NEWIOU Groundwater IROD, and MNA Assessment was not formally selected as the interim remedy. However, long-term groundwater monitoring of the site was conducted under the Travis AFB GSAP. The data were obtained by the GSAP monitoring support using natural attenuation processes to remediate the plume (refer to Section 2.2.5.8).
SS029	GET	3 – GET	Alternative 3 – GET at Site SS029 best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (62 years). The main factors considered in the FFS criteria evaluations included the following: the components of the Site SS029 GET system have already been implemented within an area of restricted access and ongoing military flightline operations, long-term interim GET system operation has been demonstrated to be effective at remediating the combined Site SS016 and SS029 plumes and preventing plume migration, and the capital costs for the Site SS029 GET system have already been incurred. Off-base EPA-approved vendor treatment of contaminant-laden LGAC will also satisfy the statutory preference for treatment. Implementation of ROD Alternative 3 – GET at Site SS029 represents a transition from approximately a decade of successful interim GET system operation (refer to Section 2.2.1). The contaminant plume at Site SS029 includes contaminants migrating to the site from the hydraulically upgradient Site SS016 plume.

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
SS030	GET	3 – GET	Alternative 3 – GET best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (22 years). The main factor considered in the FFS criteria evaluations was that the GET remedy components have already been implemented and have been demonstrated to be effective at remediating the site plume. Optimization of the interim GET system will be conducted during 2013 by installing an additional extraction well to improve hydraulic capture. Following this optimization measure, the GET system capital costs will have already been incurred. Off-base EPA-approved vendor treatment of contaminant-laden LGAC will also satisfy the statutory preference for treatment. Implementation of ROD Alternative 3 – GET at Site SS030 represents a transition from approximately a decade of successful interim GET system operation (refer to Section 2.2.1).
SD031	GET and MNA Assessment	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (15 years). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SD031 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term interim GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the plume (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediation of the entire plume under the site conditions (refer to Section 2.2.5.1).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
SD033[a]	GET and MNA Assessment[d]	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SD033 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD033 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediation of the entire plume under the site conditions (refer to Section 2.2.5.9).
SD034[a]	GET (coordinated with Site SD037) with Free Product Removal[d]	7 – Passive Skimming and EA	Alternative 7 – Passive Skimming and EA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factors considered in the FFS criteria evaluations included the following: the passive skimming and monitoring well components of the remedy have already been implemented, the processes of passive skimming and natural attenuation have been demonstrated to be effective at removing the residual LNAPL principal threat waste (i.e., free-phase Stoddard solvent containing dissolved COCs) and remediating the dissolved site plume, and the capital costs of passive skimming and monitoring have already been incurred.

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
			Implementation of ROD Alternative 7 – Passive Skimming and EA at Site SD034 follows approximately a decade of successful passive skimming of free-phase Stoddard solvent and interim GET system operation within the higher concentration portion of the plume, combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the passive skimming and GET systems (as part of the WIOU plume). Passive skimming has removed Stoddard solvent (containing dissolved COCs) to the degree that it is only intermittently measured, and the GET system component of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD034 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.9).
SS035[a]	GET and MNA Assessment[d]	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factors considered in the FFS criteria evaluations included the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SS035 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the WIOU plume, including Site SS035, combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD034 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediation of the entire plume under the site conditions (refer to Section 2.2.5.9).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
SD036[a]	GET and MNA Assessment[d]	5 – EVO and EA	Alternative 5 – EVO and EA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factors considered in the FFS criteria evaluations included the following: the EVO injection component of the remedy has already been mostly implemented during the ERD treatment demonstration, the EA monitoring well components have already been implemented, ERD treatment via EVO injection to address the residual DNAPL principal threat wastes and the higher concentration portion of the plume has been successfully demonstrated (refer to Section 2.2.3.2), the processes of natural attenuation have been demonstrated to be effective at remediating the lower concentration portion of the plume (refer to Section 2.2.5.9), and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR. Implementation of ROD Alternative 5 – EVO and EA at Site SS036 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the WIOU plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. Operation of the interim GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA has been shut down for an ERD treatment demonstration and contaminant rebound study since 2010. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD036 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediating the lower concentration portions of the WIOU plume, including the Site SD036 plume component (refer to Section 2.2.5.9).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
SD037[a]	GET and MNA Assessment[d]	5 – EVO and EA	Alternative 5 – EVO and EA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factors considered in the FFS criteria evaluations included the following: the EVO injection well components of the remedy have already been mostly implemented during the ERD treatment demonstration, the EA monitoring well components have already been implemented, ERD treatment via EVO injection to address the principal threat wastes and the higher concentration portion of the plume has been successfully demonstrated (refer to Section 2.2.3.2), the processes of natural attenuation have been demonstrated to be effective at remediating the lower concentration portion of the plume (refer to Section 2.2.5.9), and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR. Implementation of ROD Alternative 5 – EVO and EA at Site SS037 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the WIOU plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. Operation of the interim GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA has been shut down for an ERD treatment demonstration and contaminant rebound study since 2010. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD037 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediating the lower concentration portions of the WIOU plume, including the Site SD037 plume component (refer to Section 2.2.5.9).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
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Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
DP039	GET and MNA Assessment	6 – Bioreactor, Phytoremediation, EVO PRB, and EA	Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (58 years). The main factors considered in the FFS criteria evaluations included the following: the bioreactor, phytoremediation, EVO PRB, and EA monitoring well components have already been implemented during the period of interim remediation; ERD treatment via bioreactor and EVO PRB have been successfully demonstrated as being effective in treating the residual DNAPL principal threat wastes and the higher concentration portions of the plume; biological treatment via phytoremediation has been successfully demonstrated as being effective in treating a portion of the higher concentration plume; and the processes of natural attenuation were assessed as likely to be effective at remediating the lower concentration portion of the plume when combined with the bioreactor, phytoremediation, and EVO PRB remedy components. The capital costs of the bioreactor, area of phytoremediation, EVO PRB, and EA monitoring wells have already been largely incurred. Use of a bioreactor and EVO injection to facilitate ERD and biological treatment using phytoremediation will satisfy the statutory preference for treatment. Use of food-grade EVO and planted trees will provide aspects of GSR. Implementation of ROD Alternative 6 at Site DP039 follows approximately a decade of successful interim GET system operation combined with an assessment of MNA in the lower concentration portion of the plume. A successful phytoremediation treatability study was conducted within the higher concentration portion of the site plume located hydraulically downgradient of the GET system. The assessment of MNA was conducted in the lower concentration portion of the plume located hydraulically downgradient of the GET system and area of phytoremediation. Operation of the GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA was shut down in 2008 for a successful ERD treatment demonstration via the bioreactor. Another successful ERD treatment demonstration via an EVO PRB began in 2010 (refer to Section 2.2.3.2). Successful biological treatment using phytoremediation had been ongoing since 1998 (refer to Section 2.2.4).The assessment of MNA during the period of interim remediation indicated that natural physical, chemical, and biological processes alone were not adequate for remediation of the plume, and additional measures were needed to further reduce the influx of contamination from the higher concentration portions of the plume (i.e., using the bioreactor, area of phytoremediation, and EVO PRB) (refer to Section 2.2.5.10).

TABLE 2.9-2
Summary of Sites and Remedial Alternatives
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Transition		Summary of Remedy Transition Rationale
	Interim Remedial Action[a]	Remedial Alternative[b]	
			Use of organic mulch to facilitate in situ ERD treatment processes in the bioreactor provides an aspect of GSR. Use of a solar-powered pump to provide groundwater to the bioreactor provides another aspect of GSR. Also, use of planted trees for in situ biological treatment and food-grade EVO to facilitate in situ ERD treatment processes within the PRB provide additional aspects of GSR.
SS041	GET	1 – NFA	Alternative 1 – NFA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (0 years). Cleanup levels were achieved during the period of interim remediation. The main factors considered in the FFS criteria evaluations included the following: groundwater cleanup levels have already been achieved by the interim GET system, and Site SS041 is currently in No Further Remedial Action Plan status under a consensus statement signed by representatives of the AF and regulatory agencies (Travis AFB, 2005).
SD043	GET[d]	2 – MNA	Alternative 2 – MNA best satisfied the threshold and primary balancing criteria evaluated in the FFS and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years, as a component of the overall WIOU plume). The main factor considered in the FFS criteria evaluations was that site groundwater cleanup levels have already been achieved by the interim GET system, although groundwater concentrations will continue to be monitored by the GRIP under Alternative 2 – MNA to provide verification of the plume concentrations.

[a] IRAs were developed in the final NEWIOU FS Report (Radian, 1996b) or final WABOU FS Report (CH2M HILL, 1998a) and were then implemented in accordance with the final NEWIOU Groundwater IROD (Travis AFB, 1998) or final WABOU Groundwater IROD (Travis AFB, 1999).

[b] Remedial alternatives were developed in the final FFS (CH2M HILL, 2011a) and were made available for public review and comment in the final *Proposed Plan for Groundwater Cleanup* (Travis AFB, 2012b).

[c] Formerly managed under the POCO program as a site with only petroleum fuels contamination.

[d] Component site of WIOU collection of site plumes.

2.9.2 Common Elements and Distinguishing Features of Each Alternative

This section provides a summary of the elements common to each alternative and features that distinguish one (1) alternative from another. Summaries of the common elements and distinguishing features for each of the alternatives considered at Sites FT004, FT005, LF006, LF007 (Subareas LF007B, LF007C, and LF007D), LF008, SS015, SS016, ST027B, SS029, SS030, SD031, SD033, SD034, SS035, SD036, SD037, DP039, and SD043 are provided in Tables 2.9-3 through 2.9-22.

All of the remedial alternatives, except Alternative 1 – No Further Action, have the common element of LUCs. Alternative 1 has no common elements or distinguishing features. The key distinguishing feature between Alternatives 2 through 7 is treatment. Alternatives 3 through 6 include treatment, with Alternatives 3 and 4 including ex situ treatment and Alternatives 4, 5, and 6 including in situ ERD treatment. Alternatives 3 and 4 include groundwater extraction with ex situ treatment using LGAC and discharge to the stormwater drainage system. Alternatives 5 and 6 both include in situ ERD treatment using EVO injection. Alternatives 4 and 6 both include in situ ERD treatment with bioreactors. Alternative 6 also includes in situ biological treatment using phytoremediation.

Passive skimming to remove free-phase Stoddard solvent is the distinguishing feature of Alternative 7. At Site SD034, Alternative 7 includes the physical removal of Stoddard solvent, containing dissolved COCs, floating on the groundwater table and the treatment or recycling of recovered product by an off-base EPA-approved vendor. Stoddard solvent is present only at Site SD034.

Alternatives 2, 5, and 7 use natural physical, chemical, and biological processes to remediate COCs in groundwater. Alternative 2 includes MNA that was successfully demonstrated by long-term interim MNA assessments, positive results of contaminant rebound studies, and positive results of an aerobic chlorinated cometabolism enzyme study. In addition to treatment or passive skimming, Alternatives 5 and 7 include EA, which will remediate COCs in downgradient groundwater by the reduced influx of contaminants from the treated portions of the higher concentration plumes.

TABLE 2.9-3
Common Elements and Distinguishing Features – Site FT004
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET***
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).	Existing GET system operated successfully during period of interim remediation but became increasingly cost-ineffective as concentrations decreased (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	600 to 800 pounds per year of spent carbon from the NGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	35	35
Estimated capital cost ($)	0	0
Estimated annual O&M cost ($)	2,703	4,088
Estimated total O&M present worth ($)	59,641	90,200
Estimated periodic costs present worth ($)	0	73,337
Estimated total cost present worth ($)	59,641	163,538
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	35	35
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

* Existing IRA includes GET combined with MNA assessment.

Note:

ARAR = applicable or relevant and appropriate requirement

TABLE 2.9-4
Common Elements and Distinguishing Features – Site FT005
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET***
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated at similar sites during period of MNA assessment (refer to Section 2.2.5).	Reliable. Existing GET system operated successfully during period of interim remediation (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	Approximately 12,000 pounds per year of spent carbon from the SBBGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	43	10
Estimated capital cost ($)	0	0
Estimated annual O&M cost ($)	4,024	2,596
Estimated total O&M present worth ($)	101,633	41,239
Estimated periodic costs present worth ($)	0	53,034
Estimated total cost present worth ($)	101,633	94,273
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	43	21
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-5
Common Elements and Distinguishing Features – Site LF006
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	2-MNA*
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of interim remediation using MNA (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	5
Estimated capital cost ($)	0
Estimated annual O&M cost ($)	2,451
Estimated total O&M present worth ($)	11,909
Estimated periodic costs present worth ($)	0
Estimated total cost present worth ($)	11,909
Discount rate (percent)	1.6
Number of years over which cost is projected	5
Use of presumptive remedies and/or innovative technologies	No

* Existing IRA.

TABLE 2.9-6
Common Elements and Distinguishing Features – Subarea LF007B
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	2-MNA[a]
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	0[b]
Estimated capital cost ($)	0
Estimated annual O&M cost ($)	817
Estimated total O&M present worth ($)	0
Estimated periodic costs present worth ($)	0
Estimated total cost present worth ($)	0
Discount rate (percent)	0
Number of years over which cost is projected	0
Use of presumptive remedies and/or innovative technologies	No

[a] Existing IRA is MNA assessment.
[b] Cleanup levels achieved during period of interim remediation.

TABLE 2.9-7
Common Elements and Distinguishing Features – Subarea LF007C
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	3-GET*
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Existing GET system operated successfully during period of interim remediation, but required optimization to improve performance (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	600 to 800 pounds per year of spent carbon from the NGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	26
Estimated capital cost ($)	48,706
Estimated annual O&M cost ($)	15,258
Estimated total O&M present worth ($)	311,227
Estimated periodic costs present worth ($)	36,288
Estimated closeout cost present worth ($)	36,173
Estimated total cost present worth ($)	432,334
Discount rate (percent)	2.7
Number of years over which cost is projected	26
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)

* Existing IRA is GET for the entirety of the on-base and off-base portions of the plume.

TABLE 2.9-8
Common Elements and Distinguishing Features – Subarea LF007D
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	2-MNA[a]
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	23 to 49[b]
Estimated capital cost ($)	0
Estimated annual O&M cost ($)	1,069
Estimated total O&M present worth ($)	18,139
Estimated periodic costs present worth ($)	0
Estimated total cost present worth ($)	18,139
Discount rate (percent)	2.7
Number of years over which cost is projected	23
Use of presumptive remedies and/or innovative technologies	No

[a] Existing IRA is MNA assessment.
[b] Revised from the FFS (CH2M HILL, 2011a) value of greater than 100 years after re-evaluation of contaminant-specific degradation rates. The basis for this revision is provided in the *2012 Groundwater Sampling and Analysis Program Technical Memorandum* (CH2M HILL, 2012g).

TABLE 2.9-9
Common Elements and Distinguishing Features – Site LF008
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET[a]**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of interim remediation (refer to Section 2.2.5).	Existing GET system operated successfully during period of interim remediation but was demonstrated to be ineffective for the residual pesticides contamination sorbed to soil particles (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	100 to 110[b]	100 to 110[b]
Estimated capital cost ($)	0	0
Estimated annual O&M cost ($)	2,264	519
Estimated total O&M present worth ($)	46,182	10,587
Estimated periodic costs present worth ($)	0	24,959
Estimated total cost present worth ($)	46,182	35,545
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

[a] Existing IRA is GET for the entirety of the plume.
[b] Remediation time governed by total concentration of organochlorine pesticides in unfiltered groundwater samples. Cleanup levels are already achieved in filtered groundwater samples.

TABLE 2.9-10
Common Elements and Distinguishing Features – Site SS015
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA[a]	**5-EVO and EA**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Not reliable. Natural attenuation processes alone were not successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).	Reliable. In situ ERD treatment using EVO injection was successfully demonstrated during the period of interim remediation (refer to Section 2.2.3.2). Natural attenuation processes successfully demonstrated at similar sites during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	None
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	-[b]	70
Estimated capital cost ($)	0	136,971
Estimated annual O&M cost ($)	2,703	1,635
Estimated total O&M present worth ($)	55,137	33,344
Estimated periodic costs present worth ($)	0	188,159
Estimated total cost present worth ($)	55,137	358,474
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	No	Yes – in situ ERD (innovative)

[a] Existing IRA is MNA assessment.
[b] MNA demonstrated to be ineffective during the period of interim remediation. Groundwater contaminant concentrations were increasing in some site monitoring wells, and a remediation time could not be estimated.

TABLE 2.9-11
Common Elements and Distinguishing Features – Site SS016
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET[a]	**4-Bioreactor and GET**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Existing GET system operated successfully during period of interim remediation. However, GET within the higher concentration portion of the plume became increasingly ineffective as concentrations were reduced at an ever decreasing rate (refer to Section 2.2.2).	Reliable. In situ ERD treatment using a bioreactor was successfully demonstrated during the period of interim remediation (refer to Section 2.2.3.1). Existing GET system component operated successfully during period of interim remediation.
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	> 100[b]	62
Estimated capital cost ($)	0	306,116
Estimated annual O&M cost ($)	34,517	35,928
Estimated total O&M present worth ($)	704,077	732,860
Estimated periodic costs present worth ($)	57,641	93,194
Estimated total cost present worth ($)	761,718	1,116,162
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)	Yes – GET (presumptive) and in situ ERD (innovative)

[a] Existing IRA is GET.
[b] The probable presence of DNAPL results in an extended and indeterminate remediation time.

TABLE 2.9-12
Common Elements and Distinguishing Features – Site ST027B
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**2-MNA***
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	50
Estimated capital cost ($)	0
Estimated annual O&M cost ($)	2,451
Estimated total O&M present worth ($)	49,996
Estimated periodic costs present worth ($)	0
Estimated total cost present worth ($)	49,996
Discount rate (percent)	2.7
Number of years over which cost is projected	30
Use of presumptive remedies and/or innovative technologies	No

* Existing IRA is MNA assessment.

TABLE 2.9-13
Common Elements and Distinguishing Features – Site SS029
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	3-GET[a]
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Existing GET system operated successfully during period of interim remediation (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 12,000 pounds per year of spent carbon from the SBBGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	62[b]
Estimated capital cost ($)	0
Estimated annual O&M cost ($)	13,835
Estimated total O&M present worth ($)	282,210
Estimated periodic costs present worth ($)	57,640
Estimated total cost present worth ($)	339,851
Discount rate (percent)	2.7
Number of years over which cost is projected	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)

[a] Existing IRA is GET for the entirety of the plume.
[b] Remediation time is affected by interactions with the hydraulically upgradient Site SS016 plume.

TABLE 2.9-14
Common Elements and Distinguishing Features – Site SS030
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	3-GET*
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. GET system operated successfully during period of interim remediation, but required optimization to improve performance (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 12,000 pounds per year of spent carbon from the SBBGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5
Estimated time to reach remediation goals (years)	22
Estimated capital cost ($)	17,532
Estimated annual O&M cost ($)	13,835
Estimated total O&M present worth ($)	227,351
Estimated periodic costs present worth ($)	49,507
Estimated total cost present worth ($)	294,390
Discount rate (percent)	2.7
Number of years over which cost is projected	22
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-15
Common Elements and Distinguishing Features – Site SD031
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET***
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).	Existing GET system operated successfully during period of interim remediation but became increasingly cost-ineffective as concentrations decreased (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	600 to 800 pounds per year of spent carbon from the NGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	15	15
Estimated capital cost ($)	0	0
Estimated annual O&M cost ($)	2,451	2,970
Estimated total O&M present worth ($)	30,480	26,447
Estimated periodic costs present worth ($)	0	15,656
Estimated total cost present worth ($)	30,480	42,103
Discount rate (percent)	2.45	2.2
Number of years over which cost is projected	15	15
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

* Existing IRA.

TABLE 2.9-16
Common Elements and Distinguishing Features – Site SD033
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET[a]**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).	Existing GET system operated successfully during period of interim remediation but became increasingly ineffective as concentrations decreased (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	60[b]	91[b]
Estimated capital cost ($)	0[c]	0[c]
Estimated annual O&M cost ($)	2,063	2,409
Estimated total O&M present worth ($)	42,082	49,140
Estimated periodic costs present worth ($)	0	16,638
Estimated total cost present worth ($)	42,082	65,778
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

[a] Existing IRA is a combination of GET and MNA assessment.

[b] Site SD033 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Capital costs for the Site SD033 GET system and monitoring well network have already been incurred.

TABLE 2.9-17
Common Elements and Distinguishing Features – Site SD034
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET [a]	**7-Passive Skimming and EA**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Existing GET operated successfully during period of interim remediation but became increasingly ineffective as concentrations decreased (refer to Section 2.2.2).	Reliable. Existing passive skimming system operated successfully during period of interim remediation (refer to Section 2.2.2). Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 0.5 gallon of Stoddard solvent, containing dissolved COCs, removed annually. Low hazard.	Approximately 0.5 gallon of Stoddard solvent, containing dissolved COCs, removed annually. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	91[b]	60[b]
Estimated capital cost ($)	0[c]	0[c]
Estimated annual O&M cost ($)	4,114	3,655
Estimated total O&M present worth ($)	83,924	80,639
Estimated periodic costs present worth ($)	24,363	0
Estimated total cost present worth ($)	108,288	80,639
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)	No

[a] Existing IRA is a combination of GET, passive skimming, and MNA assessment.

[b] Site SD034 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Capital costs for the Site SD034 GET system, passive skimming, and monitoring well network have already been incurred.

TABLE 2.9-18
Common Elements and Distinguishing Features – Site SS035
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	2-MNA[a]
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None
Estimated time for design and construction (years)	0
Estimated time to reach remediation goals (years)	60[b]
Estimated capital cost ($)	0[c]
Estimated annual O&M cost ($)	1,320[c]
Estimated total O&M present worth ($)	2,537[c]
Estimated periodic costs ($)	0[c]
Estimated total cost present worth ($)	2,537[c]
Discount rate (percent)	2.7[c]
Number of years over which cost is projected	2[c]
Use of presumptive remedies and/or innovative technologies	No

[a] Existing IRA is MNA assessment.

[b] Site SS035 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Site SS035 has achieved cleanup levels, and 2 years of monitoring will be completed prior to evaluating the site for closure.

TABLE 2.9-19
Common Elements and Distinguishing Features – Site SD036
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET[a]	5-EVO and EA
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Existing GET system operated successfully during period of interim remediation. However, GET within the higher concentration portion of the plume became increasingly ineffective as concentrations were reduced at an ever decreasing rate (refer to Section 2.2.2).	Reliable. In situ ERD treatment using EVO injection was successfully demonstrated during the period of interim remediation (refer to Section 2.2.3.2). Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.	None
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	91[b]	60[b]
Estimated capital cost ($)	0[c]	254,210
Estimated annual O&M cost ($)	3,979	1,635
Estimated total O&M present worth ($)	81,165	33,344
Estimated periodic costs present worth ($)	18,940	472,321
Estimated total cost present worth ($)	100,106	759,875
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)	Yes – in situ ERD (innovative)

[a] Existing IRA is a combination of GET and MNA assessment.

[b] Site SD036 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Capital costs for the Site SD036 GET system and monitoring well network have already been incurred.

TABLE 2.9-20
Common Elements and Distinguishing Features – Site SD037
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET[a]	**5-EVO and EA**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Existing GET system operated successfully during period of interim remediation. However, GET within the higher concentration portion of the plume became increasingly ineffective as concentrations were reduced at an ever decreasing rate (refer to Section 2.2.2).	Reliable. In situ ERD treatment using EVO injection was successfully demonstrated during the period of interim remediation (refer to Section 2.2.3.2). Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.	None
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	91[b]	60[b]
Estimated capital cost ($)	0[c]	400,749
Estimated annual O&M cost ($)	9,032	1,635
Estimated total O&M present worth ($)	184,237	33,344
Estimated periodic costs present worth ($)	91,513	864,487
Estimated total cost present worth ($)	275,751	1,298,581
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)	Yes – in situ ERD (innovative)

[a] Existing IRA is a combination of GET and MNA assessment.

[b] Site SD037 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Capital costs for the Site SD037 GET system and monitoring well network have already been incurred.

TABLE 2.9-21
Common Elements and Distinguishing Features – Site DP039
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**3-GET[a]**	**6-Bioreactor, Phytoremediation, EVO PRB, and EA**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Existing GET system operated successfully during period of interim remediation. However, GET within the higher concentration portion of the plume became increasingly ineffective as concentrations were reduced at an ever decreasing rate (refer to Section 2.2.2).	Reliable. In situ ERD treatment using a bioreactor and EVO PRB was successfully demonstrated during the period of interim remediation (refer to Sections 2.2.3.1 and 2.2.3.2). The phytoremediation component was also successfully demonstrated during the period of interim remediation (refer to Section 2.2.4). Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.	None
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	70	58
Estimated capital cost ($)	0[b]	291,678
Estimated annual O&M cost ($)	2,039	2,629
Estimated total O&M present worth ($)	41,592	53,627
Estimated periodic costs present worth ($)	32,088	832,312
Estimated total cost present worth ($)	73,680	1,177,618
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	Yes – GET (presumptive)	Yes – in situ bioreactor, biological treatment using planted trees, and solar-powered pumps (innovative)

[a] Existing IRA is a combination of GET and MNA.
[b] Capital costs for the Site DP039 GET system have already been incurred.

TABLE 2.9-22
Common Elements and Distinguishing Features – Site SD043
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	**3-GET[a]**
Key ARARs associated with alternative	Refer to Tables B-1, B-2, and B-3.	Refer to Tables B-1, B-2, and B-3.
Long-term reliability of remedy	Reliable. Natural attenuation processes successfully demonstrated during period of MNA assessment (refer to Section 2.2.5).	Reliable. GET system operated successfully during period of interim remediation (refer to Section 2.2.2).
Quantity of untreated waste and treatment residuals to be disposed of off-site or managed on-site in a containment system and the degree of hazard remaining in such material	None	Approximately 20,000 pounds per year of spent carbon from the CGWTP is currently recycled by an off-base vendor. Low hazard.
Estimated time for design and construction (years)	0.5	0.5
Estimated time to reach remediation goals (years)	60[b]	91[b]
Estimated capital cost ($)	0[c]	0[c]
Estimated annual O&M cost ($)	1,288	1,461
Estimated total O&M present worth ($)	26,273	29,802
Estimated periodic costs present worth ($)	0	8,319
Estimated total cost present worth ($)	26,273	38,121
Discount rate (percent)	2.7	2.7
Number of years over which cost is projected	30	30
Use of presumptive remedies and/or innovative technologies	No	Yes – GET (presumptive)

[a] Existing IRA is a combination of GET and MNA assessment.

[b] Site SD043 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

[c] Capital costs for the Site SD043 GET system and monitoring well network have already been incurred.

2.9.3 Expected Outcome of Each Alternative

Tables 2.9-23 through 2.9-42 provide summaries of the expected outcomes of the alternatives considered for each site.

TABLE 2.9-23
Expected Outcomes of Each Alternative – Site FT004
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA**	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	35	35
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	35	35
Other impacts or benefits associated with alternative	Lower energy requirements and less GHG emission compared with GET system.	Uses existing IRA GET system infrastructure.

* Existing IRA is a combination of GET and MNA assessment.

TABLE 2.9-24
Expected Outcomes of Each Alternative – Site FT005
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA**	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	43	10
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	43	10
Other impacts or benefits associated with alternative	Lower energy requirements and less GHG emission compared with GET system.	Uses existing IRA GET system infrastructure.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-25
Expected Outcomes of Each Alternative – Site LF006
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**2-MNA***
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	5
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	5
Other impacts or benefits associated with alternative	Minimal GHG generation.

* Existing IRA is MNA for the entirety of the plume.

TABLE 2.9-26
Expected Outcomes of Each Alternative – Subarea LF007B
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**2-MNA[a]**
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	0[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	0[b]
Other impacts or benefits associated with alternative	Minimal GHG generation.

[a] Existing IRA is MNA assessment for the entirety of the plume.
[b] Current contaminant concentrations do not exceed cleanup levels.

TABLE 2.9-27
Expected Outcomes of Each Alternative – Subarea LF007C
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	26
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	26
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure. Incorporates GSR by using solar-powered pumps. Lower energy requirements and less GHG emission compared with a typical GET system.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-28
Expected Outcomes of Each Alternative – Subarea LF007D
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative
	2-MNA[a]
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	23 to 49[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	23 to 49[b]
Other impacts or benefits associated with alternative	Minimal GHG generation.

[a] Existing IRA is MNA assessment for the entirety of the plume.
[b] Revised from the FFS (CH2M HILL, 2011a) value of greater than 100 years after re-evaluation of contaminant-specific degradation rates (CH2M HILL, 2012g).

TABLE 2.9-29
Expected Outcomes of Each Alternative – Site LF008
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	2-MNA	3-GET*
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	> 100	100 to 110
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	> 100	100 to 110
Other impacts or benefits associated with alternative	Lower energy requirements and less GHG emission compared with GET system.	Uses existing IRA GET system infrastructure.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-30
Expected Outcomes of Each Alternative – Site SS015
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA[a]**	**5-EVO and EA**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	-[b]	70
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	-[b]	70
Other impacts or benefits associated with alternative	Minimal GHG generation.	Incorporates GSR by using low-energy in situ bioremediation via EVO to facilitate ERD.

[a] Existing IRA is MNA assessment for the entirety of the plume.
[b] MNA not effective without enhancement. Groundwater contaminant concentrations are increasing.

TABLE 2.9-31
Expected Outcomes of Each Alternative – Site SS016
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**3-GET***	**4-Bioreactor and GET**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	> 100	62
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	> 100	62
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.	Incorporates GSR by using low-energy in situ bioremediation via a bioreactor to facilitate ERD. Replaces energy-intensive OSA 2-Phase extraction and ThOX vapor treatment.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-32
Expected Outcomes of Each Alternative – Site ST027B
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**2-MNA***
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	50
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	50
Other impacts or benefits associated with alternative	Minimal GHG generation.

* Existing IRA is MNA assessment for the entirety of the plume.

TABLE 2.9-33
Expected Outcomes of Each Alternative – Site SS029
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	62
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	62
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure and includes solar-powered pumps.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-34
Expected Outcomes of Each Alternative – Site SS030
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	22
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	22
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.

* Existing IRA is GET for the entirety of the plume.

TABLE 2.9-35
Expected Outcomes of Each Alternative – Site SD031
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA**	**3-GET***
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	15	15
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	15	15
Other impacts or benefits associated with alternative	Lower energy requirements and less GHG emission compared with GET system.	Uses existing IRA GET system infrastructure.

* Existing IRA is a combination of GET and MNA assessment.

TABLE 2.9-36
Expected Outcomes of Each Alternative – Site SD033
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA**	**3-GET[a]**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	60[b]	91[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	60[b]	91[b]
Other impacts or benefits associated with alternative	Lower energy requirements and less GHG emission compared with GET system.	Uses existing IRA GET system infrastructure.

[a] Existing IRA is a combination of GET and MNA assessment.
[b] Site SD033 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

TABLE 2.9-37
Expected Outcomes of Each Alternative – Site SD034
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**3-GET[a]**	**7-Passive Skimming and EA**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	91[b]	60[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	91[b]	60[b]
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.	Lower energy requirements and less GHG emission compared with the IRA GET system.

[a] Existing IRA is a combination of GET, passive skimming, and MNA assessment.
[b] Site SD034 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

TABLE 2.9-38
Expected Outcomes of Each Alternative – Site SS035
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Element	**2-MNA[a]**
Available uses of land upon achieving cleanup levels	Unrestricted
Time frame to achieve available land use (years)	60[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water
Time frame to achieve available groundwater use (years)	60[b]
Other impacts or benefits associated with alternative	Minimal GHG generation.

[a] Existing IRA is MNA assessment for the entirety of the plume.
[b] Site SS035 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

TABLE 2.9-39
Expected Outcomes of Each Alternative – Site SD036
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET[a]	**5-EVO and EA**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	91[b]	60[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	91[b]	60[b]
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.	Incorporates GSR by using low-energy in situ bioremediation via EVO to facilitate ERD. Lower energy requirements and less GHG emission compared with the IRA GET system.

[a] Existing IRA is a combination of GET and MNA assessment.
[b] Site SD036 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

TABLE 2.9-40
Expected Outcomes of Each Alternative – Site SD037
Groundwater Record of Decision, Travis Air Force Base, California

Element	Alternative	
	3-GET[a]	**5-EVO and EA**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	91[b]	60[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	91[b]	60[b]
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.	Incorporates GSR by using low energy in situ bioremediation via EVO to facilitate ERD. Lower energy requirements and less GHG emission compared with GET system.

[a] Existing IRA is a combination of GET and MNA assessment.
[b] Site SD037 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

TABLE 2.9-41
Expected Outcomes of Each Alternative – Site DP039
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**3-GET***	**6-Bioreactor, Phytoremediation, EVO PRB, and EA**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	70	58
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	70	58
Other impacts or benefits associated with alternative	Uses existing IRA GET system infrastructure.	Incorporates multiple GSR components, including a solar-powered groundwater pump to supply a bioreactor, an existing area of planted trees, and an EVO PRB.

* Existing IRA is a combination of GET and MNA assessment.

TABLE 2.9-42
Expected Outcomes of Each Alternative – Site SD043
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Element	**2-MNA**	**3-GET[a]**
Available uses of land upon achieving cleanup levels	Unrestricted	Unrestricted
Time frame to achieve available land use (years)	60[b]	91[b]
Available uses of groundwater upon achieving cleanup levels	Drinking water	Drinking water
Time frame to achieve available groundwater use (years)	60[b]	91[b]
Other impacts or benefits associated with alternative	Minimal GHG generation.	Uses existing IRA GET system infrastructure.

[a] Existing IRA is a combination of GET and MNA assessment.
[b] Site SD043 is a component site within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including the commingled plumes that originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043.

2.10 Summary of Comparative Analysis of Alternatives

In accordance with the NCP, the alternatives for groundwater at Travis AFB were evaluated using the nine (9) criteria described in Section 121(a) and (b) of CERCLA and 40 CFR Section 300.430(e)(9)(i) as cited in NCP Section 300.430(f)(5)(i). These criteria are classified as threshold criteria, balancing criteria, and modifying criteria.

Threshold criteria are standards that an alternative must meet to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—the alternative must meet them or it is unacceptable. The following are classified as threshold criteria:

- Overall protection of human health and the environment
- Compliance with, or an applicable waiver of ARARs

Balancing criteria weigh the tradeoffs between alternatives. These criteria represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. In general, a high rating on one (1) criterion can offset a low rating on another balancing criterion. Five (5) of the nine (9) criteria are considered balancing criteria:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying criteria, which may be considered to the extent that information is available during the FFS, but can be fully considered only after public and regulator comments, are as follows:

- Community acceptance
- State/support agency acceptance

The following sections summarize how well each alternative considered for a site satisfies each evaluation criterion and indicates how it compares with the other alternatives under consideration. Relative rankings of the alternatives considered for each site are presented in Tables 2.10-1 through 2.10-20.

2.10.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment and/or LUCs.

No Further Action generally does not satisfy this threshold criterion. Overall risks of exposure to COCs are relatively small because groundwater is not currently used, no drinking water wells are threatened, and no buildings are overlying areas posing potential indoor air risks. However, there are no provisions to limit direct contact of humans with groundwater until concentrations of COCs allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited

use and unrestricted exposure and indoor air until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health (refer to Table 2.8-2). There are no provisions to reduce or monitor reductions in concentrations of COCs and associated risks.

The remaining alternatives include monitoring to provide early warning if drinking water supply wells, agricultural wells, or human receptors are threatened and LUCs to limit direct contact of humans with groundwater until concentrations of COCs allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure and until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health. For the off-base plumes originating from Subarea LF007C and Sites FT005 and SS030, Travis AFB's existing access and environmental response easements contain legal restrictions preventing the landowners from engaging in water development or soil disturbing activities that could interfere with cleanup activities. These alternatives have also demonstrated the capacity to reduce concentrations of COCs and associated risks.

2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA and NCP Section 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA Section 121(d)(4).

The alternatives have common ARARs under CERCLA Section 121(d)(2) associated with groundwater performance monitoring, cleanup levels, and LUCs. Federal MCLs are a relevant and appropriate requirement for groundwater except when there is no federal MCL for a COC or the state MCL for that COC is more stringent than the federal MCL. Groundwater does not currently meet MCLs for VOCs (primarily TCE) and organochlorine pesticides (primarily alpha-chlordane). ARARs for Travis AFB groundwater are included as Appendix C – Summary of ARARs and TBCs.

As demonstrated by the IRAs and current monitoring data, COCs in groundwater have decreased over time, have achieved the MCLs at Subarea LF007B (additional monitoring is required) and Site SS041, and have the potential to achieve the MCLs at the remaining sites. Because no provisions exist to monitor and confirm compliance with ARARs, No Further Action does not satisfy this threshold criterion. Therefore, the No Further Action alternative is not considered further in the comparative analysis of alternatives.

At Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, SS035, and SD043, a continuing source is absent, and natural attenuation processes have already reduced COCs, indicating that the sites are suitable for MNA (Alternative 2). COCs at Subarea LF007B are less than MCLs and at Site LF006 are less than or near MCLs. At Subarea LF007B, although current monitoring data already indicate COC concentrations less than MCLs, monitoring will continue at least 2 more years to meet regulatory agencies' requirements to confirm that cleanup levels have been achieved. Current concentrations of TCE at Site LF006 are 7.1 µg/L, compared with the cleanup level of 5 µg/L. The existing

well networks are adequate to monitor natural attenuation processes and compliance with ARARs.

At Site LF008, Alternative 3 – GET, also evaluated for the site, has a lower potential of achieving the MCLs and complying with chemical-specific ARARs than Alternative 2. After 7.5 years of GET, no significant change in pesticide concentrations was evident (see Section 2.2.5.6). A rebound study was initiated, and results indicate that the COCs are not dissolved in groundwater but rather sorbed to the fine soil particles suspended in the groundwater.

Alternative 3 – GET has a high potential of achieving the MCLs and complying with chemical-specific ARARs at Site FT005, Subarea LF007C, and Sites SS029 and SS030. Although decreasing COC concentration trends over the course of the rebound study initiated in 2007 and a receding plume may indicate that Alternative 2 – MNA may effectively achieve MCLs at Site FT005, recently observed increases in the concentrations of COCs at some wells indicate that GET may be more likely to achieve MCLs. At Subarea LF007C and Site SS030, only GET was evaluated because COCs have migrated beyond the Base boundary, and hydraulic capture of the plume is required. Optimization measures were conducted at Subarea LF007C and Site SS030 in 2011-2012, which improved mass removal rates (see Section 2.2.2). At Site SS029, only GET was evaluated because COCs are near the southern Base boundary, and it is required to hydraulically capture the plume. A supplemental study was conducted at Site SS029 in 2012 to evaluate optimization of the GET system (see Section 2.2.6).

At Subarea LF007C, Alternative 3 – GET must also comply with location-specific ARARs regarding the operation and optimization of the GET system within a well established vernal pool. Operational constraints with the GET system have been resolved with the USFWS.

At Sites SS015, SS016, SD036, SD037, and DP039, COC concentrations indicate the presence of DNAPLs; therefore, reductions in COCs dissolved in groundwater and achieving cleanup levels may be more difficult with Alternative 2 – MNA compared with Alternative 5 – EVO and EA evaluated for Site SS015, with Alternative 3 – GET compared with Alternative 4 – Bioreactor and GET evaluated for Site SS016, Alternative 3 – GET compared with Alternative 5 – EVO and EA evaluated for Sites SD036 and SD037, and Alternative 3 – GET compared with Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA evaluated for Site DP039. Alternatives 4, 5, and 6 provide for additional treatment of the highest residual concentrations of COCs in groundwater. EVO injections conducted at Sites SS015, SD036, SD037, and DP039 have successfully demonstrated the viability of in situ ERD treatment processes, and performance monitoring results indicate contaminants are being successfully degraded (see Section 2.2.3.2).

At Site SD034, Alternative 3 – GET and Alternative 7 – Passive Skimming and EA are equally expected to achieve the MCLs and comply with chemical-specific ARARs because they would remove Stoddard solvent (LNAPL), containing dissolved COCs, floating on the groundwater table.

2.10.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Each of the groundwater alternatives has the potential to provide long-term and permanent remedies that will meet cleanup levels and allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure to groundwater and indoor air at buildings overlying groundwater plumes at Sites FT004, SS015, SS016, SS029, SD033, SD034, SS035, SD036, SD037, and DP039. If residual TPH is present at one (1) or more sites after RAOs are achieved, then those sites will be transferred from CERCLA to the POCO program. Travis AFB has previously accomplished this type of program transfer (e.g., Site ST032 [ERP to POCO] and Site ST027B [POCO to ERP]) by preparing a technical memorandum/ report that provides the technical basis for the transfer of site administration. This technical memorandum will then be reviewed and approved by the regulatory agencies. After obtaining concurrence, Travis AFB will then take the necessary administrative actions to transfer the site from the ERP to the POCO program. This transfer will also be documented in subsequent five-year review reports.

At Sites SS015, SS016, SD036, SD037, and DP039, COC concentrations indicate the presence of DNAPLs. As discussed with the previous criterion, treatment of the highest residual concentrations of COCs in groundwater with EVO, a bioreactor, and/or phytoremediation (Alternatives 4, 5, and 6) is more likely to provide a long-term and permanent remedy compared with MNA (Alternative 2) or GET (Alternative 3).

At Site FT005, as discussed with the previous criterion, GET (Alternative 3) is more likely to provide a long-term and permanent remedy compared with MNA (Alternative 2).

At Site LF008, as discussed with the previous criterion, MNA (Alternative 2) is more likely to provide a long-term and permanent remedy compared with treatment with GET (Alternative 3).

2.10.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy. The NCP prefers remedial actions where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversibly reduce contaminant mobility, or reduce total volume of contaminated media.

Alternative 2 – MNA does not directly result in the reduction of toxicity, mobility, or volume of COCs in groundwater through treatment. Naturally occurring physical, chemical, and biological processes will be monitored at each site as reductions are achieved. Only MNA was evaluated for Site LF006, Subareas LF007B and LF007D, and Site ST027B because no active IRAs were implemented at these sites, and natural attenuation processes have been demonstrated at these sites to effectively reduce the toxicity and volume of COCs in groundwater by MNA assessments and studies (see Section 2.2.5). For Site SS035, only MNA

was evaluated because while GET was operational during the period of interim remediation, COC concentrations in the area beyond the influence of the GET system declined, and the plume was receding (see Section 2.2.5.9).

Alternatives 3, 4, 5, 6, and 7 include treatment as components of the remedies.

Alternative 3 – GET and Alternative 4 – Bioreactor and GET involve the off-base transfer and treatment/recycling of activated carbon that is laden with contaminants adsorbed from extracted groundwater. For Site FT005, Subarea LF007C, and Sites SS029 and SS030, Alternative 3 – GET uses onsite LGAC treatment of groundwater extracted from plumes with low-level threat wastes to provide permanent reductions in the toxicity and volume of contaminants. Spent carbon containing adsorbed contaminants is then regenerated by an EPA-approved off-base vendor. At Site FT005, Subarea LF007C, and Sites SS029 and SS030, only GET was evaluated because it will hydraulically capture the plumes that have either migrated beyond the Base boundary (Site FT005, Subarea LF007C, and Site SS030) or are near the southern Base boundary (Site SS029).

For Sites FT004, FT005, LF008, SD031, and SD043, which included treatment with GET as an IRA, both Alternatives 2 and 3 were evaluated. At Site LF008, after 7.5 years of GET, no significant change in pesticide concentrations was evident (see Section 2.2.5.6). Rebound study results indicate that the COCs are not dissolved in groundwater but rather sorbed to the fine soil particles suspended in the groundwater. Because Alternative 3 will not reduce the toxicity, mobility, or volume of COCs, Alternative 2 better satisfies this criterion for Site LF008. For Sites FT004, FT005, SD031, and SD043, because Alternative 3 includes treatment, it better satisfies this criterion.

Alternative 4 – EVO and GET (Site SS016); Alternative 5 – EVO and EA (Sites SS015, SD036, and SD037); and Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA (Site DP039) provide for in situ treatment of the principal threat wastes and the highest concentration portions of the site plumes to permanently reduce the toxicity and volume of contaminants.

Alternative 7 – Passive Skimming and EA provides for physical removal of the free-phase Stoddard solvent (LNAPL containing dissolved COCs) principal threat waste that poses an ongoing source of contamination to the underlying groundwater at Site SD034. Removal of the Stoddard solvent will result in a reduction of the volume of COCs dissolving into the groundwater from the Stoddard solvent source material. The Stoddard solvent removed by passive skimming will be treated or recycled by an EPA-approved off-base vendor. Site SD034 is the only site with free-phase Stoddard solvent contamination and the only site for which Alternative 7 is applicable. Alternatives 3 and 7 were evaluated for Site SD034.

2.10.5 Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved. Estimates of the times required to achieve chemical-specific ARARs at each site are provided in Tables 2.9-2 through 2.9-21. Sustainable remediation, including key sustainability metrics (i.e., carbon dioxide generation and energy consumption), are also considered.

Each of the alternatives includes monitoring to provide early warning if drinking water supply wells, agricultural wells, or human receptors are threatened and LUCs to limit direct contact of humans with groundwater and inhalation of VOCs in indoor air. For the off-base plumes originating from Site FT005, Subarea LF007C, and Site SS030, Travis AFB's existing access and environmental response easements contain legal restrictions preventing the landowners from engaging in water development or soil disturbing activities that could interfere with cleanup activities.

Activities associated with the alternatives pose minimal risk to workers, the community, and the environment, as most of the construction activities have already been conducted. Minimal materials and resources are used for Alternatives 2, 3, 6, and 7.

The total RTFs for the alternatives were estimated from approximately 5 years for Alternative 2 – MNA to greater than 100 years for Alternative 4, which is dependent on site conditions.

For Sites FT004 and SD031, remediation timeframes for both Alternatives 2 and 3 evaluated for these sites are similar (35 years for Site FT004 and 15 years for Site SD031). However, within these diffuse and low concentration plumes, the effectiveness of the GET system has decreased, as demonstrated by contaminant rebound studies conducted during the period of interim remediation. In addition, there are lower energy requirements and less GHG emission for Alternative 2 compared with Alternative 3; therefore, Alternative 2 better satisfies this criterion.

For Sites FT005 and LF008, the remediation timeframes for Alternative 2 – MNA compared with Alternative 3 – GET is estimated to take longer (Site FT005 – 43 compared with 10 years, Site LF008 – greater than 100 years compared with 100 to 110 years). However, there are lower energy requirements and less GHG emission associated with Alternative 2. Therefore, both alternatives equally satisfy this criterion. The longer remediation timeframe for Site LF008 is because COCs are not dissolved in groundwater but rather sorbed to the fine soil particles suspended in the groundwater (see Section 2.2.5.6).

For Sites SS015, SS016, SD036, SD037, and DP039, Alternatives 4 – Bioreactor and GET; 5 – EVO and EA; and 6 – Bioreactor, Phytoremediation, EVO PRB, and EA provide for additional treatment of the highest residual concentrations of COCs in groundwater, reducing remediation timeframes to 58 to 70 years compared with remediation timeframes from 91 years to greater than 100 years under Alternative 2 – MNA or Alternative 3 – GET. Alternatives 4, 5, and 6 better satisfy this criterion.

For Site SD034, Alternative 3 – GET compared with Alternative 7 – Passive Skimming is estimated to take longer (91 compared with 60 years), and there are lower energy requirements and less GHG emission associated with Alternative 7. Therefore, Alternative 7 better satisfies this criterion. The longer remediation timeframe for Site SD034 is based on the presence of Stoddard solvent (LNAPL), containing dissolved COCs, floating on the groundwater table.

For Sites SD033 and SD043, the remediation timeframe for Alternative 3 – GET compared with Alternative 2 – MNA is estimated to take longer (91 compared with 60 years). Sites SD033 and SD043 are component sites within the overall WIOU plume. The remediation time is based on the entirety of the WIOU plume achieving cleanup levels, including all the

commingled plumes originated from Sites SD033, SD034, SS035, SD036, SD037, and SD043. Treatment of the higher concentration portions of the WIOU plume within Sites SD036 and SD037 using Alternative 5 – EVO and EA will reduce the influx of contaminants into the remaining portions of the WIOU plume. This reduced influx of contamination will enhance the natural attenuation capacity of the aquifer to remediate contamination and will result in a shorter cleanup time. The physical, chemical, and biological processes of attenuation are the same under alternatives with MNA or EA components. The distinction between these alternatives is that no treatment of the higher concentration portion of a site plume is conducted under MNA, while EA is associated with site-specific treatment of those higher concentration portions of a plume.

Within these diffuse and low concentration plumes, the effectiveness of the GET system has decreased, as demonstrated by contaminant rebound studies conducted during the period of interim remediation. In addition, there are lower energy requirements and less GHG emission associated with Alternative 2. Therefore, Alternative 2 better satisfies this criterion.

2.10.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Alternatives 2 through 7 can be implemented using conventional and available equipment. Groundwater monitoring can easily continue under the existing GRIP, and LUCs are currently enforced as a component of the existing interim remedies. Alternatives 3 and 7, which include GET or skimming, are more difficult to implement compared with other alternatives that consist of MNA (Alternative 2) or in situ treatment (Alternatives 4, 5, and 6) because they include ongoing O&M and discharge of treated groundwater or recycling of removed Stoddard solvent.

GET systems (Alternative 3) have already been constructed at Subarea LF007C and Sites SS029 and SS030. The ex situ treatment process of LGAC associated with Alternative 3 is proven and reliable, and replacement system components are readily available. No difficulties associated with additional future construction or operations are anticipated. Extracted groundwater is already being successfully treated and discharged at the CGWTP.

A bioreactor and GET system (Alternative 4) have already been constructed at Site SS016 and a bioreactor at Site DP039 (Alternative 6). O&M will be minimal for bioreactors included with Alternatives 4 and 6, which consist of occasional dosing of the bioreactor and pump maintenance. Compared with ex situ treatment, in situ treatment is relatively easy to implement. Site SS016 is located within an area of active military airfield operations, and site access is restricted. The majority of the plume underlies active military aircraft parking ramps, taxiways, and runways. If necessary in the future, potential expansion of the GET system or construction would be difficult.

These alternatives are also administratively implementable. The regulatory agencies are already providing oversight of the ongoing groundwater IRAs and would continue to do so.

2.10.7 Cost

The estimated capital, O&M, and present value costs for the alternatives evaluated for each site are provided in Appendix D – Remedy Cost Estimates and include Tables D-1 through D-29.

Each alternative includes similar costs for implementing LUCs to restrict human exposure to contamination and to ensure that no activities will adversely affect implementation of the selected remedy. Examples of LUC costs are fence repairs and sign replacement, when needed. For the off-base plumes at Subarea LF007C and Sites FT005 and SS030, the cost for purchase of an additional easement is included. These easements contain legal restrictions preventing the landowners from engaging in water development or soil disturbing activities that could interfere with cleanup activities. In accordance with the Base General Plan, future buildings constructed in proximity of a groundwater plume may require installation of a vapor barrier and passive venting system. These vapor intrusion mitigation measures will result in additional building costs, but are not cost components of the remedial alternatives.

Cost estimates do not include capital costs for components constructed during the groundwater IRAs. These components include existing monitoring, injection, and extraction wells; GET systems; and bioreactors.

In general, costs for implementing Alternative 2 – MNA are less than costs for ex situ treatment with Alternative 3 – GET at Sites FT004, SD031, SD033, SD043 and in situ treatment with Alternative 5 – EVO and EA at Sites SS015, SD036, and SD037. For Site DP039, costs for Alternative 3 – GET are less than Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA. Costs for ex situ treatment with Alternative 4 – GET and Bioreactor at Site SS016 and Alternative 7 – Skimming and EA at Site SD034 are higher compared with Alternative 3 – GET because of higher annual O&M costs. For Site FT005, the cost of Alternative 2 – MNA is moderately greater than Alternative 3 – GET because the time required to achieve cleanup is approximately four (4) times greater, and a longer period of monitoring is needed. For Site LF008, the cost of Alternative 2 – MNA is moderately greater than Alternative 3 – GET because of greater long-term O&M costs.

2.10.8 State/Support Agency Acceptance

The California DTSC, San Francisco Bay Regional Water Board, and EPA have expressed their support for the following remedies selected for groundwater at each site at Travis AFB:

- Site SS041: Alternative 1 – No Further Action
- Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, SS035, and SD043: Alternative 2 – MNA
- Site FT005, Subarea LF007C, and Sites SS029 and SS030: Alternative 3 – GET
- Site SS016: Alternative 4 – Bioreactor and GET
- Sites SS015, SD036 and SD037: Alternative 5 – EVO and EA
- Site DP039: Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA
- Site SD034: Alternative 7 – Passive Skimming and EA

2.10.9 Community Acceptance

During the public comment period, the community expressed its support for the following remedies selected for groundwater at each site at Travis AFB:

- Site SS041: Alternative 1 – No Further Action
- Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, SS035, and SD043: Alternative 2 – MNA
- Site FT005, Subarea LF007C, and Sites SS029 and SS030: Alternative 3 – GET
- Site SS016: Alternative 4 – Bioreactor and GET
- Sites SS015, SD036 and SD037: Alternative 5 – EVO and EA
- Site DP039: Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA
- Site SD034: Alternative 7 – Passive Skimming and EA

Travis AFB received comments during the public meeting on October 18, 2012, regarding clarification of the preferred alternatives described therein. Three (3) verbal comments were received at the public meeting and are discussed in the Responsiveness Summary (see Section 3).

TABLE 2.10-1
Summary of Comparative Analysis of Each Alternative – Site FT004
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**2 – MNA**	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	●
Long-term Effectiveness and Permanence	●	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	●	◒
Implementability	●	◒
Cost ($)	59,641	163,538*

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-2
Summary of Comparative Analysis of Each Alternative – Site FT005
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**2 – MNA**	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	◒	◒
Implementability	●	◒
Cost ($)	101,633	94,273*

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-3
Summary of Comparative Analysis of Each Alternative – Site LF006
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**2 – MNA**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	11,909*

* Cost estimate for the existing IRA.

Note:

● = Alternative that best satisfies the criterion.

TABLE 2.10-4
Summary of Comparative Analysis of Each Alternative – Subarea LF007B
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**2 – MNA**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	817*

* Annual O&M cost estimate for the existing IRA.

Note:

● = Alternative that best satisfies the criterion.

TABLE 2.10-5
Summary of Comparative Analysis of Each Alternative – Subarea LF007C
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**3 – GET**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	432,334*

* Cost estimate for the existing IRA.

Note:

● = Alternative that best satisfies the criterion.

TABLE 2.10-6
Summary of Comparative Analysis of Each Alternative – Subarea LF007D
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**2 – MNA**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	18,139*

* Cost estimate for the existing IRA.

Note:

● = Alternative that best satisfies the criterion.

TABLE 2.10-7
Summary of Comparative Analysis of Each Alternative – Site LF008
Groundwater Record of Decision, Travis Air Force Base, California

Criterion	Alternative	
	2 – MNA	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	◒
Long-term Effectiveness and Permanence	●	◒
Reduction of Toxicity, Mobility, and Volume	●	◒
Short-term Effectiveness	●	◒
Implementability	●	◒
Cost ($)	46,182	35,545*

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-8
Summary of Comparative Analysis of Each Alternative – Site SS015
Groundwater Record of Decision, Travis Air Force Base, California

Criterion	Alternative	
	2 – MNA	**5 – EVO and EA**
Overall Protection of Human Health and the Environment	◒	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	●	◒
Implementability	◒	●
Cost ($)	55,137*	358,474

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-9
Summary of Comparative Analysis of Each Alternative – Site SS016
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**3 – GET**	**4 – Bioreactor and GET**
Overall Protection of Human Health and the Environment	◒	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	◒	●
Implementability	◒	●
Cost ($)	761,718*	1,116,162

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-10
Summary of Comparative Analysis of Each Alternative – Site ST027B
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**2 – MNA**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	49,996*

* Cost estimate for the existing IRA.

Note:

● = Alternative that best satisfies the criterion.

TABLE 2.10-11
Summary of Comparative Analysis of Each Alternative – Site SS029
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**3 – GET**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	339,851*

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.

TABLE 2.10-12
Summary of Comparative Analysis of Each Alternative – Site SS030
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**3 – GET**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	294,390*

* Cost estimate for the existing IRA.

Notes:

● = Alternative that best satisfies the criterion.

TABLE 2.10-13
Summary of Comparative Analysis of Each Alternative – Site SD031
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**2 – MNA**	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	●
Long-term Effectiveness and Permanence	●	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	●	◒
Implementability	●	◒
Cost ($)	30,480	42,103*

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-14
Summary of Comparative Analysis of Each Alternative – Site SD033
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**2 – MNA**	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	●
Long-term Effectiveness and Permanence	●	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	●	◒
Implementability	●	◒
Cost ($)	42,082	65,778*

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-15
Summary of Comparative Analysis of Each Alternative – Site SD034
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**3 – GET**	**7 – Passive Skimming and EA**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	●
Long-term Effectiveness and Permanence	●	●
Reduction of Toxicity, Mobility, and Volume	●	◒
Short-term Effectiveness	◒	●
Implementability	●	●
Cost ($)	108,288*	80,639

* Cost estimate for the existing IRA, which includes GET, Passive Skimming, and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-16
Summary of Comparative Analysis of Each Alternative – Site SS035
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative
Criterion	**2 – MNA**
Overall Protection of Human Health and the Environment	●
Compliance with ARARs	●
Long-term Effectiveness and Permanence	●
Reduction of Toxicity, Mobility, and Volume	●
Short-term Effectiveness	●
Implementability	●
Cost ($)	2,537*

* IRGs have been achieved at this site; 2 years of monitoring will be completed prior to evaluating the site for closure.

Notes:

● = Alternative that best satisfies the criterion.

TABLE 2.10-17
Summary of Comparative Analysis of Each Alternative – Site SD036
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**3 – GET**	**5 – EVO and EA**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	◒	●
Implementability	◒	●
Cost ($)	100,106*	759,875

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-18
Summary of Comparative Analysis of Each Alternative – Site SD037
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**3 – GET**	**5 – EVO and EA**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	◒	●
Implementability	◒	●
Cost ($)	275,751*	1,298,581

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-19
Summary of Comparative Analysis of Each Alternative – Site DP039
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**3 – GET**	**6 – Bioreactor, Phytoremediation, EVO PRB, and EA**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	◒	●
Long-term Effectiveness and Permanence	◒	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	◒	●
Implementability	◒	●
Cost ($)	73,680*	1,177,618

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

TABLE 2.10-20
Summary of Comparative Analysis of Each Alternative – Site SD043
Groundwater Record of Decision, Travis Air Force Base, California

	Alternative	
Criterion	**2 – MNA**	**3 – GET**
Overall Protection of Human Health and the Environment	●	●
Compliance with ARARs	●	●
Long-term Effectiveness and Permanence	●	●
Reduction of Toxicity, Mobility, and Volume	◒	●
Short-term Effectiveness	●	◒
Implementability	●	◒
Cost ($)	26,273	38,121*

* Cost estimate for the existing IRA, which includes GET and MNA components.

Notes:

● = Alternative that best satisfies the criterion.
◒ = Alternative that moderately satisfies the criterion.

2.11 Principal Threat Wastes

The NCP expects that treatment that reduces the toxicity, mobility, or volume of the principal threat wastes will be used to the extent practicable. The principal threat concept refers to the source materials at a CERCLA site considered to be highly toxic or highly mobile that generally cannot be reliably controlled in place or present an unacceptable risk to human health or the environment should exposure occur. A source material is material that contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or that acts as a source for direct exposure.

For Sites SS015, SS016, SD036, SD037, and DP039, portions of the plumes contain high contaminant concentrations, and residual DNAPL is likely present. At Sites SS015, SD036, and SD037, EVO will treat the portion of the plume with residual DNAPL and the highest concentrations of COCs. At Site SS016, a bioreactor will treat a portion of the plume with residual DNAPL and the highest concentrations of COCs. At Site DP039, the combination of a bioreactor, phytoremediation, and an EVO PRB will treat the portions of the plume with residual DNAPL and the highest concentrations of COCs.

For Site SD034, free-phase Stoddard solvent (LNAPL), containing dissolved COCs, is floating on the groundwater table and poses an ongoing source of contamination to the underlying groundwater. Passive skimming will physically remove the free-phase product to address this principal threat waste.

The remaining contaminants in groundwater do not constitute principal threat wastes as defined by CERCLA.

2.12 Selected Remedies

The remedies selected for specific groundwater sites at Travis AFB are as follows:

- **Alternative 1 – No Further Action:** Site SS041
- **Alternative 2 – MNA:** Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, SS035, and SD043
- **Alternative 3 – GET:** Site FT005, Subarea LF007C, and Sites SS029 and SS030
- **Alternative 4 – Bioreactor and GET:** Site SS016
- **Alternative 5 – EVO and EA:** Sites SS015, SD036, and SD037
- **Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA:** Site DP039
- **Alternative 7 – Passive Skimming and EA:** Site SD034

The primary indicators of remedial action performance will be satisfying the RAOs for groundwater at Travis AFB and protecting human health and the environment. Performance measures are defined herein as the RAOs (see Section 2.8) plus the required actions to achieve the objectives, as defined in this section. It is anticipated that successful implementation, operation, maintenance, and completion of the performance measures will achieve protective and legally compliant remedies for groundwater at Travis AFB.

The AF is responsible for implementing, maintaining, and monitoring the remedial actions identified herein for the duration of the remedies selected in this ROD. The AF will exercise this responsibility in accordance with CERCLA and the NCP. Concurrence by EPA, the California DTSC, and San Francisco Bay Regional Water Board is required for any modification of the remedy inconsistent with the objectives of this ROD.

2.12.1 Summary of the Rationale for the Selected Remedies

The AF, EPA, California DTSC, and the San Francisco Bay Regional Water Board believe that the selected remedy for a site meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria (including sustainability). The selected remedies are expected to reduce concentrations of COCs in groundwater, achieve cleanup levels based on federal and more stringent State of California MCLs and cleanup levels for protection of indoor air that were established to achieve RAOs, as well as include LUCs to prevent access or use of groundwater, including development of on-base water wells, to restrict soil disturbances in circumstances where contaminated groundwater or vapors might be encountered, maintain the integrity of current and future remedial and monitoring systems, and to restrict land use to industrial purposes only until the concentrations of COCs are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure (refer to Table 2.8-1), and as well as limit exposure to VOCs emanating from groundwater to indoor air until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human

health (refer to Table 2.8-2). An alternative was selected over other alternatives evaluated for a site because it ranked highest or equally ranked highest in the threshold and primary balancing criteria and represents the most reasonable value for the money (see Tables 2.10-1 through 2.10-20). The costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time. The preference for treatment will be met at Site FT005, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD034, SD036, SD037, and DP039.

2.12.2 Descriptions of the Selected Remedies

Except Alternative 1 – No Further Action, all of the remedies include the common components of groundwater monitoring and LUCs. The key distinguishing feature between Alternatives 2 through 7 is treatment. Alternatives 3 through 7 include treatment, with Alternatives 3 and 4 including ex situ treatment and Alternatives 4, 5, and 6 including in situ treatment. Alternative 7 includes physical removal of Stoddard solvent floating on the groundwater table and treatment or recycling of the recovered product by an EPA-approved off-base vendor.

Alternatives 2, 5, and 7 use natural physical, chemical, and biological processes to remediate COCs in groundwater. Alternative 2 includes MNA, which was successfully demonstrated by long-term interim MNA assessments, positive results of contaminant rebound studies, and positive results of an aerobic chlorinated cometabolism enzyme study. In addition to treatment or passive skimming, Alternatives 5 and 7 include EA, which will remediate COCs in downgradient groundwater by the reduced influx of contaminants following treatment of the portions of the plumes with the highest concentrations.

Descriptions of the components for each of the remedies are provided in the following subsections. A layout of the remedies is shown on Figure 2.12-1. LUC boundaries for groundwater and soil vapor emanating from groundwater are shown on Figures 2.12-12 through 2.12-14.

Changes, if they occur, to the remedies described in this ROD will be documented using a technical memorandum in the Administrative Record, an ESD, or ROD amendment.

The following subsections describe each of the selected remedies. A site-by-site summary of the remedies is also provided in Table 2.12-1 – Basis for Remedy Summary. This table provides a summary of the COCs, concentrations, and plume dimensions, as well as the status of the interim remedy, the selected remedy, RAOs, and the basis for remedy selection at each site.

2.12.2.1 Alternative 1 – No Further Action

No Further Action is the selected remedy for Site SS041.

Site SS041 had pesticide contaminants in its surface soil and groundwater. A 2003 soil remedial action cleaned up surface soil and achieved residential cleanup levels. An interim groundwater remedial action cleaned up the Site SS041 groundwater contaminant (heptachlor epoxide) to below its interim cleanup goal (0.01 µg/L) and its practical quantitation limit (0.01 µg/L). The NFRAP status for Site SS041 is documented in a December 14, 2005, consensus statement that was signed by the representatives of the lead and regulatory agencies (Travis AFB, 2005a).

2.12.2.2 Alternative 2 – Monitored Natural Attenuation

Alternative 2 uses natural physical, chemical, and/or biological processes at Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, SS035, and SD043 to achieve RAOs. The groundwater at Subarea LF007B and Site SS035 has already achieved cleanup levels; however, additional groundwater monitoring is required. In accordance with regulatory agencies requirements, at least 2 additional years of monitoring will be conducted at each site to confirm that cleanup levels have been achieved.

This alternative also discontinues the operation of existing IRA GET systems at Sites FT004, LF008, SD031, SD033, and SD043. When groundwater cleanup levels for all COCs are achieved within the monitoring network for a site, and confirmed by 2 years of annual LTM, the RAOs will be considered satisfied for the site, and the groundwater remedial action will be considered complete. Groundwater monitoring will stop, and the completion of the remedial action and a plan to decommission all remedy infrastructure as part of the site closure process will be documented in the annual GRISR.

In the event that plume migration or increasing concentrations are observed at Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites ST027B, SD031, SD033, SS035, and SD043, then GET system operations could be resumed. However, resuming GET system operation at Site LF008 is not considered a viable action because groundwater pumping was demonstrated to agitate the aquifer and mobilize fine soil particles with sorbed contaminants (CH2M HILL, 2012d). The AF will keep the Site LF008 GET system in place in the highly unlikely event that the migration of contaminants away from the site is discovered by future monitoring and a resumption of pumping is required for hydraulic containment of the contaminants.

In some cases, an alternative remedial approach, such as combining EVO injections and EA, could be implemented to treat portions of plumes with elevated concentrations of VOCs, if determined by the AF to be technically and economically feasible. This treatment would be conducted mainly to accelerate site cleanup.

2.12.2.3 Alternative 3 – GET

Alternative 3 entails active groundwater remediation using the GET systems previously installed as part of the IRA at Site FT005, Subarea LF007C, and Sites SS029 and SS030. Contaminated groundwater would continue to be extracted using horizontal and/or vertical extraction wells, treated at the NGWTP (Site FT005 and Subarea LF007C) and SBBGWTP (Sites SS029 and SS030), and the treated water discharged to the stormwater drainage system.

After a period of active remediation under Alternative 3, continued progress toward RAOs at Site FT005, Subarea LF007C, and Sites SS029and SS030 may be achieved by transitioning from the active GET remedy to an effective program of MNA under Alternative 2. This potential remedy transition will be based on the performance monitoring data and cost data obtained during the period of LTO. Over long-term GET system operation, it is possible that the plume contaminant concentrations will decline at an ever decreasing rate and the cost-effectiveness of the remedy will become relatively low. That is, high costs will be incurred to achieve increasingly modest reductions in the plume concentrations above cleanup levels. In this event, site-specific contaminant rebound studies will be conducted to demonstrate plume

stability and continued reductions in concentrations towards cleanup levels using natural physical, chemical, and biological processes. The AF will prepare an ESD to document the change of the remedy from Alternative 3 – GET to Alternative 2 – MNA.

In the event that plume migration or increasing concentrations are observed at a GET site, then optimization of the GET system will be evaluated. Potential optimization actions could include increasing the pumping rates in individual extraction wells or adding new extraction and/or monitoring wells. In some cases, an alternative remedial approach, such as combining EVO injections and EA, could be implemented, if determined by the AF to be technically and economically feasible. In the future, if groundwater in the off-base portions of the plumes at Sites FT005 and SS030 meets cleanup levels, an in situ treatment system, such as an EVO PRB, may be installed at Site SS029, and the GET system will be shut down to lower energy requirements and GHG emissions. The in situ treatment system would be designed to treat the entirety of the Site SS029 plume and all the contaminant mass migrating hydraulically downgradient from Site SS016.

GET at Site FT005. Under Alternative 3, optimized groundwater extraction, treatment at the SBBGWTP, and discharge of treated water into the stormwater drainage system would continue at Site FT005 until RAOs are achieved. A conceptual design of Alternative 3 at Site FT005 is shown on Figure 2.12-3.

The GET system at Site FT005 has been effective at controlling the migration of groundwater contamination, reducing the plume size, and reducing contaminant concentrations (CH2M HILL, 2008a, 2011a). No fundamental changes to the current GET system are required, although optimization of the groundwater extraction well network to improve system performance will be continually evaluated. Extracted groundwater would continue to be conveyed to the existing SBBGWTP for treatment using LGAC. The treated water would then be discharged to the Main Branch of Union Creek at the existing outfall.

GET at Subarea LF007C. A conceptual design of Alternative 3 at Subarea LF007C is shown on Figure 2.12-2.

A data gaps investigation was conducted during 2011–2012 to more fully characterize the off-base portion of the plume. Following evaluation of the characterization data, additional extraction wells may be installed to improve hydraulic capture and removal of TCE from the off-base portion of the plume.

During the times of year when a vernal pool at the site is dry, extracted groundwater would be conveyed to a small skid-mounted treatment unit and treated using LGAC. The LGAC unit would be located at the NGWTP, or other nearby on-base location, but treatment of groundwater using the NGWTP air stripper would be discontinued. The AF would beneficially reuse the treated water by pumping it to the Duck Pond via the existing conveyance system.

During the wet season, GET system operation at Subarea LF007C is discontinued in accordance with USFWS requirements to prevent potential adverse impacts to the vernal pool (USFWS, 2002).

GET at Site SS029. A conceptual design of Alternative 3 at Site SS029 is shown on Figure 2.12-3.

The GET system at Site SS029 has been effective at controlling the migration of groundwater contamination (CH2M HILL, 2008a, 2011b). No changes to the current GET system are required. Extracted groundwater would continue to be conveyed to the existing SBBGWTP for treatment using LGAC. The treated water would then be discharged to the Main Branch of Union Creek at the existing outfall.

GET at Site SS030. A conceptual design of Alternative 3 at Site SS030 is shown on Figure 2.12-3.

Operation of the Site SS030 interim GET system was modified in 2011 to improve the hydraulic capture of the off-base plume. As described in Section 8.3 of the 2011 Annual RPO Report (CH2M HILL, 2012d), operational changes (i.e., RPO) to the existing GET system were made to maintain hydraulic capture for the entirety of the plume by increasing the rate of groundwater extraction. Groundwater monitoring data obtained under the GSAP and GRIP demonstrated that hydraulic capture of the plume was achieved and that TCE concentrations within the eastern side of the plume are declining (CH2M HILL, 2012d). Further optimization of the GET system involves the installation of an additional extraction well to further improve hydraulic capture of the off-base plume and reduce the wear on the existing extraction well pumps resulting from sustained high-speed operation.

The ability of the Site SS030 GET system to maintain progress toward RAOs and achieve cleanup levels for the entirety of the plume will be verified prior to and during the RD phase under the Travis AFB GRIP and reported in annual GRISRs. If groundwater performance monitoring during the period of LTO indicates that hydraulic capture is not being maintained (e.g., increasing well concentrations), then further investigation of the eastern side of the plume will be conducted to verify hydraulic capture and remediation of that portion of the plume. Following evaluation of the characterization data, operation of the existing extraction wells may be modified and/or additional extraction wells may be installed to more fully achieve hydraulic capture of the off-base portion of the plume. All such optimizations will be incorporated into Alternative 3 as RPO activities. Extracted groundwater will continue to be conveyed to the existing SBBGWTP for treatment using LGAC. The treated water will then be discharged to the Main Branch of Union Creek at the existing outfall.

2.12.2.4 Alternative 4 – Bioreactor and GET

Alternative 4 combines the following two (2) components to remediate the Site SS016 plume:

- Bioreactor
- GET

A conceptual design of Alternative 4 at Site SS016 is shown on Figures 2.12-4 and 2.12-5. The Site SS016 and Site SS029 plumes are connected and are most effectively addressed together. Untreated groundwater COCs originating from Site SS016, primarily from the OSA, will eventually migrate to Site SS029. Therefore, the plumes will be treated as one (1) plume and eventually closed together.

In 2010, a bioreactor was constructed at Site SS016 within the OSA portion of the plume as a demonstration of in situ treatment (refer to Section 2.2.3.1). The bioreactor uses ERD processes to break down chlorinated VOCs within the portion of the plume with the highest concentrations of contaminants. Contaminated groundwater from existing horizontal extraction well EW003x16 is circulated through the bioreactor using a solar-powered pump. As a result of these actions, the continuing source of TCE contamination into the hydraulically downgradient portions of the Site SS016 plume has been and will continue to be reduced. Residual contamination from the OSA will be addressed by existing vertical groundwater extraction wells EW605x16 and EW610x16. A conceptual cross section of a bioreactor is shown on Figure 2.12-6.

Groundwater extraction within the TARA portion of Site SS016 will continue under Alternative 4 using the two (2) existing horizontal extraction wells (EW001x16 and EW002x16).

Extracted groundwater will be treated using LGAC at the CGWTP and then discharged into the stormwater drainage system.

After a period of active remediation under Alternative 4, continued progress toward RAOs at Site SS016 may be achieved by transitioning from the active Bioreactor and GET remedy to an effective program of MNA under Alternative 2. This potential remedy transition will be based on the performance monitoring data and cost data obtained during the period of LTO. Over long-term Bioreactor and GET system operation, it is possible that the plume contaminant concentrations will decline at an ever decreasing rate and the cost-effectiveness of the remedy will become relatively low. That is, high costs will be incurred to achieve only modest reductions in the plume concentrations above cleanup levels. In this event, a site-specific contaminant rebound study will be conducted to demonstrate plume stability and continued reductions in concentrations toward cleanup levels using natural physical, chemical, and biological processes. The AF will prepare an ESD to document the change of the remedy from Alternative 4 – Bioreactor and GET to Alternative 2 – MNA.

It is likely that the OSA bioreactor will reach the limits of effective treatment well before the RAOs are achieved by the GET system for the remainder of the plume. At that time, the bioreactor will be decommissioned, and GET system operation will continue. When all RAOs are achieved, groundwater extraction and monitoring will stop, and the completion of the remedial action and a plan to decommission all remedy infrastructure as part of the site closure process will be documented in the annual GRISR.

Treatment residuals following complete degradation of chlorinated VOCs through the ERD processes using the bioreactor include non-regulated end-products such as ethene and ethane. Incomplete ERD, resulting from the stalling of these processes, has the potential to create intermediate treatment residuals such as cis-1,2-DCE and/or vinyl chloride. Vinyl chloride is the most toxic potential treatment residual resulting from incomplete ERD treatment. Within the anaerobic treatment zone created by installation of the bioreactor, creation of vinyl chloride is expected as part of normal ERD processes. Based on analytical results obtained during the OSA bioreactor treatment demonstration, full degradation of vinyl chloride within the treatment zone is expected as those processes continue through completion to form ethane, ethene, and methane (refer to Section 2.2.3). Outside of the treatment zone, the aquifer is aerobic. Vinyl chloride readily degrades under aerobic conditions, so any vinyl chloride

that migrates beyond the bioreactor treatment zone will degrade aerobically shortly after entering the downgradient portion of the aquifer (CH2M HILL, 2012d).

If performance monitoring identifies any unanticipated or adverse outcomes from installation of the bioreactor, then the AF will evaluate and carry out performance enhancement measures to correct the deficiencies. The end result of these measures will be a return of the bioreactor's ability to remediate contaminated groundwater, a transition to a more effective remedial alternative, or the application of an additional remedial alternative in a downgradient location. Potential adverse outcomes could include the following:

- Incomplete reductive dechlorination or transformation that stalls at cis-1,2-DCE and/or vinyl chloride
- Increases in concentrations of VOCs immediately downgradient of the bioreactor treatment zone
- Migration of contaminant plume/lack of plume stability

Potential performance enhancement measures for one (1) or more of these outcomes include the following, listed in ascending order of field effort:

- Increased monitoring
- Installation of additional monitoring wells
- Boosting dissolved organic carbon levels in the bioreactor recirculation water (e.g., adding vegetable oil or high fructose corn syrup into the existing distribution manifold)
- Bioaugmentation of the water circulated through the bioreactor (i.e., supplement native microbes with a proprietary microbial consortium [e.g., KB-1®] if the native microbes prove incapable of complete degradation of TCE through cis-1,2-DCE to non-toxic ethene)
- Expansion and restart of the OSA GET system
- Implementation of another remedial technology

The AF and the regulatory agencies will base the selection of the appropriate performance enhancement measure(s) on the type and severity of the adverse outcome.

In the event that plume migration or increasing concentrations are observed downgradient of the GET component of the remedy, then optimization of the GET system will be evaluated. Potential optimization actions could include increasing the pumping rates in individual extraction wells or adding new extraction and/or monitoring wells.

The land use at Site SS016 consists primarily of active military airfield operations, including aircraft parking ramps, taxiways, and runways. Access to the great majority of the site is restricted. Implementation of any remedial action or optimization measure will be constrained by these access restrictions and the requirement to avoid adverse impacts to the military mission of Travis AFB.

2.12.2.5 Alternative 5 – EVO and EA

Alternative 5 combines the following two (2) components to remediate the Site SS015, SD036, and SD037 plumes:

- **EVO Injection –** Edible oil substrates are injected into the portions of the plumes with the highest concentrations of contaminants to facilitate anaerobic degradation of chlorinated VOCs. These high concentration portions of the plume are a continuing source of contamination into the hydraulically downgradient portions of the plume.
- **EA –** In conjunction with ERD treatment of the portions of the plumes with the highest concentrations of contaminants, physical, chemical, and/or biological processes of natural attenuation will reduce the mass, toxicity, volume, or concentration of contaminants in the remaining portions of the plume.

Treatment using EVO injections will be continued until COC concentrations are less than 1,000 µg/L. Then, EA monitoring will be conducted for the entirety of the plume until cleanup levels are achieved. It is likely that the injected EVO will reach the limits of effective treatment well before the RAOs are achieved by attenuation processes within the remainder of the plume. At that time, in situ treatment using EVO injections will be discontinued and EA monitoring will continue. When groundwater cleanup levels for all COCs are achieved within the monitoring network for the site, and confirmed by 2 years of annual LTM, the RAOs will be considered satisfied for the sites. Groundwater monitoring will stop, and the completion of the remedial action and a plan to decommission all remedy infrastructure as part of the site closure process will be documented in the annual GRISR. This alternative discontinues the operation of the Site SD036 and Site SD037 GET systems. In the event that plume migration or increasing concentrations are observed at either site, then active remediation using these systems can be readily resumed or an alternative technology could be implemented.

Treatment residuals following complete degradation of chlorinated VOCs through the ERD processes facilitated by EVO injection include non-regulated end-products such as ethene and ethane. Incomplete ERD, resulting from the stalling of these processes, has the potential to create intermediate treatment residuals such as cis-1,2-DCE and/or vinyl chloride. Vinyl chloride is the most toxic potential treatment residual resulting from incomplete ERD treatment. Within the anaerobic treatment zone created by EVO injection, creation of vinyl chloride is expected as part of normal ERD processes. Based on analytical results obtained during the EVO treatment demonstrations, full degradation of vinyl chloride within the treatment zones is expected as those processes continue through completion to form ethane, ethene, and methane (refer to Section 2.2.3). Outside of the treatment zones, the aquifer is aerobic. Vinyl chloride readily degrades under aerobic conditions, so any vinyl chloride that migrates beyond the ERD treatment zone will degrade aerobically shortly after entering the downgradient portion of the aquifer (CH2M HILL, 2012d).

If performance monitoring of the remedy identifies any unanticipated or adverse outcomes from injection of EVO, then the AF will evaluate and carry out enhancement measures to correct the deficiencies. The end result of these measures will either be a return of the EVO's ability to remediate contaminated groundwater, a transition to a more effective remedial

alternative, or the application of an additional remedial alternative in a hydraulically downgradient location. Potential adverse outcomes could include the following:

- Incomplete reductive dechlorination or transformation that stalls at cis-1,2-DCE and/or vinyl chloride
- Increases in concentrations of VOCs immediately downgradient of the EVO treatment zone
- Migration of contaminant plume/lack of plume stability

Potential performance enhancement measures for one (1) or more of these outcomes include the following, listed in ascending order of field effort:

- Increased monitoring
- Installation of additional monitoring wells
- Sustaining high dissolved organic carbon levels within the EVO treatment zone (e.g., injecting high fructose corn syrup)
- Bioaugmentation of the EVO solution injected into the treatment zone (i.e., supplement native microbes with a proprietary microbial consortium [e.g., KB-1®] if the native microbes prove incapable of complete degradation of TCE through vinyl chloride to non-toxic ethene)
- Expansion and restart of the GET systems
- Implementation of another remedial technology

The AF and the regulatory agencies will base the selection of the appropriate performance enhancement measure(s) on the type and severity of the adverse outcome.

EVO and EA at Site SS015. A conceptual design of Alternative 5 at Site SS015 is shown on Figure 2.12-7.

There is no GET system associated with Site SS015. In the unlikely event that plume migration or increasing concentrations are observed at this site, a contingency remedy would have to be designed and carried out, taking into account the considerable restrictions posed by the presence of a fuel truck parking area and maintenance facility above the plume.

EVO and EA at Site SD036. A conceptual design of Alternative 5 at Site SD036 is shown on Figure 2.12-9.

This alternative continues the performance monitoring of the EVO injections. Groundwater monitoring for natural attenuation will continue within the untreated portions of the overall WIOU plume, including the distal portions of Site SD036.

EVO and EA at Site SD037. A conceptual design of Alternative 5 at Site SD037 is shown on Figure 2.12-10.

This alternative continues the performance monitoring of the EVO injections. Groundwater monitoring for natural attenuation will continue within the untreated portions of the overall WIOU plume, including the distal portions of Site SD037.

2.12.2.6 Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA

Alternative 6 combines the following three (3) in situ bioremediation technology processes and monitored EA to remediate the Site DP039 plume:

- **In Situ Bioremediation**
  - **Bioreactor –** The bioreactor installed in December 2008 as a technology demonstration project actively treats the portion of the plume with the highest concentrations by circulating extracted groundwater through an organic mulch mixture to reduce contaminant mass and volume via ERD processes. Contaminated groundwater from an extraction well is pumped through a pipe system onto the mulch column. The water then trickles through the mulch column and into the aquifer before being captured and recirculated by an extraction well. A sustainable source of electric power to the extraction well pump is provided by solar panels (CH2M HILL, 2009b).
  - **Phytoremediation –** A phytoremediation zone is downgradient of the bioreactor and consists of a grove of engineer-planted eucalyptus trees. The trees take in contaminated groundwater and either absorb the contaminants or transpire them, providing additional reduction of contaminant mass and volume. Root growth also contributes to the breakdown of contaminants into harmless compounds (Parsons, 2010).
  - **EVO PRB –** A demonstration PRB of edible vegetable oil was installed in 2010 using injection wells in the portion of the aquifer downgradient of the phytoremediation zone. Injection of EVO across the leading edge of the 500-µg/L portion of the plume anaerobically degrades the higher concentrations of TCE and other chlorinated VOCs. This portion of the plume is a continuing source of contamination into the hydraulically downgradient area of EA. The injected EVO is expected to provide effective treatment for approximately 2 to 3 years. Supplemental injection of EVO will be conducted using the injection wells, if required, to maintain the treatment process.
- **EA –** Physical, chemical, and/or biological processes will remediate the residual contaminants in the distal portion of the Site DP039 plume. The effectiveness of natural attenuation in the lower concentration distal portions of the plume is now enhanced, because contaminant migration into this part of the plume from the higher concentration portion of the plume is greatly reduced. The existing site monitoring wells will be incorporated into the implementation of EA.

Alternative 6 discontinues the operation of the Site DP039 GET system. A conceptual design of the implementation of Alternative 6 is shown on Figure 2.12-11. The land use at Site DP039 is mostly open space. Building 755 was demolished in 2009, and there are currently no office facilities or other buildings at the site.

Treatment using the bioreactor will continue until groundwater influent COC concentrations into the bioreactor are at cleanup levels. The hydraulically downgradient area of phytoremediation will be maintained until cleanup levels are achieved in the underlying groundwater being treated by the trees. Further downgradient, treatment using the EVO PRB will continue until groundwater COC concentrations entering the PRB treatment zone are less than or equal to cleanup levels. Then, EA monitoring will be

conducted for the entirety of the plume until cleanup levels are achieved. When groundwater cleanup levels for all COCs are achieved within the monitoring network for the site, and confirmed by 2 years of annual LTM, the RAOs will be considered satisfied. Groundwater monitoring will stop, and the completion of the remedial action and a plan to decommission all remedy infrastructure as part of the site closure process will be documented in the annual GRISR.

Treatment residuals following complete degradation of chlorinated VOCs through the ERD processes facilitated by EVO injection and installation of the bioreactor include non-regulated end-products such as ethene and ethane. Incomplete ERD, resulting from stalling of these processes, has the potential to create intermediate treatment residuals such as cis-1,2-DCE and/or vinyl chloride. Vinyl chloride is the most toxic potential treatment residual resulting from incomplete ERD treatment. Within the anaerobic treatment zone created by EVO injection and the bioreactor, creation of vinyl chloride is expected as part of normal ERD processes. Based on analytical results obtained during the EVO injection and bioreactor treatment demonstrations, full degradation of vinyl chloride within the treatment zones is expected as those processes continue through completion to form ethane, ethene, and methane (refer to Section 2.2.3). Outside of the treatment zones, the aquifer is aerobic. Vinyl chloride readily degrades under aerobic conditions, so any vinyl chloride that migrates beyond the ERD treatment zones will degrade aerobically shortly after entering the downgradient portion of the aquifer (CH2M HILL, 2012d).

Bioreactor Performance Enhancement Measures. If performance monitoring identifies any unanticipated or adverse outcomes from installation of the bioreactor, then the AF will evaluate and carry out performance enhancement measures to correct the deficiencies. The end result of these measures will be a return of the bioreactor's ability to remediate contaminated groundwater, a transition to a more effective remedial alternative, or the application of an additional remedial alternative in a downgradient location. Potential adverse outcomes could include the following:

- Incomplete reductive dechlorination or transformation that stalls at cis-1,2-DCE and/or vinyl chloride
- Increases in concentrations of VOCs immediately downgradient of the bioreactor treatment zone
- Migration of contaminant plume/lack of plume stability

Potential performance enhancement measures for one (1) or more of these outcomes include the following, listed in ascending order of field effort:

- Increased monitoring
- Installation of additional monitoring wells
- Boosting dissolved organic carbon levels in the bioreactor recirculation water (e.g., adding vegetable oil or high fructose corn syrup into the existing distribution manifold)
- Bioaugmentation of the water circulated through the bioreactor (i.e., supplement native microbes with a proprietary microbial consortium [e.g., KB-1®] if the native microbes prove incapable of complete degradation of TCE through cis-1,2-DCE to non-toxic ethene)

- Expansion and restart of the Site DP039 GET system
- Implementation of another remedial technology

The AF and the regulatory agencies will base the selection of the appropriate performance enhancement measure(s) on the type and severity of the adverse outcome.

Phytoremediation Performance Enhancement Measures. If performance monitoring identifies any unanticipated or adverse outcomes from installation of the tree stand, then the AF will evaluate and carry out performance enhancement measures to correct the deficiencies. The end result of these measures will be a return of the tree stand's ability to remediate contaminated groundwater, a transition to a more effective remedial alternative, or the application of an additional remedial alternative in a downgradient location. Potential adverse outcomes could include the following:

- Increases in concentrations of VOCs immediately downgradient of the tree stand
- Migration of contaminant plume/lack of plume stability
- Releases of VOCs into the atmosphere from the transpiration processes of the tree stand

Potential performance enhancement measures for one (1) or more of these outcomes include the following, listed in ascending order of field effort:

- Increased monitoring
- Installation of additional monitoring wells
- Expansion of the tree planting area
- Conducting a simple air study to assess releases of VOCs from the tree stand
- Implementation of another remedial technology

The AF and the regulatory agencies will base the selection of the appropriate performance enhancement measure(s) on the type and severity of the adverse outcome.

EVO PRB Performance Enhancement Measures. Similarly, if performance monitoring identifies any unanticipated or adverse outcomes from installation of the EVO PRB, then the AF will evaluate and carry out performance enhancement measures to correct the deficiencies. The end result of these measures will either be a return of the PRB's ability to remediate contaminated groundwater, a transition to a more effective remedial alternative, or the application of an additional remedial alternative in a downgradient location.

Potential outcomes could include the following:

- Increases in concentrations of VOCs immediately downgradient of the EVO PRB treatment zone
- Decrease in the permeability of the EVO PRB treatment zone, resulting in an upgradient pooling of contaminated groundwater
- Migration of contaminant plume/lack of plume stability
- Incomplete reductive dechlorination or transformation that stalls at cis-1,2-DCE or vinyl chloride

Potential performance enhancement measures for one (1) or more of these outcomes include the following, listed in ascending order of field effort:

- Increased monitoring
- Installation of additional monitoring wells
- Supplemental injection of EVO using existing PRB injection wells
- Installation of additional PRB injection wells
- Bioaugmentation (i.e., supplement native microbes with a proprietary microbial consortium [e.g., KB-1®] if the native microbes prove incapable of complete degradation of TCE through cis-1,2-DCE to non-toxic ethene)
- Installation of recirculation loops to allow additional residence time of contaminants within the PRB treatment zone; the recirculation system could potentially be extended to include the area of phytoremediation located hydraulically upgradient of the PRB
- Extending the existing PRB to better intercept the migrating plume
- Installing an additional PRB at another location (e.g., at the toe of the plume)
- Expanding and restarting the Site DP039 GET system

Travis AFB will base the selection of the appropriate performance enhancement measure(s) on the type and severity of the adverse outcome.

2.12.2.7 Alternative 7 – Passive Skimming and EA

Alternative 7 includes the following two (2) components to remediate the Site SD034 plume:

- **Passive skimmer –** Floating free-phase Stoddard solvent, containing dissolved COCs, will be removed using the passive skimmers previously installed in the existing network of vertical extraction wells. This action minimizes the dissolution of COCs from the nonaqueous Stoddard solvent medium into the underlying groundwater and minimizes the spread of contamination into previously uncontaminated zones by using recovery and disposal techniques appropriate to the hydrogeologic conditions at the site. The presence of free-phase Stoddard solvent is limited to the original release area and is not migrating (CH2M HILL, 2011b).
- **EA –** In the distal portions of the plume, natural attenuation will be monitored to address low concentration dissolved-phase contamination. The existing Site SD034 monitoring wells will be incorporated into the monitoring of EA within the overall WIOU plume. The effectiveness of EA in the untreated portion of the plume will be enhanced by continuing to conduct passive skimming to remove the ongoing source of COCs dissolving into the groundwater from the free-phase Stoddard solvent.

Stoddard solvent, containing dissolved COCs, floating on the groundwater table will be physically removed using previously installed passive skimmers and recycled by an EPA-approved off-base vendor until a maximum thickness of 0.01 foot is achieved at every compliance point (monitoring wells), or to the maximum extent practicable. When removal of free-phase Stoddard solvent (NAPL) floating on the groundwater table is considered complete

(i.e., maximum thickness of 0.01 foot is achieved), then passive skimming will be discontinued. The low concentrations of dissolved COCs at Site SD034 do not warrant an active treatment component for the remedy. As reported in the 2010-2011 Annual GSAP Report, the COCs dissolved in the groundwater at Site SD034 include TCE and vinyl chloride at maximum concentrations of 5.8 and 2.1 µg/L (MW02x34). Therefore, groundwater monitoring will continue throughout the WIOU plume, including Site SD034, as part of the EA component of the remedy. When groundwater cleanup levels for all COCs are achieved within the monitoring network for the site and are confirmed by 2 years of annual LTM, the RAOs will be considered satisfied for the site. At that time, groundwater monitoring will stop, and the completion of the remedial action and a plan to decommission all remedy infrastructure as part of the site closure process will be documented in the annual GRISR report.

Resuming GET system operation is not considered a viable alternative technology. The interim GET system operated for almost a decade and did not remove all the Stoddard solvent. No improvement in free product removal performance is expected by resuming GET system operations, and such a system would have a relatively large carbon footprint. Also, expansion of the GET system would be constrained by the proximity of active aircraft maintenance activities in Building 811. In the event that plume migration or increasing concentrations are observed within the EA portion of the plume, then GET system operations could be resumed in those areas. An alternative remedial approach, such as combining EVO and EA, could possibly be implemented in some portions of the plume, if determined by the AF to be technically and economically feasible.

2.12.2.8 Land Use Controls

Resource Uses and Risk Exposure Assumptions for LUCs. California has designated all groundwater of the state as potential drinking water. While Travis AFB currently does not use the aquifer under the main base as potable drinking water, and does not plan to do so in the future, as it obtains its drinking water from the City of Vallejo and/or drinking water wells at the off-base golf course, to assess the need for LUCs, contamination at these groundwater sites was assessed for risk under a potable water use scenario.

The need for LUCs to address risk posed by volatile COCs emanating from groundwater to indoor air was also assessed for industrial worker and hypothetical future resident scenarios.

Risks Necessitating LUCs. The groundwater plumes at these groundwater sites, both on- and off-base, are not safe for drinking water. Accordingly, the base must impose LUCs and monitor and enforce its off-base access easements over the plumes to ensure groundwater is not used for potable purposes until it is remediated to MCLs that allow for unlimited use and unrestricted exposure.

Groundwater contamination at portions of Sites FT004, SS015, SS016, SS029, and DP039 poses an indoor air vapor intrusion risk to industrial workers. Risks are also posed to potential future residents at these sites and at Subarea LF007C and Sites SS030, SD033, SS035, SD036, and SD037. Accordingly, the base must impose LUCs to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.

Performance Objectives. The performance objective of LUCs for groundwater is to prevent access or use of groundwater, including development of on-base water wells, until groundwater cleanup levels are met that allow for unlimited use and unrestricted exposure. They will restrict soil excavation and other subsurface work in circumstances where workers might encounter contaminated groundwater or vapors. The LUCs will also maintain the integrity of current and future remedial and monitoring systems, such as monitoring and extraction wells. They will restrict land use over contaminated groundwater plumes to industrial purposes only.

The performance objective of LUCs for vapor intrusion is to restrict industrial building construction on portions of Sites FT004, SS015, SS016, SS029, and DP039 (see Figure 2.12-13) unless vapor barriers and passive venting systems are included. The LUCs will be maintained until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.

Location of LUCs. Maps showing the boundaries of groundwater LUCs (Figure 2.12-12) and groundwater-to-indoor air LUCs (Figures 2.12-13 and 2.12-14) and associated data fields will be included in the Base General Plan. The boundaries of the off-base LUCs at Site FT005, Subarea LF007C, and Site SS030 are within the boundaries of the easements already purchased by the AF from the private landowners.

Duration of LUCs. LUCs for groundwater will be maintained on groundwater sites and use restricted until cleanup levels are achieved that allow for unlimited use and unrestricted exposure (refer to Table 2.8-1).

LUCs for vapor intrusion will be maintained until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that the VOCs emanating from groundwater to indoor air are at levels that allow for unlimited use of and unrestricted exposure to indoor air (refer to Table 2.8-2).

Mechanisms for Achieving LUC Performance Objectives. The internal procedures that Travis AFB will use to implement the LUCs include but are not limited to the following:

- **Base Civil Engineer Work Requests –** One (1) tool for achieving the LUC performance objectives is the AF Form 332 (AF332) or Base Civil Engineer Work Request. This form must be submitted and approved before the start of any construction project at Travis AFB. One (1) step in the approval process for this form is a comparison of the construction site with all constraints that are described in the Base General Plan. The AF332 serves as the document for communicating any construction constraints to the appropriate offices. Any constraints at the site result in the disapproval of the form unless the requester makes appropriate modifications to the construction plans.
- **Excavation Permits –** Travis AFB also uses the 60th Air Mobility Wing Form 55 or Excavation Permit to enforce soil and sediment disturbance restrictions. The requester submits the permit to the Civil Engineer Squadron for any project that involves mechanical soil or sediment excavation, such as trench digging for underground utilities or soil excavation for building foundations. If constraints involving soil disturbance or worker safety exist at the excavation area, the permit describes the appropriate

procedures that workers must implement before the start of excavation to prevent unknowing exposure to contamination.

- **The Base Environmental Impact Analysis Process (EIAP) –** EIAP is conducted pursuant to the National Environmental Policy Act, as promulgated for the AF in 32 CFR 989, et. seq., to assess the potential environmental impact of any federal action initiated by or involving Travis AFB. An AF Form 813 (AF813) initiates the EIAP. Both AF332s and excavation permits are subject to an evaluation under the EIAP. The proponent of a proposed action is required to submit the AF332 or excavation permit with AF813 so that the appropriate environmental analysis of the proposed action and alternatives to the proposed action is accomplished prior to any construction activities. The EIAP works to ensure proposed construction sites take into account the constraints that are described in the Base General Plan and known to the AFCEC Environmental Restoration Installation Support Team (IST). The EIAP also ensures that all environmental factors, such as LUCs, are considered in the selection of locations for construction projects.

- **Travis AFB General Plan –** The Base General Plan is a long-range planning tool that provides a framework for selecting the locations of future facilities needed to carry out the Base mission (Travis AFB, 2002). The Base General Plan describes the specific LUCs for each site, the reasons for the controls, and the areas where the controls are applied. For a LUC to remain protective, Base personnel must have access to information concerning its existence, purpose, and maintenance requirements. The Base General Plan provides the important information management to ensure that LUC management takes place and that the LUC's presence is effectively communicated.

- **Base Well Permitting System –** All Travis AFB ERP groundwater monitoring, extraction, and injection wells are managed under the GRIP. Approval of the construction of new wells is received during the regulatory review and acceptance of work plans for groundwater remedial actions and technology demonstration projects. Approval of the decommissioning of old wells is received during the regulatory review and acceptance of the annual GRISR. All modifications to the Travis AFB well network receive Base approval through the submission and approval of the AF Form 332 and the 60AMW Form 55, as described above.

The AF will notify EPA in advance of any changes to internal procedures associated with the selected remedy that might affect the LUCs.

The AF is responsible for implementing, maintaining, monitoring, reporting, and enforcing LUCs. The AF has an obligation to inform, monitor, enforce, and bind, where appropriate, authorized lessees, tenants, contractors, and other authorized occupants of the groundwater sites of LUCs impacting the sites. Although the AF may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, the AF shall retain ultimate responsibility for remedy integrity.

Whenever the AF transfers real property that is subject to institutional controls and resource use restrictions to another federal agency, the transfer documents shall require that the federal transferee include the institutional controls, and applicable resource use restrictions, in its resource use plan or equivalent resource use mechanism. The AF shall advise the recipient federal agency of all obligations contained in the ROD, including the obligation

that a State Land Use Covenant will be executed and recorded pursuant to 22 CCR Section 67391.1 in the event the federal agency transfers the property to a non-federal entity.

Whenever the AF proposes to transfer real property subject to resource use restrictions and institutional controls to a non-federal entity, it will provide information to that entity in the draft deed and transfer documents regarding necessary resource use restrictions and institutional controls, including the obligation that a State Land Use Covenant will be executed and recorded pursuant to 22 CCR Section 67391.1. The signed deed will include institutional controls and resource restrictions equivalent to those contained in the State Land Use Covenant and this ROD.

The AF will provide notice to EPA and the State at least six (6) months prior to any transfer or sale of Travis AFB so that EPA and the State can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective institutional controls. If it is not possible for the facility to notify EPA and the State at least 6 months prior to any transfer or sale, then the facility will notify EPA and the State as soon as possible but no later than 60 days prior to the transfer or sale of any property subject to institutional controls. In addition to the land transfer notice and discussion provisions above, the AF further agrees to provide EPA and the State with similar notice, within the same time frames, as to federal-to-federal transfer of property. The AF shall provide a copy of the executed deed or transfer assembly to EPA and the State.

The AF shall notify EPA and state 45 days in advance of any proposed land use changes that are inconsistent with land use control objectives or the selected remedy.

Any activity that is inconsistent with the LUC objectives or use restrictions or any other action that may interfere with the effectiveness of the LUCs will be addressed by the AF as soon as practicable, but in no case will the process be initiated later than ten days after the AF becomes aware of the breach. The AF will notify EPA and the state as soon as practicable, but no longer than ten days after discovery of any activity that is inconsistent with the LUC objectives or use restrictions, or any other action that may interfere with the effectiveness of the LUCs. The AF will notify EPA and the state regarding how the AF has addressed or will address the breach within ten days of sending the EPA and state notification of the breach. For corrective measures taken after the notification, the AF shall notify EPA and the state when the measures are complete.

Monitoring of the environmental use restrictions and controls will be conducted annually by the AF. The monitoring results will be included in a separate report or as a section of another environmental report, if appropriate, and provided to EPA and the State. The annual monitoring reports will be used in preparation of the Five-year Review to evaluate the effectiveness of the remedy. The annual monitoring report, submitted to the regulatory agencies by the AF, will evaluate the status of the LUCs and how any LUC deficiencies or inconsistent uses have been addressed. The annual evaluation will address whether the use restrictions and controls referenced above were communicated in the deed(s), whether the owners and state and local agencies were notified of the use restrictions and controls affecting the property, and whether use of the property has conformed to such restrictions and controls.

Travis AFB shall not modify or terminate LUCs, implementation actions, or land use that are associated with the selected remedy without the approval of EPA and the opportunity

for concurrence by the State. Travis AFB shall seek prior concurrence of EPA and the State before any anticipated action that may disrupt the effectiveness of the LUCs or any action that may alter or negate the need for LUCs.

Three (3) solvent plumes have migrated off-base. These plumes are associated with Subarea LF007C and Sites FT005 and SS030 and lie beneath private property. To manage the groundwater IRAs for these sites, Travis AFB purchased long-term easements that grant access rights to the United States, its representatives, agents, and contractors for the purpose of conducting environment responses on the properties. The easements contain enforceable restrictions that prevent the landowners from interfering or abridging the exercise of the government's rights under the easements and prevent landowners from engaging in water development or soil disturbing activities that could interfere with cleanup activities. The AF would view any residential development and any well drilling on the properties covered by the easements as interfering with the government's easement and would take appropriate action to prevent interference with its rights under the easements.

Additionally, Solano County Ordinance, Chapter 13.10, makes it a misdemeanor to construct a well without a Solano County permit and requires the permit requester to notify the County of all wells within a 100-foot radius of the proposed well site. Given the number of monitoring and extraction wells that the government is operating on the easements, this ordinance ensures that Travis AFB will be notified of a landowner's well drilling plans. Additionally, Travis AFB's wells are frequently monitored, and any landowner actions potentially interfering with the easements would be observed. The landowner would be contacted to rectify the situation. To date, no such activities have been observed, and there are no known drinking water wells that draw water from the plumes, as confirmed by the frequent presence of base and contractor personnel in the off-base area as part of conducting the interim remedies. The AF will purchase additional easements in the event the off-base plumes remain contaminated at the expiration of the terms of the existing easements. Thus, throughout their duration, the easements restrict development of new wells and incompatible use of the water below the property.

2.12.2.9 Performance Monitoring

For each of the remedies, except Alternative 1 – No Further Action, a period of LTO will be conducted after the remedial action has been installed and the remedy is fully in-place. Monitoring data obtained during the period of LTO will be used to assess whether the remedy is performing as intended. The LTO monitoring will continue until groundwater cleanup levels have been achieved for the entirety of a site plume. When that is achieved, the response will be complete and then a period of LTM will begin. The LTM will be conducted semiannually for an additional 2 years to verify that the concentrations of contaminants have been permanently reduced to cleanup levels or below. At the conclusion of the period of LTM, a site closeout report will be developed to document that cleanup levels have been achieved. Estimates for the periods of LTO and LTM for each site are summarized in Table 2.12-2 – Summary of Performance Monitoring.

Performance monitoring will be conducted under the Travis AFB GRIP and in accordance with applicable EPA guidance documents, including the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (EPA, 1998) and *Performance Monitoring of MNA Remedies for VOCs in Groundwater* (EPA, 2004a). Existing Travis AFB documents, groundwater data, and assessments of IRA performance will also be used in the

development of the sampling requirements identified in the GRIP and GRISRs. Laboratory analyses of samples will be conducted in accordance with the RD/RA QAPP (CH2M HILL, 2009a). Monitoring results will be provided in annual GRISRs.

As remediation of the contaminant plumes progresses under each site remedy, it is expected that the distribution of groundwater contamination will change over time. Different portions of some plumes will achieve cleanup levels more rapidly than others. For example, under Alternative 5 – EVO and EA, the portions of the plumes at Sites SS015, SD036, and SD037 undergoing active ERD treatment will likely achieve cleanup levels more quickly than the portions of the plumes where the processes of natural attenuation are employed. A summary of the estimated cleanup times for the site plumes is provided in Table 2.12-2 – Summary of Performance Monitoring.

The performance monitoring well network for each site and remedy will be initially developed during the RD phase. However, as the plumes change over time, the monitoring networks will evolve appropriately for the future conditions. As the plumes change in shape and concentration, some monitoring wells may no longer be necessary and/or new wells may be required to adequately monitor the progress of remediation. It is also possible that the frequency of monitoring may increase or decrease under future conditions or that the required list of analytes may increase or decrease. Corrective actions to remedies potentially resulting from deficiencies identified in five-year reviews may also trigger changes to the monitoring schemes. Potential changes to the performance monitoring will be specified in the annual GRISRs and implemented under the GRIP.

2.12.3 Summary of Estimated Remedy Costs

This section provides breakdowns of the estimated costs associated with implementing and maintaining each remedial alternative. Cost estimates are provided in Appendix D.

The information in these cost estimate summary tables is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternatives. Major changes may be documented in the form of a memorandum in the Administrative Record file, an ESD, or a ROD amendment. These are order-of-magnitude engineering cost estimates that are expected to be within +50 to -30 percent of the actual project costs.

2.12.4 Expected Outcomes of Selected Remedy

The expected outcome of each selected remedy is the reduction of concentrations of COCs in groundwater to the lowest of either the state or federal MCLs and to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure (refer to Table 2.8-1). The selected remedies, including implementing all previously described LUCs, will allow Travis AFB to continue its designated existing mix of land uses.

Land use that would result in human exposure to contaminants in indoor air based on an industrial risk scenario is restricted until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health at Sites FT004, SS015, SS016,

SS029, and DP039 (refer to Table 2.8-2). Under a hypothetical residential scenario, land use that would result in human exposure to indoor air contaminants is restricted until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health at Site FT004, Subarea LF007C, and Sites SS015, SS016, SS029, SS030, SD033, SS035, SD036, SD037, and DP039 (refer to Table 2.8-2).

Land overlying plumes originating from Sites FT005, LF006, LF008, ST027B, SD031, SD034, SS041, and SD043 is currently considered suitable for continued industrial use or potential future residential use. The vapor intrusion pathway is not a potential future concern under either a residential or industrial exposure scenario at these sites. Withdrawal or use of groundwater that would result in human exposures to contaminants is restricted until the groundwater cleanup levels are met at each site. On the basis of available data, the total RTFs for the remedies at each site are estimated as follows:

- Site FT004: 35 years
- Site FT005: 10 years
- Site LF006: 5 years
- Subarea LF007B: 0 years
- Subarea LF007C: 26 years
- Subarea LF007D: 23 to 49 years
- Site LF008: 100 to 110 years
- Site SS015: 70 years
- Site SS016: 62 years
- Site ST027B: 50 years
- Site SS029: 62 years
- Site SS030: 22 years
- Site SD031: 15 years
- Site SS033: 60 years
- Site SD034: 60 years
- Site SS035: 60 years
- Site SD036: 60 years
- Site SD037: 60 years
- Site SD039: 58 years
- Site SS041: 0 years
- Site SD043: 60 years

The contaminated groundwater from Sites SD033, SD034, SS035, SD036, SD037, and SD043 has merged, so Travis AFB is addressing groundwater from all of these sites as a part of a single plume (i.e., the WIOU plume). Groundwater at Site SS035 has achieved cleanup goals. Groundwater monitoring will be performed at this site for 2 years prior to evaluating the site for closure.

Continued monitoring and evaluation of site conditions and CERCLA Five-year Reviews will be conducted to ensure the remedies are functioning optimally. Site data will be evaluated periodically to determine the progress in achieving the RAOs with the selected remedies. Implementing alternative remedies or new treatment technologies that might reduce costs, accelerate site cleanup, or provide additional protection to human health or the environment will be considered if a remedy selected for a site no longer effectively provides for protection of human health and the environment.

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
FT004	TCE cis-1,2-DCE 1,2-DCA Chloroform Bromodichloromethane 1,1-DCE Vinyl chloride 1,4-DCB	**204 J-** **12.6 J+** ND 3.8 0.73 J- 0.77 **14.8** ND	TCE plume approximate dimensions: Length: 950 feet Width: 250 feet Thickness: 30 feet Area: 250,893 ft^2 Volume: 1,455,170 ft^3	<u>GET and MNA Assessment</u> Plume size and concentrations of COCs have been reduced by approximately 10 years interim remediation (GET combined with MNA Assessment), but remain above cleanup levels. Monitoring data do not indicate significant plume migration. A contaminant rebound study began in December 2007 and included the shutdown of selected extraction wells. In February 2009, the remaining extraction wells were shut down. Data obtained during the rebound study do not indicate significant increases in plume concentrations or plume migration after GET system operations were discontinued.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (35 years). The main factors supporting selection of the remedy include the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2007. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the plume (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.1).
FT005	TCE 1,2-DCA cis-1,2-DCE Chloroform Bromodichloromethane	**5.6 J-** **5.8** 0.48 J- 0.29 J- ND	1,2-DCA plume approximate dimensions: Length: 600 feet Width: 400 feet Thickness: 25 to 30 feet Area: 1,258,142 ft^2 Volume: 11,323,278 ft^3 The majority of the contaminant plume extends to off-base privately owned property.	<u>GET</u> Plume size and concentrations of COCs have been reduced by approximately 10 years of interim remediation, but remain above cleanup levels in some wells. A contaminant rebound study began in December 2007, and the majority of the GET system has been shut down. Groundwater extraction has been resumed at selected wells when localized increases in the concentrations of COCs are observed during monitoring events.	Alternative 3 – GET	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Pumps extract contaminated groundwater from the aquifer and provide hydraulic containment of the plume. Extracted groundwater is treated using LGAC at a centralized treatment plant. Treated groundwater is discharged to the stormwater drainage system. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 3 – GET will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (10 years). The main factors supporting selection of the remedy include the following: the GET remedy components have already been implemented, GET has been demonstrated to be effective at remediating the entirety of the site plume, and the GET system capital costs have already been incurred. Treatment of contaminant-laden LGAC by an off-base EPA-approved vendor will also satisfy the statutory preference for treatment. Implementation of ROD Alternative 3 – GET at Site FT005 represents a continuation of approximately a decade of successful interim GET system operation (refer to Section 2.2.5.2).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
LF006	TCE 1,1-DCE	**6.9** ND	TCE plume approximate dimensions: Length: 400 feet Width: 350 feet Thickness: 25 to 30 feet Area: 110,447 ft^2 Volume: 662,680 ft^3	MNA Plume size and concentrations of COCs have been reduced by approximately 10 years of interim remediation, but remain above cleanup levels. Monitoring data have not indicated significant plume migration.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (5 years). The main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of Alternative 2 – MNA at Site LF006 is a continuation of approximately a decade of successful MNA during the period of interim remediation (refer to Section 2.2.5.3).
LF007B Subarea	Benzene 1,4-DCB Chlorobenzene	ND ND ND	No plume dimensions. Contaminant concentrations already less than cleanup levels. Area: 0 ft^2 Volume: 0 ft^3	MNA Assessment Plume size and concentrations of COCs have been reduced to below cleanup levels by interim remediation. Monitoring data over approximately 10 years of MNA assessment did not indicate significant plume migration.	Alternative 2 – MNA	Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Groundwater cleanup levels were achieved by natural attenuation processes during the period of interim remediation. Verification of the cleanup levels will be conducted under Alternative 2. Other main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the subarea plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site LF007B represents a transition from approximately a decade of successful MNA Assessment (CH2M HILL, 2010b) (refer to Section 2.2.5.4).
LF007C Subarea	TCE Vinyl chloride 1,1-DCE 1,2-DCA 1,2-Dichloropropane	**10.3** ND ND ND 0.3 J	TCE plume approximate dimensions: Length: 620 feet Width: 220 feet Thickness: 25 feet Area: 110,330 ft^2 Volume: 485,452 ft^3 The majority of the contaminant plume extends to off-base privately owned property.	GET Plume is stable. Monitoring data over approximately 10 years of interim GET system operation did not indicate significant reductions in plume size or concentrations of COCs. Therefore, GET system optimization will be conducted during 2013 to improve the extent of hydraulic capture and increase the rate of contaminant mass removal.	Alternative 3 – GET	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health. Prevent or minimize further migration of the contaminant plume.	Solar-powered pumps extract contaminated groundwater from the aquifer and provide hydraulic containment of the plume. Extracted groundwater is treated using LGAC at a centralized treatment plant. Treated groundwater is beneficially reused at the on-base Duck Pond recreation area. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 3 – GET will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (26 years). The main factors supporting selection of the remedy include the following: the GET remedy components have already been mostly implemented. GET system optimizations will take place during 2013 that will result in increased groundwater pumping rates, improved hydraulic capture of the plume, and an increased rate of contaminant mass removal. The optimized interim GET system will be more effective at remediating the site plume. Following the completion of the 2013 optimization activities, the GET system capital costs will be largely incurred. Treatment of contaminant-laden LGAC by an off-base EPA-approved vendor will also satisfy the statutory preference for treatment. The use of solar-powered groundwater extraction pumps and beneficial reuse of treated groundwater in the on-base Duck Pond provides aspects of GSR. Implementation of ROD Alternative 3 – GET at Subarea LF007C represents a continuation of approximately a decade of interim GET system operation (refer to Section 2.2.2.1).

TABLE 2.12-1
Basis for Remedy Summary
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Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
LF007D Subarea	Benzene Vinyl chloride 1,4-DCB 1,1-DCE Chlorobenzene	**2.2** ND **12.6** ND 30.2	Plume is limited to a small area in the vicinity of MW261x07. Area: 31,000 ft^{2} [d] Volume: 248,000 ft^{3} [d]	MNA Assessment Plume is stable. Monitoring data over approximately 10 years of MNA assessment indicated decreasing concentrations and did not indicate significant plume migration.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (23 to 49 years). The main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Subarea LF007D represents a transition from approximately a decade of successful MNA Assessment (refer to Section 2.2.5.5).
LF008	Alpha-chlordane Heptachlor Heptachlor epoxide	**0.43** ND **0.017 J-**	Alpha-chlordane plume approximate dimensions: Length: 195 feet Width: 112 feet Thickness: 35 feet Area: 33,368 ft^{2} Volume: 233,576 ft^{3}	GET Plume is stable and was hydraulically captured by IRA GET system during approximately 10 years of interim remediation. Plume size and concentrations of COCs remained stable and above cleanup levels. GET system operations were discontinued in December 2008 to conduct a contaminant rebound study. Data obtained during the rebound study did not indicate significant increases in concentrations of COCs or plume migration after GET system operations were discontinued.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (100 to 110 years). The main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of MNA will be effective because the site plume has been stable or contracting, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site LF008 represents a transition from approximately a decade of mostly ineffective interim GET system operation. Pesticide contaminant concentrations were stable during the period of active GET. The interim GET system was shut down for a contaminant rebound study in 2008. No significant change in contaminant concentrations has been observed since discontinuing GET system operations. Filtered and non-filtered sample data indicate that residual pesticides contaminants are strongly sorbed to soil particles and not dissolved in the groundwater. Therefore, MNA is a viable remedy under these site conditions (refer to Section 2.2.5.6).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
SS015	TCE cis-1,2-DCE Vinyl chloride 1,2-DCA PCE	**226** **598** **70.6** 0.3 J 3.1	cis-1,2-DCE plume approximate dimensions: Length: 360 feet Width: 160 feet Thickness:10 to 15 feet Area: 55,994 ft^2 Volume: 78,392 ft^3	<u>MNA Assessment</u> Plume concentrations remain above cleanup levels. Monitoring data over approximately 10 years of MNA assessment indicated increases in concentrations of some COCs (primarily cis-1,2-DCE and vinyl chloride). These increases probably resulted from incomplete anaerobic degradation of TCE following an abbreviated vegetable oil treatability study conducted in 2000-2001. Additional site characterization conducted in 2010 indicated local plume migration in the direction of local groundwater flow along the southwest-northeast axis of the plume. A successful demonstration of ERD treatment via EVO injection within the highest concentration portion of the plume began in 2010. This demonstration followed the abbreviated vegetable oil injection treatability study conducted during 2000-2001 within the same area.	Alternative 5 – EVO and EA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of contaminants from principal threat wastes and the highest concentrations of the plume into hydraulically downgradient groundwater. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the plume followed by natural attenuation. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	In situ treatment with EVO in the highest concentration portion of the plume and EA within the hydraulically downgradient and lower concentration portion of the plume. An edible oil substrate (i.e., EVO) is injected into the higher concentration portion of the plume to facilitate ERD treatment processes and anaerobically degrade chlorinated VOCs. In the lower concentration portion of the plume, naturally occurring physical, chemical, and biological processes remediate COCs, which will be enhanced by the reduced influx of contaminants from the treated portion of the plume. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 5 – EVO and EA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (70 years). The main factors supporting selection of the remedy include the following: the EVO injection well components of the remedy have already been mostly implemented during the ERD treatment demonstration and the EA monitoring well components have already been implemented, the effectiveness of ERD treatment via EVO injection to address residual DNAP principal threat wastes and the higher concentration portion of the plume has been successfully demonstrated, the processes of natural attenuation are assessed as likely to be effective at remediating the lower concentration portion of the plume when combined with the EVO injection component (refer to Section 2.2.5.7), and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR. Implementation of ROD Alternative 5 – EVO and EA at Site SS015 represents a transition from approximately a decade of an ultimately unsuccessful MNA Assessment for the entirety of the site plume (refer to Section 2.2.5.7) to a more effective strategy of active ERD treatment for the principal threat wastes and highest concentration portion of the plume taken in combination with natural attenuation processes in the lower concentration portion of the plume. ERD treatment using EVO injection has been demonstrated to be effective at remediating the principal threat wastes and the highest concentration portion of the plume (refer to Section 2.2.3.2). Natural attenuation processes within the lower concentration portion of the plume will be more effective after the ongoing source of contamination is greatly reduced by the ERD treatment component of the remedy (refer to Section 2.2.5.7).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
SS016 and SS029	TCE cis-1,2-DCE Vinyl chloride Benzene Chloroform 1,4-DCB Bromodichloromethane 1,2-DCA 1,1-DCE PCE	**40,200** **8,230** **812** ND 0.42 J **710** ND **13.4 J** **50.2 J** **108**	Sites SS016 and SS029 TCE plume approximate dimensions: Length: 5,700 feet Width: 1,400 feet Thickness: 25 to 40 feet Area: 7,112,191 ft^2 Volume: 41,250,708 ft^3	<u>GET</u> Plume concentrations remain above cleanup levels. The combined Sites SS016 and SS029 plumes were hydraulically captured by the combined site-specific IRA GET systems over approximately 10 years of interim remediation. Monitoring data indicated that some migration of the Site SS016 plume into the hydraulically downgradient Site SS029 plume was occurring. However, combined IRA GET system operations are continuing to maintain hydraulic capture and reduce contaminant concentrations for the combined plume. A successful demonstration of ERD treatment via an in situ bioreactor at Site SS016 began in 2010.	Alternative 4 – Bioreactor and GET (Site SS016) Alternative 3 – GET (Site SS029)	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of contaminants from principal threat wastes and the highest concentrations of the plume into hydraulically downgradient groundwater. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the plume followed by natural attenuation. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	For Site SS016, Alternative 4 involves treatment of COCs in groundwater with an in situ bioreactor and extraction and ex situ treatment with a GET system. An in situ bioreactor installed within the highest concentration portion of the plume facilitates ERD treatment processes to anaerobically degrade chlorinated VOCs. Groundwater within the hydraulically downgradient portions of the plume will continue to be extracted and treated ex situ with LGAC. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded. For Site SS029, Alternative 3 involves continued groundwater extraction and ex situ treatment of COCs in groundwater with LGAC. Hydraulic containment of plumes will be continued using the existing GET system. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 4 – Bioreactor and GET at Site SS016 will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (62 years). The main factors include the following: the bioreactor and GET system components of the Site SS016 remedy have already been implemented within an area of restricted access and ongoing military flightline operations. ERD treatment via a bioreactor was successfully demonstrated as being effective for addressing the residual DNAPL principal threat wastes and the highest concentration portions of the Site SS016 plume, and GET system operation has been demonstrated to be effective at remediating the remainder of the higher concentration plume. The capital costs for both the bioreactor and GET system components of the remedy have already been largely incurred. Use of an in situ bioreactor under Alternative 4 will satisfy the statutory preference for treatment. Treatment of contaminant-laden LGAC by an off-base EPA-approved vendor will also satisfy the statutory preference for treatment. Use of organic mulch to facilitate in situ ERD treatment processes in the bioreactor provides an aspect of GSR. Implementation of ROD Alternative 4 at Site SS016 follows approximately a decade of interim GET system operation. Operation of the GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system within this portion of the plume was shut down in 2010 for a successful ERD treatment demonstration via the bioreactor to address the principal threat wastes and the highest concentration portion of the plume (refer to Section 2.2.3.1). The remainder of the GET system remained in operation and continues to operate successfully within a high concentration portion of the plume (refer to Section 2.2.2.2). The lower concentration portion of the plume that is not hydraulically captured by the Site SS016 GET system is intercepted and hydraulically captured by the downgradient Site SS029 GET system. Alternative 3 – GET at Site SS029 will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (62 years). The main factors include the following: the components of the Site SS029 GET system have already been implemented within an area of restricted access and ongoing military flightline operations. Long-term interim GET system operation has been demonstrated to be effective at remediating the combined Sites SS016 and SS029 plumes and preventing plume migration. The capital costs for the Site SS029 GET system have already been incurred. Treatment of contaminant-laden LGAC by an off-base EPA-approved vendor will also satisfy the statutory preference for treatment. Implementation of Alternative 3 at Site SS029 follows approximately a decade of successful interim GET system operation.

TABLE 2.12-1
Basis for Remedy Summary
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Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
ST027B	TCE[e] Vinyl chloride[e] cis-1,2-DCE[e] Benzene Toluene	**435** **7.1** **338** 0.32 J ND	TCE plume approximate dimensions: Length: 650 feet Width: 400 feet Thickness: 30 to 35 feet Area: 183,134 ft^{2e} Volume: 1,281,938 ft^{3e} Formerly managed under the POCO program. Chlorinated VOCs were detected after the IROD was finalized and IRAs implemented.	MNA[e] Plume is stable at concentrations above cleanup levels. Monitoring data obtained during periods of POCO and ERP program management did not indicate significant increases in COC concentrations and did not indicate plume migration.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (50 years). The main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site ST027B represents a transition from MNA as the POCO program presumptive remedy for the site and the period of MNA assessment after CERCLA contaminants were detected in 1999. Site ST027B was not included in the Groundwater IROD for the NEWIOU, and MNA Assessment was not formally selected as the interim remedy. However, long-term groundwater monitoring of the site was conducted under the Travis AFB GSAP. The data were obtained by the GSAP monitoring support using natural attenuation processes to remediate the plume (refer to Section 2.2.5.8).
SS030	TCE Chloroform Bromodichloromethane 1,2-DCA	**48.8** 7.4 ND ND	TCE plume approximate dimensions: Length: 1,400 feet Width: 400 feet Thickness: 20 to 40 feet Area: 455,647 ft^2 Volume: 1,822,588 ft^3 The majority of the contaminant plume extends onto off-base privately owned property.	GET Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. The plume was hydraulically captured by the interim GET system over approximately 10 years of interim remediation. GET system operations continue to maintain hydraulic capture of the plume and reduce contaminant concentrations. In 2010-2011, additional investigation was conducted to further characterize the distribution of COCs and possible plume migration. The rate of groundwater extraction was then increased to more fully capture the plume. Additional GET system optimization will be conducted during 2013 by installing an additional extraction well to further improve hydraulic capture of the plume and increase the rate of contaminant mass removal.	Alternative 3 – GET	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	Pumps extract contaminated groundwater from the aquifer and provide hydraulic containment of the plume. Extracted groundwater is treated using LGAC at a centralized treatment plant. Treated groundwater is discharged to the stormwater drainage system. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 3 – GET will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (22 years). The main factors supporting selection of the remedy include the following: the GET remedy components have already been mostly implemented and have been demonstrated to be effective at remediating the site plume, and the GET system capital costs have already been incurred. Treatment of contaminant-laden LGAC by an off-base EPA-approved vendor will also satisfy the statutory preference for treatment. GET system optimizations will take place during 2013 that will result in improved hydraulic capture of the plume and an increased rate of contaminant mass removal. Implementation of Alternative 3 – GET at Site SS030 represents a continuation from approximately a decade of successful interim GET system operation (refer to Section 2.2.1).

TABLE 2.12-1
Basis for Remedy Summary
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Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
SD031	TCE Benzene 1,1-DCE cis-1,2-DCE Carbon tetrachloride Chloroform 1,2-DCA Vinyl chloride	**7.1 J-** ND **56.7** 0.78 J- ND 0.17 J ND ND	1,1-DCE plume approximate dimensions: Length: 300 feet Width: 150 feet Thickness: 25 to 30 feet Area: 54,255 ft^2 Volume: 260,424 ft^3	<u>GET and MNA Assessment</u> Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. Monitoring data obtained over approximately 10 years of interim remediation did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in December 2007. Data obtained during the rebound study did not indicate significant increases in concentrations of COCs or plume migration after GET system operations were discontinued.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (15 years). The main factors supporting selection of the remedy include the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SD031 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. Plume concentrations under long-term interim GET operation had declined at an ever-decreasing rate and had become cost-ineffective. After shutdown of the GET system, natural attenuation processes were evaluated for the entirety of the plume (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.1).
SD033 (component of WIOU)	TCE 1,1-DCE 1,2-DCA cis-1,2-DCE	**99.2** ND ND **50**	Site contamination is within the overall WIOU plume.[f]	<u>GET and MNA Assessment</u> Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. Monitoring data obtained over approximately 10 years of interim remediation indicated declining plume concentrations and did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant increases in concentrations of COCs or plume migration after GET system operations were discontinued.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years). The main factors supporting selection of the remedy include the following: the monitoring well components of MNA have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the site plume, and the capital costs have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SD033 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD033 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.9).

TABLE 2.12-1
Basis for Remedy Summary
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SD034 (component of WIOU)	TCE Vinyl chloride 1,1-DCE Benzene cis-1,2-DCE PCE	**5.8** **2.1** ND 0.21 J 5.7 ND	Free-phase Stoddard solvent intermittently measured floating on groundwater table. Site contamination is within the overall WIOU plume.[f]	<u>GET with Free Product Removal</u> Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. Monitoring data obtained over approximately 10 years of interim remediation indicated declining plume concentrations and did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant increases in concentrations of COCs or plume migration after GET system operations were discontinued. Free-phase Stoddard solvent containing dissolved COCs continues to be intermittently detected floating on the groundwater table.	Alternative 7 – Passive Skimming and EA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Remove free-phase Stoddard solvent containing dissolved COCs floating on the groundwater table and potentially impacting designated beneficial uses to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Stoddard solvent floating on the groundwater table and containing dissolved COCs is physically removed using passive skimmers. Removal of the free-phase Stoddard solvent providing an ongoing source of contamination then supports natural physical, chemical, and biological processes in remediating COCs dissolved in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 7 – Passive Skimming and EA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years). The main factors supporting selection of the remedy include the following: the passive skimming and monitoring well components of the remedy have already been implemented, the processes of passive skimming and natural attenuation have been demonstrated to be effective at removing the residual LNAPL principal threat waste (i.e., free-phase Stoddard solvent containing dissolved COCs) and remediating the dissolved site plume, and the capital costs of passive skimming and monitoring have already been incurred. Implementation of ROD Alternative 7 – Passive Skimming and EA at Site SD034 follows approximately a decade of successful passive skimming of free-phase Stoddard solvent and interim GET system operation within the higher concentration portion of the plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the passive skimming and GET systems. Passive skimming has removed Stoddard solvent to the point that it is only intermittently measured, and the GET system component of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD034 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.9).

TABLE 2.12-1
Basis for Remedy Summary
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Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy		Basis for Remedy Selection
						RAOs	Description	
SS035 (component of WIOU)	TCE	ND	Site contamination is within the overall WIOU plume.[f]	GET and MNA Assessment Plume size and concentrations of COCs have been reduced to below cleanup levels by interim remediation. Monitoring data obtained over approximately 10 years of interim remediation indicated declining plume concentrations and did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant increases in concentrations of COCs or plume migration after GET system operations were discontinued.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Groundwater cleanup levels were achieved during the period of interim remediation. Verification of the cleanup levels will be conducted under Alternative 2. Other main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred. Implementation of ROD Alternative 2 – MNA at Site SS035 follows approximately a decade of successful interim GET system operation within the higher concentration portion of the WIOU plume, including Site SS035, combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. The GET system part of the IRA has been shut down for a contaminant rebound study since 2010. Plume concentrations under long-term GET operation had declined at an ever-decreasing rate and had become cost-ineffective. Natural attenuation processes have since been evaluated for the entirety of the WIOU plume, including Site SD034 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for plume remediation under the site conditions (refer to Section 2.2.5.9).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
SD036 (component of WIOU)	Vinyl chloride TCE 1,1-DCE cis-1,2-DCE 1,2-DCA Benzene Bromodichloromethane PCE	**1,100** **14,400** **12.5 J-** **3,870** **1.2** 0.59 ND **13.3 J**	Site contamination is within the overall WIOU plume.[f]	<u>GET and MNA Assessment</u> Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. Monitoring data obtained over approximately 10 years of interim remediation indicated declining plume concentrations and did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant increases in concentrations of COCs or plume migration after GET system operations were discontinued. A successful demonstration of ERD treatment via EVO injection began in 2010.	Alternative 5 – EVO and EA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of contaminants from principal threat wastes and the highest concentrations of the plume into hydraulically downgradient groundwater. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the plume followed by natural attenuation. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	In situ treatment with EVO in the highest concentration portion of the plume and EA within the hydraulically downgradient and lower concentration portion of the plume. An edible oil substrate (i.e., EVO) is injected into the higher concentration portion of the plume to facilitate ERD treatment processes and to anaerobically degrade chlorinated VOCs. In the hydraulically downgradient and lower concentration portion of the plume, naturally occurring physical, chemical, and biological processes remediate COCs, which will be enhanced by the reduced influx of contaminants from the treated portion of the plume. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 5 – EVO and EA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years). The main factors supporting selection of the remedy include the following: the EVO injection component of the remedy has already been mostly implemented during the ERD treatment demonstration, the EA monitoring well components have already been implemented, ERD treatment via EVO injection to address the residual DNAPL principal threat wastes and the higher concentration portion of the plume has been successfully demonstrated (refer to Section 2.2.3.2), the processes of natural attenuation have been demonstrated to be effective at remediating the lower concentration portion of the plume (refer to Section 2.2.5.9), and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR. Implementation of ROD Alternative 5 – EVO and EA at Site SD036 follows approximately a decade of partially successful interim GET system operation within the higher concentration portion of the WIOU plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. Operation of the interim GET system to address principal threat wastes and the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA has been shut down for an ERD treatment demonstration and contaminant rebound study since 2010. Natural attenuation processes have since been evaluated for the remainder of the WIOU plume, including Site SD036 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediating the lower concentration portions of the WIOU plume, including the Site SD036 plume component (refer to Section 2.2.5.9).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
SD037 (component of WIOU)	1,1-DCE 1,2-DCA Benzene Bromodichloromethane Carbon tetrachloride PCE TCE Vinyl chloride cis-1,2-DCE	4.6 ND **7.6** ND **7.6** **212** **1,720** **26.3** **749**	TCE plume approximate dimensions: Length: 4,650 feet Width: 750 feet Thickness: 20 to 90 feet Area: 1,626,667 ft^2 Volume: 13,664,003 ft^3 Site SD037 plume dimensions represent the overall WIOU plume.[f]	<u>GET and MNA Assessment</u> Plume size and concentrations of COCs have been reduced by interim remediation but remain above cleanup levels. Monitoring data obtained over approximately 10 years of interim remediation indicated declining plume concentrations and did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant increases in concentrations of COCs or plume migration after GET system operations were discontinued. A successful demonstration of ERD treatment via EVO injection began in 2010.	Alternative 5 – EVO and EA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of contaminants from principal threat wastes and the highest concentrations of the plume into hydraulically downgradient groundwater. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the plume followed by natural attenuation. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	In situ treatment with EVO in the highest concentration portion of the plume and EA within the hydraulically downgradient and lower concentration portion of the plume. An edible oil substrate (i.e., EVO) is injected into the higher concentration portion of the plume to facilitate ERD treatment processes and to anaerobically degrade chlorinated VOCs. In the hydraulically downgradient and lower concentration portion of the plume, naturally occurring physical, chemical, and biological processes remediate COCs, which will be enhanced by the reduced influx of contaminants from the treated portion of the plume. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 5 – EVO and EA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (60 years). The main factors supporting selection of the remedy include the following: the EVO injection well components of the remedy have already been mostly implemented during the ERD treatment demonstration, the EA monitoring well components have already been implemented, ERD treatment via EVO injection to address the residual DNAPL principal threat wastes and the higher concentration portion of the plume has been successfully demonstrated (refer to Section 2.2.3.2), the processes of natural attenuation have been demonstrated to be effective at remediating the lower concentration portion of the plume (refer to Section 2.2.5.9), and the capital costs of EVO injection wells and EA monitoring wells have already been largely incurred. Use of EVO injection to facilitate ERD under Alternative 5 will also satisfy the statutory preference for treatment. Use of food-grade EVO to facilitate in situ ERD treatment processes provides an aspect of GSR. Implementation of ROD Alternative 5 – EVO and EA at Site SD037 follows approximately a decade of partially successful interim GET system operation within the higher concentration portion of the WIOU plume combined with MNA Assessment in the lower concentration portion of the plume located hydraulically downgradient of the GET system. Operation of the interim GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA has been shut down for an ERD treatment demonstration and contaminant rebound study since 2010. Natural attenuation processes have since been evaluated for the remainder of the WIOU plume, including Site SD037 (CH2M HILL, 2010b). Assessments of MNA during the period of interim remediation and during the period of the rebound study indicate that natural physical, chemical, and biological processes are viable for remediating the lower concentration portions of the WIOU plume, including the Site SD037 plume component (refer to Section 2.2.5.9).

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy: RAOs	Selected Remedy: Description	Basis for Remedy Selection
DP039	1,1-DCE 1,2-DCA 1,1,1-TCA 1,1,2-TCA Bromodichloromethane Methylene chloride PCE TCE Vinyl chloride	**2,210** **5.2** ND ND ND **24** ND **1,740** **48**	TCE plume approximate dimensions: Length: 1,720 feet Width: 820 feet Thickness: 20 to 45 feet Area: 1,144,580 ft^2 Volume: 9,614,472 ft^3	<u>GET and MNA Assessment</u> Plume is stable. Monitoring data obtained over approximately 10 years of interim remediation did not indicate significant plume migration. The interim GET system was shut down for a contaminant rebound study in April 2010. Data obtained during the rebound study have not indicated significant plume migration after GET system operations were discontinued. A successful treatability study of phytoremediation began in 1998. The planted trees continue to mature as an ongoing demonstration of phytoremediation treatment. A successful demonstration of ERD treatment via an in situ bioreactor began in 2008. A successful demonstration of ERD treatment via an injected EVO PRB began in 2010.	Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of contaminants from principal threat wastes and the highest concentrations of the plume into hydraulically downgradient groundwater. Includes cleanup of groundwater, to the extent practicable, within the highest concentration portions of the plume followed by natural attenuation. Prevent or minimize further migration of the contaminant plume. Restrict inhalation of COCs that are volatilizing from groundwater into indoor air until those levels do not pose unacceptable risk to human health.	In situ treatment of COCs in the higher concentration portions of the plume using the combination of a bioreactor, phytoremediation, and an injected EVO PRB to facilitate biological processes and EA within the remainder of the downgradient plume. Operation of the GET system is discontinued. An in situ bioreactor installed within the highest concentration portion of the plume facilitates ERD treatment processes to anaerobically degrade chlorinated VOCs. A grove of planted eucalyptus trees supplements treatment within a portion of the plume that is hydraulically downgradient of the bioreactor as the plume flows beneath the trees. A PRB of injected edible vegetable oil across the leading edge of the source area (i.e., a biobarrier) continues to treat the portion of the aquifer downgradient of the bioreactor and tree grove. Naturally occurring physical, chemical, and biological processes remediate COCs in downgradient groundwater, which will be enhanced by the reduced influx of contaminants from the treated portions of the plume. LUCs restrict groundwater access and use and residential and industrial land uses. Groundwater-to-indoor-air LUCs enforced when risk-based groundwater-to-indoor-air concentrations are exceeded.	Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Costs are proportional to the effectiveness of the remedy by achieving long-term effectiveness and permanence within a reasonable time (58 years). The main factors supporting selection of the remedy include the following: the bioreactor, phytoremediation, EVO PRB, and EA monitoring well components of the remedy have already been implemented; ERD treatment via bioreactor and EVO PRB have been successfully demonstrated as being effective in treating the residual DNAPL principal threat wastes and the higher concentration portions of the plume; biological treatment via phytoremediation has been successfully demonstrated as being effective in treating a portion of the higher concentration plume; and the processes of natural attenuation were assessed as likely to be effective at remediating the lower concentration portion of the plume when combined with the bioreactor, phytoremediation, and EVO PRB remedy components. The capital costs of the bioreactor, area of phytoremediation, EVO PRB, and EA monitoring wells have already been largely incurred. Use of a bioreactor and EVO injection to facilitate ERD and biological treatment using phytoremediation satisfy the statutory preference for treatment. Use of food-grade EVO and planted trees provides aspects of GSR. Implementation of ROD Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA at Site DP039 follows approximately a decade of partially successful interim GET system operation combined with an assessment of MNA in the lower concentration portion of the plume. A successful phytoremediation treatability study was conducted within the higher concentration portion of the site plume located hydraulically downgradient of the GET system. The assessment of MNA was conducted in the lower concentration portion of the plume located hydraulically downgradient of the GET system and area of phytoremediation. Operation of the GET system within the highest concentration portion of the plume had become increasingly cost-ineffective as contaminant concentrations were being reduced at an ever-decreasing rate. As a result, the GET system component of the IRA was shut down in 2008 for a successful ERD treatment demonstration via the bioreactor. Another successful ERD treatment demonstration via an EVO PRB began in 2010 (refer to Section 2.2.3.2). Successful biological treatment using phytoremediation had been ongoing since 1998 (refer to Section 2.2.4).The assessment of MNA during the period of interim remediation indicated that natural physical, chemical, and biological processes alone were not adequate for remediating the distal portion of the plume, and additional measures were needed to reduce the influx of contamination from the hydraulically upgradient and higher concentration portions of the plume (i.e., the bioreactor, area of phytoremediation, and EVO PRB) (refer to Section 2.2.5.10). Use of organic mulch to facilitate in situ ERD treatment processes in the bioreactor provides an aspect of GSR. Also, use of planted trees for in situ biological treatment and food-grade EVO to facilitate in situ ERD treatment processes within the PRB provides additional aspects of GSR.

TABLE 2.12-1
Basis for Remedy Summary
Groundwater Record of Decision, Travis Air Force Base, California

Site	COCs	Concentration (µg/L)[a,b]	Plume Size[c]	Interim Remedy/Status	Selected Remedy	Selected Remedy		Basis for Remedy Selection
						RAOs	Description	
SS041	Heptachlor epoxide	ND	No plume dimensions. Contaminant concentrations already less than cleanup levels. Area: 0 ft^2 Volume: 0 ft^3	GET Plume size and concentrations of COCs have been reduced to below cleanup levels by interim remediation. The site has been in NFRAP status since 2005.	Alternative 1 – NFA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	No further actions, including no LUC provisions, will occur to remediate or manage COCs in groundwater. Operation of the GET system remains discontinued.	Alternative 1 – NFA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Groundwater cleanup levels were achieved during the period of interim remediation. Site SS041 is currently in NFRAP status under a consensus statement signed by representatives of the AF and regulatory agencies (Travis AFB, 2005a).
SD043 (component of WIOU)	TCE	0.7	Site contamination is within the overall WIOU plume.[f]	GET Plume size and concentrations of COCs have been reduced to below cleanup levels by interim remediation. Monitoring data obtained over approximately 10 years of interim remediation did not indicate significant plume migration. Data obtained during an ongoing rebound study have not indicated increases in concentrations of COC or plume migration after GET system operations were discontinued in April 2010.	Alternative 2 – MNA	Restrict human ingestion and direct dermal contact with contaminated groundwater and reduce concentrations of COCs in groundwater to restore designated beneficial uses, to the maximum extent practicable. Prevent or minimize further migration of the contaminant plume.	Naturally occurring physical, chemical, and biological processes remediate COCs in groundwater. Operation of the GET system is discontinued. LUCs restrict groundwater access and use and residential and industrial land uses.	Alternative 2 – MNA will achieve the RAOs and best satisfies the threshold and primary balancing evaluation criteria and represents the most reasonable value for the money. Groundwater cleanup levels were achieved during the period of interim remediation. Verification of the cleanup levels will be conducted under Alternative 2. Other main factors supporting selection of the remedy include the following: the MNA remedy components have already been implemented, the processes of natural attenuation have been demonstrated to be effective at remediating the entirety of the site plume, and the capital costs for the MNA monitoring well network have already been incurred.

[a] **Bolded** concentrations are above the groundwater cleanup level (refer to Table 2.8-1).
[b] Current concentration after approximately a decade of interim remediation. Source: GSAP 2010-2011 Annual Report (CH2M HILL, 2012a).
[c] Estimated based on the groundwater COC with greatest areal extent. Groundwater pore volume estimated from the plume area, saturated thickness, and a porosity of 20 percent.
[d] Contamination is limited to a small area in the vicinity of MW261x07. Plume areas and volumes are based on an approximate 100-foot plume radius around this well.
[e] Portion of Site ST027 formerly managed under the Travis AFB POCO program. Chlorinated VOCs regulated under CERCLA were not detected in the Area B portion of plume (i.e., Site ST027B) until after the NEWIOU Groundwater IROD was finalized.
[f] Included in Site SD037 estimates. The plume areas and volumes for Sites SD033, SD034, SS035, SD036, SD037, and SD043 comprise the overall WIOU plume. These site contaminant plumes are inseparably commingled and are addressed as a single WIOU plume. Site SD037 is selected as representative of the WIOU plume because the ERP site boundary has the greatest geographic extent of the component sites.

TABLE 2.12-2
Summary of Performance Monitoring
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Component	Portion of Plume Addressed by Remedy Component	Duration of LTO[a] (years)	Duration of LTM[b] (years)	Duration of LTO and LTM (years)	Comment
FT004	Alternative 2 – MNA	Entirety of plume	35	2	37	Plume remediated during period of LTO by natural physical, chemical, and biological processes.
FT005	Alternative 3 – GET	Entirety of plume	10	2	12	Plume remediated during period of LTO by physical removal of contaminants using groundwater pumping. Majority of plume is located off-base.
LF006	Alternative 2 – MNA	Entirety of plume	5	2	7	Plume remediated during period of LTO by natural physical, chemical, and biological processes.
LF007B	Alternative 2 – MNA	Entirety of plume	0	2	2	Cleanup levels already achieved by natural attenuation processes during the period of interim remediation.
LF007C	Alternative 3 – GET	Entirety of plume	26	2	28	Plume remediated during period of LTO by physical removal of contaminants using groundwater pumping. Majority of plume is located off-base.
LF007D	Alternative 2 – MNA	Entirety of plume	23 to 49	2	25 to 51	Plume remediated during period of LTO by natural physical, chemical, and biological processes.
LF008	Alternative 2 – MNA	Entirety of plume	100 to 110	2	102 to 112	Organochlorine pesticides sorbed to fine soil particles and not detected in filtered groundwater samples.
SS015	Alternative 5 – EVO	Highest concentration portion of plume	5 to 10	--[b]	--[b]	Portion of plume being actively treated using ERD processes via injection of EVO.
	Alternative 5 – EA	Lower concentration portion of plume	70	2	72	Portion of plume located hydraulically downgradient of the EVO remedy component.

TABLE 2.12-2
Summary of Performance Monitoring
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Component	Portion of Plume Addressed by Remedy Component	Duration of LTO[a] (years)	Duration of LTM[b] (years)	Duration of LTO and LTM (years)	Comment
SS016	Alternative 4 – Bioreactor	Highest concentration portion of plume	5 to 10	--[b]	--[b]	Portion of plume being actively treated using ERD processes.
	Alternative 4 – GET	Low to moderate concentration portion of plume	62	2	64	Component of treatment train.
ST027B	Alternative 2 – MNA	Entirety of plume	50	2	52	Plume remediated during period of LTO by natural physical, chemical, and biological processes.
SS029	Alternative 3 – GET	Entirety of plume	62	2	64	Plume remediated during period of LTO by physical removal of contaminants using groundwater pumping. COCs likely migrating to site from the hydraulically upgradient Site SS016 plume.
SS030	Alternative 3 – GET	Entirety of plume	22	2	24	Plume remediated during period of LTO by physical removal of contaminants using groundwater pumping. Majority of plume is located off-base.
SD031	Alternative 2 – MNA	Entirety of plume	15	2	17	Plume remediated during period of LTO by natural physical, chemical, and biological processes.
SD033	Alternative 2 – MNA	Entirety of plume	60	2	62	Plume remediated during period of LTO by natural physical, chemical, and biological processes. Component of overall WIOU plume.
SD034	Alternative 7 – Passive Skimming	Portion of plume with free-phase Stoddard solvent (LNAPL)	5 to 10	2	7 to 12	Portion of plume with localized free-phase Stoddard solvent (containing dissolved COCs).
	Alternative 7 – EA	Remainder of plume	60	2	62	Portion of plume with only dissolved contamination. Component of overall WIOU plume.

TABLE 2.12-2
Summary of Performance Monitoring
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Component	Portion of Plume Addressed by Remedy Component	Duration of LTO[a] (years)	Duration of LTM[b] (years)	Duration of LTO and LTM (years)	Comment
SS035	Alternative 2 – MNA	Entirety of plume	60	2	62	Component site within the overall WIOU plume. Cleanup levels within the Site SS035 administrative boundaries were achieved during the period of interim remediation. Duration of LTO and LTM given for the entirety of the WIOU plume.
SD036	Alternative 5 – EVO	Highest concentration portion of plume	5 to 10	--[b]	--[b]	Portion of plume being actively treated using ERD processes via injection of EVO.
	Alternative 5 – EA	Lower concentration portion of plume	60	2	62	Portion of plume located hydraulically downgradient of the EVO remedy component. Component of overall WIOU plume.
SD037	Alternative 5 – EVO	Highest concentration portion of plume	5 to 10	--[b]	--[b]	Portion of plume being actively treated using ERD processes via injection of EVO.
	Alternative 5 – EA	Lower concentration portion of plume	60	2	62	Portion of plume located hydraulically downgradient of the EVO remedy component. Component of overall WIOU plume.
DP039	Alternative 6 – Bioreactor	Highest concentration portion of plume	5 to 10	--[b]	--[b]	Portion of plume actively treated using ERD processes using an organic mulch bioreactor. Component of treatment train.
	Alternative 6 – Phytoremediation	High concentration and shallow portion of plume	--[a]	--[b]	--[b]	Portion of plume actively treated using biological processes. Component of treatment train.
	Alternative 6 – EVO PRB	High concentration portion of plume	--[a]	--[b]	--[b]	Portion of plume actively treated using ERD processes via injection of EVO. Component of treatment train.
	Alternative 6 – EA	Lower concentration portion of plume	58	2	60	Portion of plume located hydraulically downgradient of the bioreactor, area of phytoremediation, and EVO PRB remedy components.

TABLE 2.12-2
Summary of Performance Monitoring
Groundwater Record of Decision, Travis Air Force Base, California

Site	Remedy Component	Portion of Plume Addressed by Remedy Component	Duration of LTO[a] (years)	Duration of LTM[b] (years)	Duration of LTO and LTM (years)	Comment
SS041	Alternative 1 – NFA	Entirety of plume	0	0	0	Cleanup levels achieved during the period of interim remediation. Site SS041 in NFRAP status (Travis AFB, 2005a).
SD043	Alternative 2 – MNA	Entirety of plume	60	2	62	Component site within the overall WIOU plume. Cleanup levels within the Site SD043 administrative boundaries were achieved during the period of interim remediation. Duration of LTO and LTM given for the entirety of the WIOU plume.

[a] Performance monitoring during the period of LTO is conducted until cleanup levels are achieved for the entirety of the plume.
[b] Monitoring during the period of LTM is to ensure that cleanup levels have been achieved for the entirety of the plume. Includes the higher concentration portion of a plume undergoing active treatment (including the highest concentration portion of the plume at Sites SS015, SS016, SD036, SD037, and DP039) and the lower concentration portion of a plume being remediated by natural physical, chemical, and biological processes.

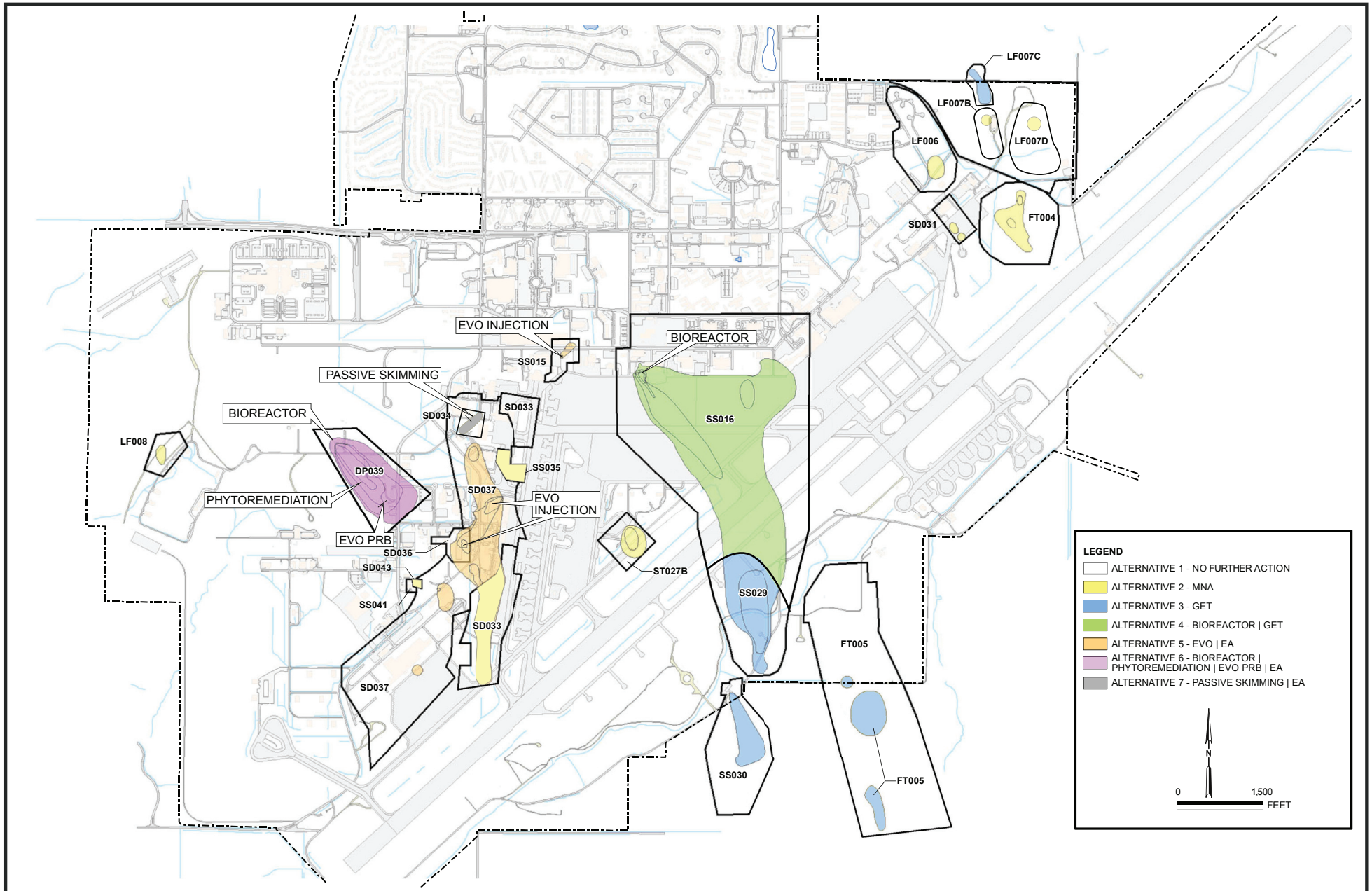
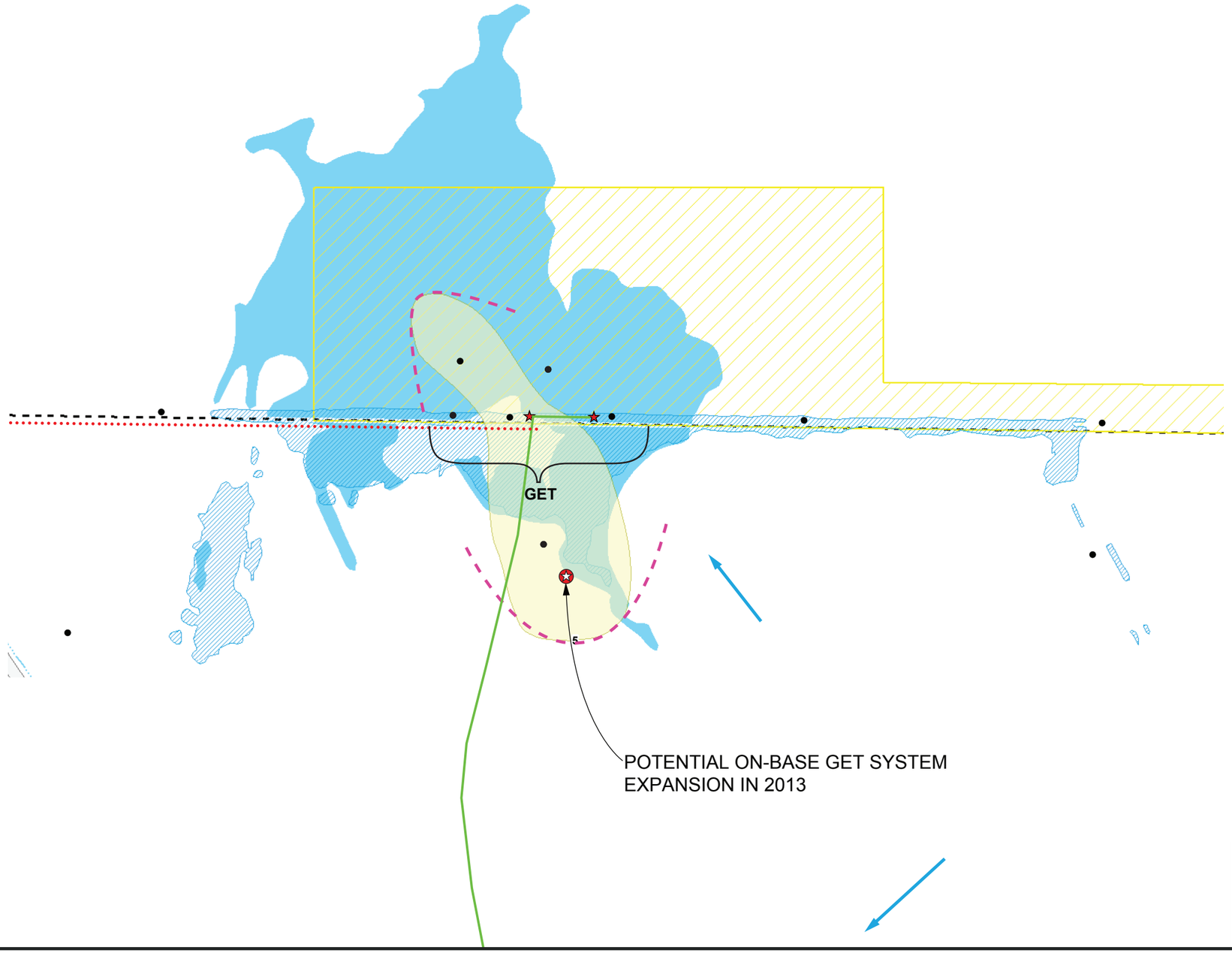
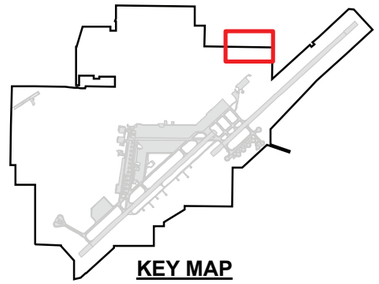


FIGURE 2.12-1
OVERVIEW OF SITES AND ALTERNATIVES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC





KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- EXTRACTION WELL
- PROPOSED EXTRACTION WELL

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- EASEMENT
- SURFACE WATER/VERNAL POOL
- WETLANDS
- BASE BOUNDARY
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- UNTREATED WATER PIPING
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- PROPOSED UNTREATED WATER PIPING

N

0 100 200 FEET

FIGURE 2.12.-2
CONCEPTUAL DESIGN
ALTERNATIVE 3 – GET AT SITE LF007C
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

SS016

SS029

SS030

FT005

UNION CREEK

SBBGWTP

1125

1130

1115

100

5

0.5

KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- PLANNED MONITORING WELL
- EXTRACTION WELL
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- UNTREATED WATER PIPING
- TREATED WATER PIPING
- SURFACE WATER
- BASE BOUNDARY

1,2-DCA CONCENTRATIONS (µg/L)

- 1,2-DCA ≥ 0.5 µg/L

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000

NOTE: DASHED LINE INDICATES APPROXIMATE BOUNDARY

N

0 250 500 FEET

REFERENCE: 2010-2011 GSAP REPORT

FIGURE 2.12-3
CONCEPTUAL DESIGN ALTERNATIVE 3 – GET AT SITES FT005, SS029, AND SS030
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

EW003x16
BIOREACTOR
100,000
10,000
1,000
100
5
EW001x16
EW002x16
TARA
GET
OSA
SS016
EW610x16
EW605x16
ST032
ST027
SS016
SS029
GET
SS030
WP017
FT005
MAIN BRANCH UNION CREEK

KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- PIEZOMETER
- EXTRACTION WELL
- PLANNED MONITORING WELL
- APPROXIMATE EXTENT OF HYDRAULIC CAPTURE
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- HORIZONTAL EXTRACTION WELL
- UNTREATED WATER PIPING

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE < 100
- 100 ≤ TCE < 1,000
- 1,000 ≤ TCE < 10,000
- 10,000 ≤ TCE < 100,000
- TCE ≥ 100,000
- SURFACE WATER
- FENCE
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- ERP SITE BOUNDARY

N

0 225 450 FEET

REFERENCES: 2010-2011 GSAP REPORT

ES051412034344SAC

FIGURE 2.12-4
CONCEPTUAL DESIGN ALTERNATIVE 4 – BIOREACTOR AND GET AT SITE SS016
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

TO CGWTP

EW003x16 (EXTRACTED GROUNDWATER USED TO IRRIGATE BIOREACTOR)

BIOREACTOR

TPE-W

GROUNDWATER CONVEYANCE PIPELINE FROM DOWNGRADIENT EXTRACTION WELLS EW605x16 AND EW610x16

5
100
1,000
10,000

Map Extent

KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- PIEZOMETER
- EXTRACTION WELL
- 2-PHASE EXTRACTION WELL (INACTIVE)
- PLANNED MONITORING WELL
- OSA HORIZONTAL EXTRACTION WELL
- ThOx UNIT (FORMER)
- ROAD
- PAVED AREA
- BUILDING
- UNTREATED WATER PIPING

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- TCE >10,000

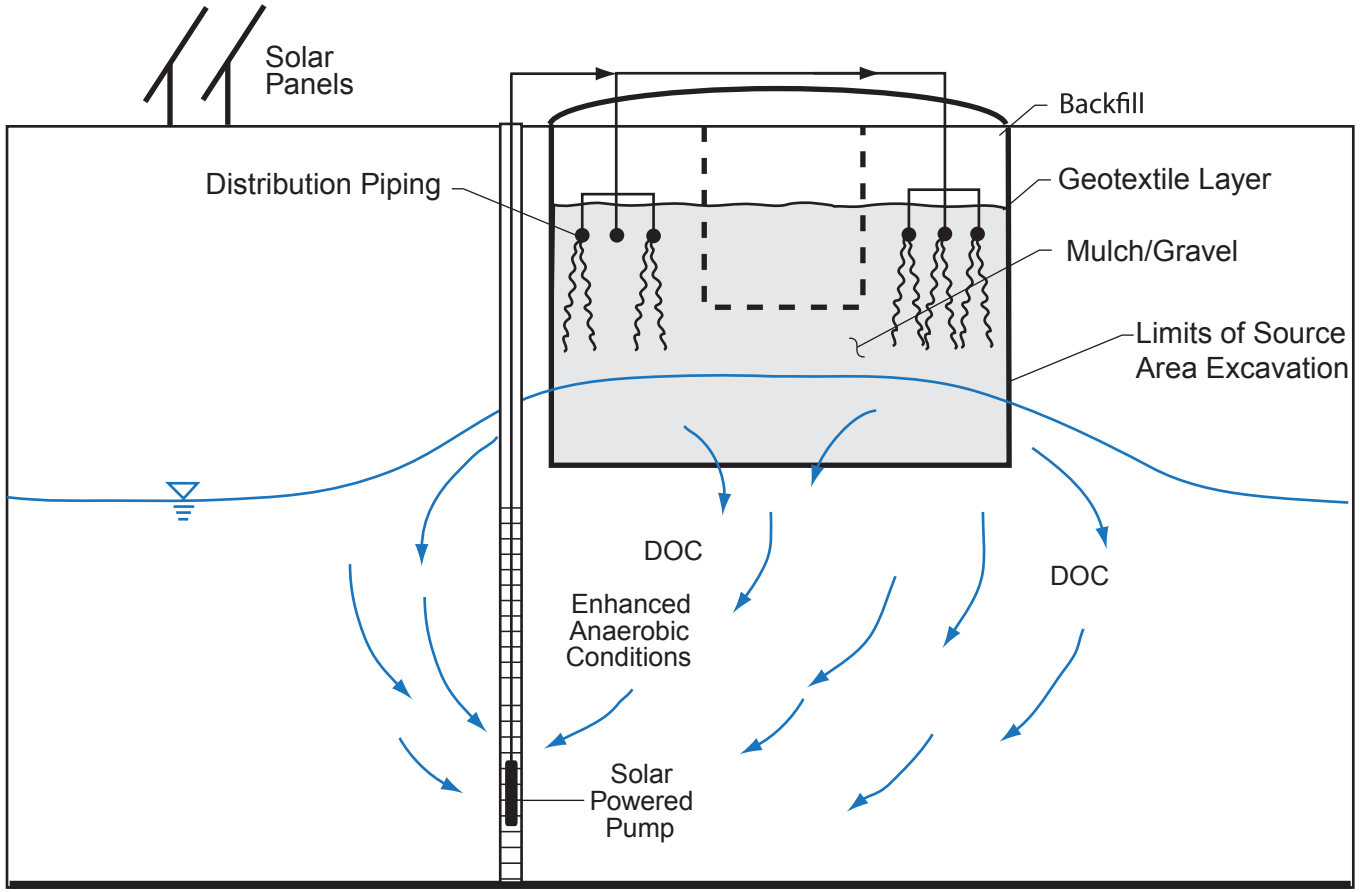
REFERENCE: 2010-2011 GSAP REPORT

N

0 25 50 FEET

FIGURE 2.12-5
CONCEPTUAL DESIGN ALTERNATIVE 4 – BIOREACTOR AND GET AT SITE SS016 OSA SOURCE AREA
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC



LEGEND

Groundwater Flow Direction

DOC Dissolved Organic Carbon

FIGURE 2.12-6
CONCEPTUAL DESIGN
ALTERNATIVES 4 AND 6
TYPICAL BIOREACTOR CROSS SECTION
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

BUILDING 549

MW2130X15

LANE STREET

MW2119X15

MW2118X15

EA

MW2105X15

HANGAR AVENUE

MW2124X15

MW104X15

MW624X15

MW2103X15

MW2129X15

MW2106X15

IW2127X15

IW2126X15

BUILDING 554

MW2104X15

MW216X15

IW2128X15

MW625X15

MW2132X15

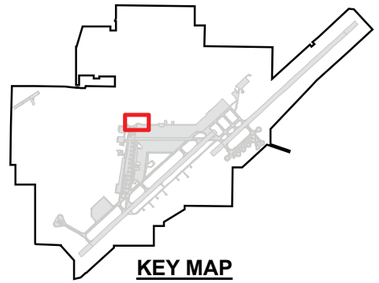
100

6

MW2131X15

MW306X15

MW105X15



KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- PLANNED MONITORING WELL
- EVO INJECTION WELL
- LOCAL GROUNDWATER FLOW DIRECTION
- 6 — CIS-1,2-DCE CONCENTRATIONS CONTOUR (µg/L)
- 6 ≤ CIS-1,2-DCE < 100
- 100 ≤ CIS-1,2-DCE < 1,000
- CIS-1,2-DCE ≥ 1,000
- EVO TREATMENT DEMONSTRATION
- EVO TREATMENT FINAL BUILDOUT
- FENCE

REFERENCE: 2010-2011 GSAP REPORT

N

0 25 100 FEET

FIGURE 2.12-7
CONCEPTUAL DESIGN
ALTERNATIVE 5 – EVO AND EA
AT SITE SS015
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

KEY MAP

PASSIVE SKIMMING

EA

A

SD034

DP039

5

100

1,000

EVO PRB

EA

EVO TREATMENT ZONE

EA

EVO TREATMENT ZONE

SD036

EA

EA

A'

SS014

LEGEND

- PERFORMANCE MONITORING WELL
- EXTRACTION WELL
- PLANNED MONITORING WELL
- INJECTION WELL
- PIEZOMETER
- A—A' CROSS SECTION LINE
- GROUNDWATER FLOW DIRECTION

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE < 100
- 100 ≤ TCE < 1,000
- 1,000 ≤ TCE < 10,000
- 10,000 ≤ TCE < 100,000
- TCE ≥ 100,000
- FENCE
- SURFACE WATER
- BUILDINGS
- ABOVEGROUND STORAGE TANKS
- UNPAVED AREA
- PAVED AREA
- ROAD
- ERP SITE BOUNDARY
- EVO TREATMENT DEMONSTRATION
- EVO TREATMENT FINAL BUILDOUT

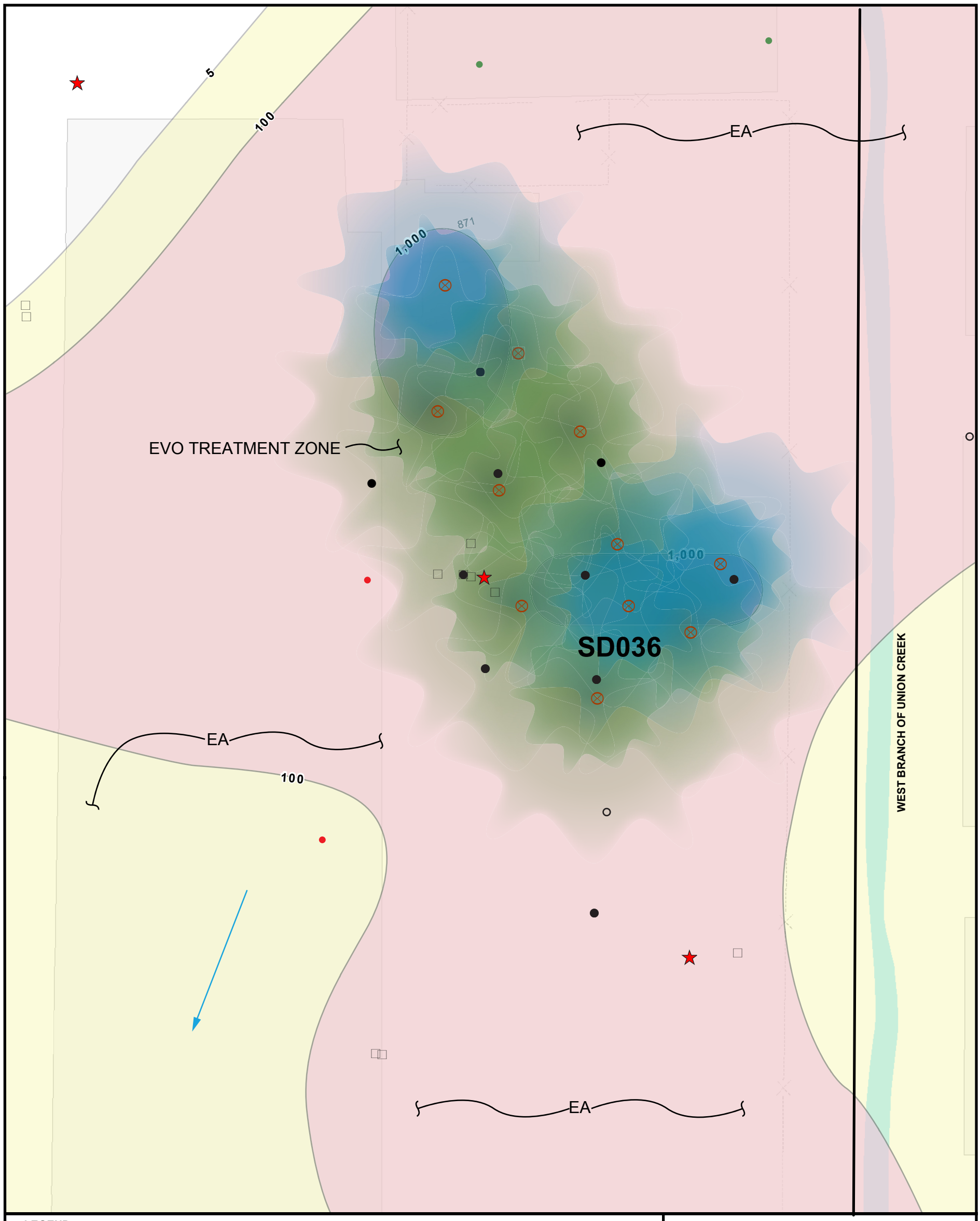
N

0 375 FEET

REFERENCE: 2010-2011 GSAP REPORT

ES051412034344SAC

FIGURE 2.12-8
CONCEPTUAL DESIGN ALTERNATIVE 5 – EVO AND EA AT SITES SD036 AND SD037
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA



LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- PLANNED MONITORING WELL
- PIEZOMETER
- EXTRACTION WELL (INACTIVE)
- EVO INJECTION WELL
- EVO TREATMENT DEMONSTRATION
- EVO TREATMENT FINAL BUILDOUT
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- FENCE
- ROAD
- PAVED AREA
- BUILDING
- ERP SITE BOUNDARY

TCE CONCENTRATIONS (µg/L)

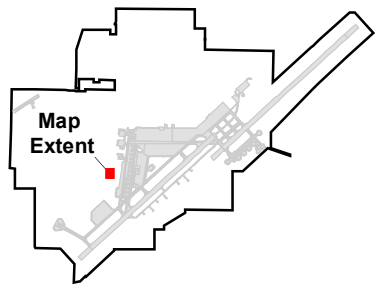
- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- 1,000 ≤ TCE <10,000
- SURFACE WATER

N

0 15 30 FEET

REFERENCE: 2010-2011 GSAP REPORT

KEY MAP



ES051412034344SAC

FIGURE 2-12.9
CONCEPTUAL DESIGN ALTERNATIVE 5 – EVO AND EA AT SITE SD036
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

SD037

BOYLES STREET

BOYLES STREET

5

100

1,000

837

100

5

EVO TREATMENT ZONE

RAGSDALE STREET

EA

834

1821

V STREET

V STREET

EA

836

GOODALL STREET

841

RAGSDALE STREET

EA

LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- EXTRACTION WELL (INACTIVE)
- PLANNED MONITORING WELL
- EVO INJECTION WELL
- EVO TREATMENT DEMONSTRATION
- EVO TREATMENT FINAL BUILDOUT
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- FENCE
- ROAD
- PAVED AREA
- BUILDING
- ERP SITE BOUNDARY

REFERENCE: 2010-2011 GSAP REPORT

ES051412034344SAC

TCE CONCENTRATIONS (µg/L)

- 5 ≤ TCE <100
- 100 ≤ TCE <1,000
- TCE ≥ 1,000

N

0 25 100 FEET

KEY MAP

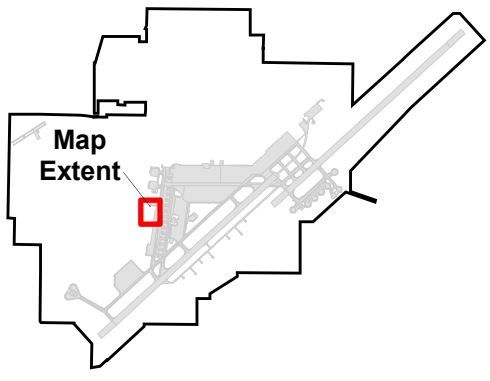
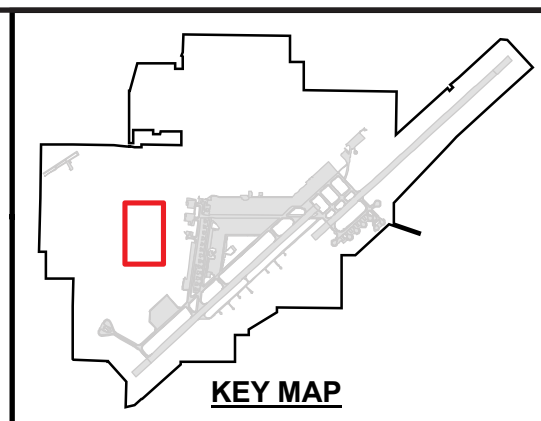


FIGURE 2.12-10
CONCEPTUAL DESIGN
ALTERNATIVE 5 – EVO AND EA AT SITE SD037
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA



KEY MAP

LEGEND

- PERFORMANCE MONITORING WELL
- COMPLIANCE MONITORING WELL
- UPGRADIENT MONITORING WELL
- EXTRACTION WELL (INACTIVE)
- PLANNED MONITORING WELL
- EVO INJECTION WELL
- EVO TREATMENT DEMONSTRATION
- EVO TREATMENT FINAL BUILDOUT
- UNTREATED WATER PIPING
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- 5 APPROXIMATE ISOCONCENTRATION CONTOURS (µg/L)
- FENCE
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

TCE CONCENTRATION (µg/L)

- 5 ≤ TCE < 100
- 100 ≤ TCE < 500
- 500 ≤ TCE < 1,000
- 1,000 ≤ TCE < 10,000

NOTES:

EA = ENHANCED ATTENUATION
EVO = EMULSIFIED VEGETABLE OIL
PRB = PERMEABLE REACTIVE BARRIER
REFERENCE: 2010-2011 GSAP REPORT

BIOREACTOR

DP039

PHYTOREMEDIATION AREA

1,000

500

100

5

EA

888

EVO PRB

833

EVO TREATMENT ZONE

N

0 150 300 FEET

FIGURE 2.12-11
CONCEPTUAL DESIGN ALTERNATIVE 6 – BIOREACTOR, PHYTOREMEDIATION, EVO PRB, AND EA AT SITE DP039
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

ES051412034344SAC

LF007C
LF006
LF007B
LF007D
FT004
SD031
SS015
SS016
SD034
SD033
LF008
DP039
SS035
SD037
ST027B
SD036
SD043
SS041
SD033
SS029
SD037
FT005
SS030
PETERSON TRACT
JOHNSON TRACT

LEGEND
- BASE BOUNDARY
- ON-BASE GROUNDWATER LAND USE CONTROLS BOUNDARY
- OFF-BASE GROUNDWATER LAND USE CONTROLS BOUNDARY
- ERP SITE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

N
0 700 1,400
FEET

FIGURE 2.12-12
LAND USE CONTROL BOUNDARIES FOR GROUNDWATER
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

\\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_12-12_BASEWIDE_GWLUC_AREAS.MXD SSCOPES 4/22/2014 1:00:44 PM

LF007C
LF007
LF006
FT004
SD031
SS015
SS016
SD034
SD033
LF008
DP039
SS035
SD037
ST027B
SD036
SD043
SS041
SD033
SD037
SS029
FT005
SS030

LEGEND

- INDUSTRIAL GROUNDWATER-TO-INDOOR-AIR LAND USE CONTROL BOUNDARY
- BASE BOUNDARY
- ERP SITE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

NOTE:
LUC BOUNDARIES ARE BASED ON EXCEEDANCES OF GROUNDWATER-TO-INDOOR-AIR RBCs AND INCLUDE A 100 FOOT BUFFER ZONE.

N

0 750 1,500
FEET

FIGURE 2.12-13
INDUSTRIAL GROUNDWATER-TO-INDOOR-AIR LAND USE CONTROL BOUNDARIES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_12-13_BASEWIDE_SVILUC_AREAS.MXD MSCHROCK 11/26/2012 5:15:44 PM

LF007C
LF006
LF007B
LF007D
FT004
SD031
SS015
SS016
SD034
SD033
LF008
DP039
SS035
SD037
ST027B
SD036
SD043
SS041
SD033
SD037
SS029
FT005
PETERSON TRACT
SS030
JOHNSON TRACT

LEGEND

- ON-BASE RESIDENTIAL GROUNDWATER-TO-INDOOR-AIR LAND USE CONTROLS BOUNDARY
- OFF-BASE RESIDENTIAL GROUNDWATER-TO-INDOOR-AIR LAND USE CONTROLS BOUNDARY
- BASE BOUNDARY
- ERP SITE BOUNDARY
- BUILDINGS
- UNPAVED AREA
- PAVED AREA
- ROAD
- SURFACE WATER

NOTE:
LUC BOUNDARIES ARE BASED ON EXCEEDANCES OF GROUNDWATER-TO-INDOOR-AIR RBCs AND INCLUDE A 100 FOOT BUFFER ZONE.

N

0 700 1,400
FEET

FIGURE 2.12-14
RESIDENTIAL GROUNDWATER-TO-INDOOR-AIR LAND USE CONTROL BOUNDARIES
GROUNDWATER RECORD OF DECISION
TRAVIS AIR FORCE BASE, CALIFORNIA

RDD \\BALDUR\PROJ\TRAVIS\381355_2012ROD_REPORT\MAPFILES\FIGURE2_12-14_BASEWIDE_SVRLUC_AREAS.MXD MSCHROCK 12/11/2012 2:21:22 PM

2.13 Statutory Determinations

Under CERCLA Section 121 (as required by NCP Section 300.430(f)(5)(ii)), the lead agency must select remedies that are protective of human health and the environment, comply with ARARs, are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, periodic Five-year Reviews are required if after the remedy, hazardous substances will remain in place above levels allowing for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. CERCLA also includes (1) a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element; and (2) a bias against offsite disposal of untreated wastes.

The following subsections discuss how the selected remedies meet these statutory requirements.

2.13.1 Protection of Human Health and the Environment

This section discusses how the selected remedies will adequately protect human health and the environment through treatment and/or LUCs:

- **Alternative 1 – No Further Action:** The selected remedy at Site SS041 will protect human health and the environment because no COCs are currently found in the groundwater at concentrations equal to or greater than cleanup levels.
- **Alternative 2 – MNA:** The selected remedy at Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, and SD043 will protect human health and the environment by using the physical, chemical, and biological processes of natural attenuation. LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be implemented to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.
- **Alternative 3 – GET:** The selected remedy at Site FT005, Subarea LF007C, and Sites SS029 and SS030 will protect human health and the environment by physically removing groundwater contaminants using extraction wells and on-base treatment of contaminated groundwater using carbon adsorption. The alternative will operate and LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be implemented to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health. LUCs that restrict access to groundwater include the groundwater

underlying off-base easements at Site FT005, Subarea LF007C, and Site SS030 purchased by the AF from private landowners. These easements contain legal restrictions preventing the landowners from engaging in water development or soil disturbing activities that could interfere with cleanup activities.

- **Alternative 4 – Bioreactor and GET:** The selected remedy at Site SS016 will protect human health and the environment by using in situ ERD treatment of the principal threat wastes within the portions of the plume with the highest contaminant concentrations (via a bioreactor) in combination with GET in the distal portions of the plume. The alternative will operate and LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be implemented to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.
- **Alternative 5 – EVO and EA:** The selected remedy at Sites SS015, SD036, and SD037 will protect human health and the environment by using in situ ERD treatment of the principal threat wastes within the portions of the plumes with the highest concentrations of contaminants (via EVO injection) in combination with the processes of natural attenuation in the distal portions of the plumes. The alternative will operate and LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be implemented to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.
- **Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA:** The selected remedy at Site DP039 will protect human health and the environment by using in situ ERD treatment (via bioreactor and EVO PRB) and in situ biological treatment (phytoremediation) of the principal threat wastes within the portions of the plumes with the highest concentrations of contaminants in combination with the processes of natural attenuation in the distal portions of the plume. The alternative will operate and LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be implemented to restrict residential and industrial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.
- **Alternative 7 – Passive Skimming and EA:** The selected remedy at Site SD034 will protect human health and the environment by combining the physical removal of Stoddard solvent free product, containing dissolved COCs, to address the principal threat waste and the processes of natural attenuation to address the lower

concentrations of COCs in the distal portions of the plume. The alternative will operate and LUCs will be implemented until groundwater COC concentrations are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. Stoddard solvent will be removed to a thickness of 0.01 foot, or to the maximum extent practicable, in a manner that minimizes the migration of COCs into previously uncontaminated groundwater.

Performance monitoring of the alternatives will be conducted under the Travis AFB GRIP. The results of the monitoring will be provided to the regulatory agencies in monthly status updates and in annual GRISRs. Similarly, the status of LUCs will be provided in annual LUC reports. The next Five-year Review of remedial systems at Travis AFB is scheduled for 2018.

2.13.2 Compliance with ARARs

Remedial actions must comply with both federal and state ARARs. ARARs include substantive provisions of any promulgated federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate for a CERCLA site or action.

ARARs fall into three (3) categories: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs are health-based or risk-management-based numbers that provide concentration limits for the occurrence of a chemical in the environment at agreed-upon points of compliance. Location-specific ARARs restrict activities in certain sensitive environments. Action-specific ARARs are activity-based or technology-based, and typically control remedial activities that generate hazardous wastes (such as with those covered under RCRA). Materials "to be considered" (TBC) are non-promulgated advisories, guidance, or proposed standards issued by federal or state government that are not legally binding, but that may provide useful information or recommended procedures. These materials are not potential ARARs, but are evaluated for each Superfund site in developing potential performance standards for the CERCLA remedy as deemed appropriate by the lead agency.

Appendix C summarizes the chemical-specific, location-specific, and action-specific ARARs and TBCs for the selected remedies at Travis AFB and describes how the selected remedies address each one (1) at agreed-upon points of compliance. Once a TBC is selected in a Record of Decision as a requirement, it becomes a binding performance standard with which the chosen remedy must comply.

2.13.3 Cost Effectiveness

The selected remedies represent the most reasonable value for the money, and costs are proportional to the effectiveness of the remedies by achieving long-term effectiveness and permanence within a reasonable time. Minimizing the need for additional infrastructure, equipment, O&M, or studies and maximizing the continued operation of existing IRAs results in value and cost savings.

In the AF's judgment and as described in Section 2.10, more rapid cleanup of groundwater to levels allowing for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure would not be technically feasible or cost effective. Sites LF008, SS015, SS016, SD034, SD036, SD037, and DP039 have longer remediation timeframes associated with each of the alternatives evaluated for these sites. At Site LF008, COCs are not dissolved in groundwater but rather sorbed to the fine soil particles suspended in the groundwater; therefore, estimates of the time to achieve cleanup levels for both alternatives evaluated are from 100 to greater than 100 years.

At Sites SS015, SSS016, SD036, SD037, and DP039, high concentrations of COCs (indicative of DNAPL) remain even after more than a decade of interim remediation. Estimates of the time to achieve cleanup levels are greater than approximately 60 years even using treatment included in the selected remedies. Expanding the scope of treatment areas under these alternatives would be required to potentially reduce the time to achieve cleanup levels and is not considered technically feasible based on the presence of a large volume of contaminated groundwater. At Site SS016, it is also not considered technically feasible to expand the treatment areas beneath airfield infrastructure, such as parking ramps, taxiways, and runways. The required expansion of groundwater treatment systems in the vicinity of aircraft hangars, fuel hydrant systems, and other supporting airfield infrastructure would be difficult or impossible, depending on the nature of the industrial activities and the restrictions associated with them (CH2M HILL, 2012h).

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedies include permanent solutions and represent the maximum extent to which treatment is practicable at each site. The selected remedies have the potential to provide long-term and permanent remedies that will meet cleanup levels and include LUCs to limit direct contact until they are met. The selected remedies are also expected to effectively treat COCs in groundwater. The selected remedies include treatment of groundwater with the highest concentrations of COCs, potentially reducing the toxicity and volume of COCs in groundwater. They also provide monitoring and evaluation to confirm reductions in COC mass and concentrations and confirm whether the plume is mobile, stable, or receding. Because long-term effectiveness and permanence and reduced toxicity and volume are achieved through the selected remedies, they provide the best balance of tradeoffs in terms of the balancing criteria.

2.13.5 Preference for Treatment as a Principal Element

The NCP establishes the expectation that treatment will be used to address the principal threats posed by a site wherever practicable (40 CFR 300.430[a][1][iii][A]). The selected remedies for Site FT005, Subarea LF007C, and Sites SS029 and SS030 (Alternative 3 – GET) use onsite treatment of groundwater extracted from plumes with low-level threat wastes. The selected remedies for Site SS016 (Alternative 4 – EVO and GET); Sites SS015, SD036, and SD037 (Alternative 5 – EVO and EA); and Site DP039 (Alternative 6 – Bioreactor, Phytoremediation, EVO PRB, and EA) are focused on treatment of the principal threat wastes and the highest concentration portions of these site plumes. Treatment of these principal threat wastes and the highest concentrations of contaminated groundwater thereby satisfy the statutory preference for treatment as a principal element of the remedies. More complete

summaries of the use of treatment to satisfy the statutory preference are provided in the following list:

- The selected remedies for Site FT005, Subarea LF007C, and Sites SS029 and SS030 (Alternative 3 – GET) satisfy the statutory preference for treatment as a principal element of the remedy through off-base destructive treatment of contaminant-laden LGAC by an EPA-approved vendor. This treatment will permanently and significantly reduce the volume and toxicity of groundwater contaminants extracted from plumes with low-level threat wastes.

- At Site SS016 (Alternative 4 – Bioreactor and GET), in situ ERD treatment of the highest concentration portion of the plume with a bioreactor satisfies the statutory preference for treatment as a principal element of the remedy at this site. Residual DNAPL likely exists at the site and constitutes the principal threat waste. The remedy will treat contaminants via ERD processes as they dissolve into the groundwater from the DNAPL source material. The ERD treatment processes will permanently and significantly reduce the volume and toxicity of the principal threat wastes and the highest concentrations of contaminants dissolved in groundwater. Offbase destructive treatment of contaminant-laden LGAC by an EPA-approved vendor also satisfies the statutory preference for treatment as a principal element of the remedy at this site.

- At Sites SS015, SD036, and SD037 (Alternative 5 – EVO and EA), in situ ERD treatment of the highest concentration portions of the plume using EVO injection satisfies the statutory preference for treatment as a principal element of the remedies at these sites. Residual DNAPL likely exists at these sites and constitutes the principal threat wastes. The remedy will treat contaminants via ERD processes as they dissolve into the groundwater from the DNAPL source material. The ERD treatment processes will thereby permanently and significantly reduce the volume and toxicity of the principal threat wastes and the highest concentrations of contaminants dissolved in groundwater.

- In situ treatment of the highest concentration portions of the Site DP039 plume using the combination of a bioreactor, phytoremediation, and EVO PRB satisfies the statutory preference for treatment as a principal element of the remedy at this site. Residual DNAPL likely exists at the site and constitutes the principal threat waste. The remedy will treat contaminants via ERD (bioreactor and EVO PRB) and biological (phytoremediation) processes as they dissolve into the groundwater from the DNAPL source material. The ERD and biological treatment processes will thereby permanently and significantly reduce the volume and toxicity of the principal threat wastes and the highest concentrations of contaminants dissolved in groundwater.

At Site SD034, Alternative 7 – Passive Skimming and EA satisfies the statutory preference for treatment as a principal element of the remedy. Residual Stoddard solvent (LNAPL containing dissolved COCs) exists at the site and constitutes the principal threat waste that poses an ongoing source of groundwater contamination. The remedy will entail the physical removal of free-phase Stoddard solvent by passive skimming followed by off-base recycling by an EPA-approved vendor. Although the selected remedies for Site SS041 (Alternative 1 – No Further Action) and Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, and SD043 (Alternative 2 – MNA) do not strictly satisfy

the statutory preference for treatment, the immediate need for further active remediation at these sites is not warranted for the following reasons:

- **Site SS041**
  - COCs in groundwater were removed as a part of an interim action (GET system consisting of ex situ treatment of extracted groundwater with UV/Ox and carbon adsorption) performed from 1999 to 2005, and cleanup levels were achieved by the interim action.
- **Sites FT004 and LF006, Subareas LF007B and LF007D, and Sites LF008, ST027B, SD031, SD033, and SD043**
  - MNA was successfully demonstrated by long-term interim MNA assessments (CH2M HILL, 2010b), results of contaminant rebound studies (CH2M HILL, 2012d), and results of an aerobic chlorinated cometabolism enzyme study (CH2M HILL, 2012b) (refer to Section 2.2.5).
  - MNA assessment data demonstrated that concentrations of COCs in groundwater have significantly declined at Sites FT004, LF006, and SD031. Natural attenuation processes at Subarea LF007B have reduced COC concentrations to less than cleanup levels. At Subarea LF007D, the concentrations of COCs remained stable over approximately a decade of MNA assessment, but the plume is small (limited to the vicinity of one [1] well) and is not migrating (CH2M HILL, 2010b).
  - In 2010, the GET systems at Sites FT004, LF008, SD031, SD033, and SD043 were shut down as part of a contaminant rebound study. The concentrations of COCs have not increased in the absence of active GET, providing additional support for selection of the MNA remedy (CH2M HILL, 2012d).
  - There is no evidence from the existing monitoring network that COCs in groundwater are migrating beyond current site boundaries (CH2M HILL, 2010b).
  - The downgradient extent of the Site ST027B groundwater plume is approximately 3,200 feet from the Base boundary. The plume is stable and not migrating.
  - The interim GET systems at Sites FT004, LF008, SD031, and SD043 had become increasingly less cost-effective over approximately a decade of operation. At Sites FT004, SD031, SD033, and SD043, the GET systems reduced COC concentrations and the extent of contamination, but the unit cost of COC removal was high and increasing. At Site LF008, COC concentrations remained stable over approximately a decade of GET system operation.
  - Groundwater at Travis AFB is of low quality and not currently used for any domestic or industrial purposes. No drinking water wells are, or are projected to be, threatened.
  - LUCs will be maintained on these sites to prevent access or use of groundwater, including development of water wells, to restrict soil excavation and other subsurface work, to maintain the integrity of current and future remedial and monitoring systems, and to restrict land use to industrial purposes only until the

concentrations of COCs in the groundwater are at such levels to allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure. LUCs will also be maintained to restrict residential and commercial land uses until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health.

2.13.6 Five-year Review Requirements

Because the selected remedies result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure for more than 5 years from initiation of the remedies, a protectiveness review will be conducted within 5 years after initiation of remedial actions to verify that the remedies are, or will be, protective of human health and the environment.

The ROD signature date signifies the initiation of remedial action and the end of the period of interim remediation being conducted under the final NEWIOU Groundwater IROD (Travis AFB, 1998) and final WABOU Groundwater IROD (Travis AFB, 1999).

Five-year reviews will be conducted until concentrations of hazardous substances, pollutants, or contaminants remaining onsite are reduced to levels that allow for designated beneficial uses of groundwater (domestic, municipal, agricultural, and industrial supply) as well as unlimited use and unrestricted exposure and until concentrations of volatile COCs in groundwater posing a potential indoor air risk are at such levels that VOCs emanating from groundwater to indoor air do not pose unacceptable risk to human health. The next Five-year Review of remedial systems at Travis AFB is scheduled for 2018. The last Five-year Review was finalized in 2013 (Endpoint, 2013).

2.14 Documentation of Significant Changes

No significant changes were made to the selected remedies as originally identified in the Proposed Plan. COCs identified in the Proposed Plan, but not included in the ROD, are nickel and bis(2-ethylhexyl)phthalate. The rationale for their exclusion as COCs is provided in the following list:

- In 2002, nickel was demonstrated to be leaching from the stainless steel well casings used in some monitoring well construction and not representative of groundwater contamination.
- Also in 2002, bis(2-ethylhexyl)phthalate was recognized as a field and/or laboratory artifact and also not representative of groundwater contamination.
- Cleanup levels for aldrin, acetone, naphthalene, and chloromethane were described in the FFS and Proposed Plan as MCLs; they are actually EPA RSLs, since none of these compounds have a State of California or federal primary MCL.

Also, RAOs for Environmental Protection are listed in the Proposed Plan, but not in Section 2.8, because no ecological risks for groundwater are identified in this ROD.