2.0 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) define the performance requirements for the remedial alternatives. RAOs can be subdivided into general RAOs, that are applicable to all Comprehensive Environmental Response Compensation and Liability Act (CERCLA) sites, and specific RAOs, that are applicable to conditions at North/East/West Industrial Operable Unit (NEWIOU). Specific RAOs must ensure that compliance with potential Applicable or Relevant and Appropriate Requirements (ARARs) is achieved.

2.1 General and Specific Remedial Action Objectives for NEWIOU

General RAOs for the remedial action are to:

- Protect human health by reducing the risk of potential exposures to contaminants identified in the human health risk assessment (HRA);
- Protect potential environmental receptors;
- Mitigate contaminated media for present and future land use;
- Use permanent solutions and alternative treatment technologies to the maximum extent practicable; and
- Implement remedial actions that do not impact the Base's mission.

Specific RAOs derived from these general objectives are identified in Table 2-1. To meet these specific objectives, a range of remedial alternatives are developed in Section 3.0.

2.2 Interim Remediation Goals

Potential remedial alternatives are evaluated against the RAOs and also specific performance goals. The specific performance goals used in the FS are the interim

Table 2-1

Specific Remedial Action Objectives for NEWIOU

Remedial Action Objectives
• For groundwater and surface water actions: attain potential contaminant-, action-, and location-specific ARARs to the extent possible. For purposes of the FS, analysis, contaminant-specific ARARs, i.e., target levels, are assumed to be the more stringent of MCLs and EPA Ambient Water Quality Criteria and HI < 1. Cleanup levels will be established after regulatory comments are incorporated into the Feasibility Study and as the proposed plan is being developed and reviewed by the public. (It is possible that areas of containment will be established for the constituents of concern rather than numerical levels.)
• For soil and sediment actions: attain potential contaminant-, action-, and location-specific ARARs to the extent possible. For purposes of the FS, contaminant-specific ARARs, i.e., target levels, are assumed to be PRGs and HI < 1. Contaminant-specific ARARs for sediment include ecological benchmark values. Cleanup levels, or the designation of a containment zone, will be established after regulatory comments are incorporated into the Feasibility Study and as the proposed plan is being developed and reviewed by the public.
• Reduce contaminant concentrations that pose an unacceptable level of ecological risk, (i.e., Site SD001, LF007, OT010, and SD033).
• Prevent any contaminant concentrations exceeding potential ARARs from migrating off base (LF007, SS029, and FT005).
• Maintain or provide mitigation for any vernal pools that may be affected by remedial actions taken (LF006 and LF007).
• Coordinate remedial actions with ongoing interim removal actions, e.g., TARA.
• Ensure that any caps installed over sites prevent downward migration of contaminants by limiting infiltration and ensure the caps include an appropriate grade to control surface water runoff (LF006 and LF007).
• Sites will be consolidated whenever possible to cost effectively treat groundwater (e.g., FT005, SS029, and SS030).
• Reuse treated groundwater on base whenever possible — i.e., for industrial or irrigation use.
• Ensure any discharge of treated water to Union Creek meets substantive NPDES requirements.
• Consider use of existing groundwater treatment plants, e.g., TARA, Outfall III treatment system.
• Select alternatives that include treatment, where applicable and practicable, as opposed to alternatives that are limited to simply moving contamination to disposal sites.
• Meet all Federal Facilities Agreement dates.
• Do not impact Travis AFB's mission.

remediation goals (IRGs) for specific contaminants of concern (COCs) developed during the Remedial Investigation (RI) effort (see Section 1.0). The RI used IRGs as well as HRAs to define areas where remediation should be considered and to identify COCs. IRGs are not cleanup levels, but are based on regulatory ARARs, and are consistent with the general and specific RAOs. The IRGs will be used in the Feasibility Study (FS) as a performance endpoint when evaluating remedial alternatives. The IRGs associated with human health risks for soil, sediment, groundwater, and surface water are listed in Table 2-2. IRGs have also been developed for ecological risk and are shown in Tables 1-2, 1-3, and 1-5. They are not shown in Table 2-2 since they are site-specific, even for the same COC.

2.3 ARARs

As part of the CERCLA process, Travis AFB has solicited state and federal standards and regulations (i.e., ARARs) pertinent to the remediation work at Travis AFB. The applicability of the submitted ARARs is examined in Appendix A: Analysis of Potential ARARs. A partial discussion of ARARs is provided below.

ARARs can be divided into three classifications: chemical-, location-, and action-specific.

2.3.1 Chemical-Specific ARARs

Chemical-specific ARARs are typically health-based or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values. These values, in turn, represent the acceptable amount or concentration of a chemical that may be found in, or discharged to, the environment (soil, groundwater, surface water, or air) as a result of the ultimate remedial action selected.

Potential sources for chemical-specific ARARs include: Federal Groundwater Protection Standards; Federal Drinking Water Standards; California Drinking Water

Table 2-2

Summary of Interim Remediation Goals for NEWIOU

Environmental Medium	Contaminant of Concern	Interim Remediation Goals[3]	Basis for IRGs	Applied Sites[4]
Water (Groundwater and surface water)	**VOCs**			
	Trichloroethene (TCE)	5 µg/L	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1 PRGs[1]	FT003 FT004 LF006 LF007 SS015 SS016 SS029 SS030 SD031 ST032 SD033 SD034 SD036 SD037
	1,1-Dichloroethene	6 µg/L		
	1,2-Dichloroethane	.5 µg/L		
	1,2-Trichloroethane	32 µg/L		
	1,2-Dichloropropane	5 µg/L		
	1,4-Dichlorobenzene	5 µg/L		
	Vinyl Chloride	.5 µg/L		
	Benzene	1 µg/L		
	Chlorobenzene	39 µg/L		
	Chloroform	1.81 µg/L		
	Dichlorobromomethane	100 µg/L		
	Tetrachloroethene (PCE)	5 µg/L		
	Xylenes	1,750 µg/L		
	SVOCs			
	Bis(2-ethylhexyl)phthalate	4.8 µg/L	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1	FT002 LF007 SD034 SD037

Table 2-2

(Continued)

Environmental Medium	Contaminant of Concern	Interim Remediation Goals[3]	Basis for IRGs	Applied Sites[4]
Water (Groundwater and surface water) (cont'd)	**Pesticides/PCBs** PCBs	.5 μg/L	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1	LF007
	Dioxins 2,3,7,8-TCDDeq	.45 pg/L	PRGs	FT004 LF007
	Metals Nickel	100 μg/L	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1	FT004 FT005 SS015 SS016 SS030 SD031

Table 2-2

(Continued)

Environmental Medium	Contaminant of Concern	Interim Remediation Goals[3]	Basis for IRGs	Applied Sites[4]
Soils	**SVOCs**			
	Bis(2-ethylhexyl)phthalate	32/140 mg/kg[2]	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1	LF007 SD033 SD034 SD036
	Benzo(a)anthracene	.61/2.6 mg/kg[2]		
	Benzo(a)pyrene	.061/.26 mg/kg[2]		
	Benzo(b)fluoranthene	.610/2.6 mg/kg[2]		
	Benzo(k)fluoranthene	6.0/26 mg/kg[2]		
	Dibenzo(a,h)anthracene	.061/.26 mg/kg[2]		
	Indeno(1,2,3-cd)pyrene	.61/2.6 mg/kg[2]		
	Pesticides/PCBs			
	PCB-1260	.066/.34 mg/kg[2]	MCLs. Federal (SDWA, RCRA) and State MCLs are enforceable. HI <1	FT002 FT005 OT010 SS016 WP017 SS035

Table 2-2

(Continued)

Environmental Medium	Contaminant of Concern	Interim Remediation Goals[3]	Basis for IRGs	Applied Sites[4]
Soils (cont'd)	**Metals**			
	Antimony	31/680 mg/kg[2]	PRGs HI <1	OT010
	Beryllium	.14/1.1 mg/kg[2]		
	Cadmium	38/850 mg/kg[2]		
	Cobalt	4,600/97,000 mg/kg[2]		
	Copper	2,800/63,000 mg/kg[2]		
	Mercury	TBD		
	Molybdenum	380/8,500 mg/kg[2]		
	Lead	400/1,000 mg/kg[2]		
	Silver	380/8,500 mg/kg[2]		
	Vanadium	540/12,000 mg/kg[2]		
	Zinc	23,000/100,000 mg/kg[2]		
	PAHs			
	Fluoranthene	2,600/27,000 mg/kg[2]	PRGs HI <1	FT003 SS015 SS016
	Dioxins/Furans			
	2,3,7,8-TCDDeq	.45 pg/L	PRGs HI <1	

1 = U.S. EPA, 1993
2 = Residential/Industrial Scenarios
3 = Ecological IRGs have also been developed for COCs at specific IRP sites. These are found in Tables 1-2, 1-3, and 1-5.
4 = Soil Sites SS029 and SS030 are not listed as Applied Sites because soil COC concentrations are below IRGs as shown in Table 1-3.

HI = Hazard Index
MCLs = Maximum Contaminant Levels
PAHs = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated Biphenyl
PRGs = Preliminary Remediation Goals
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
SVOCs = Semivolatile Organic Compounds
TBD = To Be Determined
TCE = Trichloroethene
VOCs = Volatile Organic Compounds

Standards; Federal Water Quality Standards; California Surface Water Quality Standards, State Board Resolution No. 88-63; State Board Resolution No. 92-49; and Title 23, California Code of Regulations, Division 3, Chapter 15.

2.3.2 Potential Location-Specific ARARs

Potential location-specific ARARs are requirements that affect the management of hazardous constituents, or the units in which they are managed, due to the location of the unit(s). They might be triggered, for example, if groundwater remediation were selected as a remedial action that required the construction of new surface wastewater treatment units. Examples of sensitive locations for such units include wetlands, flood plains, historic areas, and wildlife refuges. Potential location-specific ARARs include: Resource Conservation and Recovery Act (RCRA) (40 CFR Section 264.18, 18 AAC Section 63.040); the Migratory Bird Treaty Act, Fish and Wildlife Conservation Act of 1980; and the Endangered Species Act and Clean Water Act Section 404.

2.3.3 Potential Action-Specific ARARs

Potential action-specific ARARs are technology-based or activity-based requirements that may be triggered by any particular remedial action chosen for the NEWIOU. Potential action-specific ARARs do not in themselves determine the remedial action; rather, they place restrictions on the manner in which a selected alternative may be achieved. While the remedial action for the NEWIOU has yet to be specified, it is useful to consider potential ARARs as early as possible. Potential action-specific ARARS include: RCRA and the Clean Water Act.

Based on the RAOs, IRGs, and ARARs, general response actions and technical process options were developed. The development and screening of process options is discussed in Section 3.0.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF POTENTIAL ALTERNATIVES

To identify and screen remedial technologies, the environmental conditions at each of the sites and the remedial action objectives (RAOs) were considered. The objective was to develop alternatives capable of addressing the range of site sizes, the suite of contaminant types, the range of contaminant concentrations, and the relatively uniform hydrologic conditions at Travis Air Force Base (AFB). For a single site, the strategy for developing alternatives is not complicated: the specific media and contaminants at the site are identified, and applicable process options are identified, screened, and selected. A process option is a specific action or technology that can apply to one or more components of the environmental concerns at the site. The process options are then combined into alternatives that are evaluated in detail for the site. An alternative addresses the entire environmental concern at the site. The Feasibility Study (FS) process can become very complicated when identifying and evaluating alternatives for many sites. When attempting to evaluate many sites, there occurs a geometric expansion of the permutations of process options and alternatives. For example, if 30 process options exist for soil and water, and there are 20 sites, 600 evaluations could be performed to screen process options.

The strategy to develop a manageable number of process options was to identify and screen process options based on the medium, type of contamination, and the range of volumes of impacted media at Travis AFB. Process options were identified that were potential candidates for any of the environmental impacts in the North/East/West Industrial Operable Unit (NEWIOU). Process options were screened out if they were not implementable or effective in considering the environmental impacts in the NEWIOU. This is beneficial because the permutations are greatly reduced, and non-suitable technologies are removed before they complicate the screening by site.

To develop alternatives, the process options that passed the screening were evaluated for similar effectiveness, implementability, and total cost, as well as cost sensitivity to volume, after which a representative option was selected. As an example, if five treatment technologies were similarly effective, could be implemented equally, and had the same order of magnitude costs for similar volumes or concentrations to be treated, one option was selected to represent the other technologies. This approach reduces the permutations of alternatives that would score essentially the same during the detailed analysis. The selection of a representative technology does not exclude the others from ultimately being implemented.

When treatment options could score differently (depending upon volumes and concentrations, for example), separate alternatives were developed. For example, granular activated carbon (GAC) was not used to represent ultraviolet oxidation (UV-OX) since at high concentrations, UV-OX and GAC have different costs and benefits. In this case, different alternatives were developed, one with GAC and one with UV-OX.

After the suite of alternatives were developed, their applicability to the sites was identified. Since the strategy was to identify alternatives that address the range of conditions at Travis AFB, most alternatives apply to most of the sites. The only variability occurs where a site has a unique combination of contaminants that requires multiple treatment systems (e.g., GAC alone is not applicable to a metals- and volatile organic compound [VOC]-contaminated site).

This approach of developing alternatives based on the range of conditions at Travis AFB reduces the permutations for sites with similar problems. The approach to minimizing the permutations will be carried forward to the detailed analysis of alternatives. Sites will be grouped by contaminant type, concentrations, media affected, and location on the Base. Sites for which remedial alternatives would score the same for effectiveness and implementability will be grouped together during the Detailed Analysis of Alternatives (DAA). This does not mean that the same alternative will be executed at each site within the group. Since the cost for implementing the alternatives could vary by the geographic location and specific hydrogeologic conditions of the site, the cost of the alternatives will be identified for each site in the group.

The specific application of the strategy is discussed in the following sections.

3.1 Identification of Process Options

The identification process began by defining general response actions. A general response action is a non-specific action that alone, or in combination with other actions, could potentially satisfy the RAOs. For example, collection, treatment, and discharge is a non-specific process option.

Potential remedial technologies were then developed for the components of the general response action. For example, groundwater collectors is a remedial technology. Finally, specific process option(s) for each general response action were then identified for each technology. This final step identifies specific available processes or technologies that apply to the general technology. For example, vertical wells are specific process options for the groundwater collection aspect of the example general process option. This identification process is displayed below in Figure 3-1.

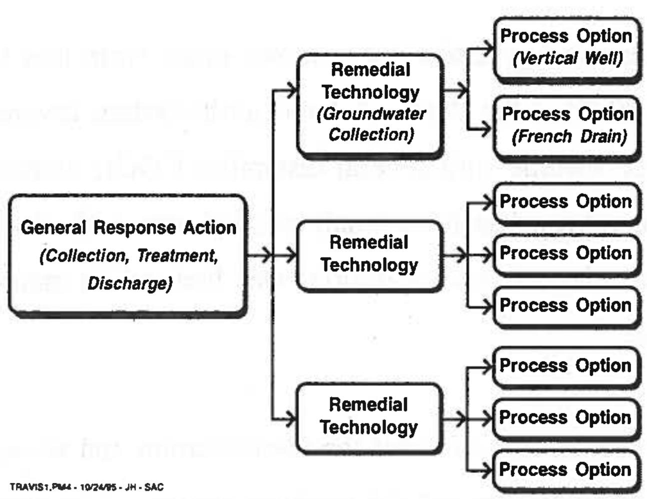

Figure 3-1. Technology and Process Option Identification

Once the process options were identified, they were screened and selected for applicability to the conditions at the sites. The screening process considers the effectiveness and implementability of the process option. The viability of remedial process options is largely defined by the specific contaminants that are present in the soil and water, local hydrology, regional geology, seasonal rainfall patterns, and the need to not impact the Base's mission.

The primary contaminant in groundwater is trichloroethene (TCE) and metals (i.e., nickel); soil contamination includes metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbon (TPH), pesticides and polychlorinated biphenyls (PCBs). The selected treatment processes must be capable of removing the contaminants of concern (COCs) and still function in the presence of the chemicals not specifically targeted by the technology. To a large degree this guides the choice of treatment processes.

Also, the extent (volume and area) and location of the groundwater and soil contamination varies. Some groundwater plumes are commingled; some are located in and around the flight line; some are isolated; and some have a large smear zone. These factors affect the method of extraction and discharge as well as the location of treatment facilities. For plumes in the flight line, options that impact Base operations are not suitable.

Contaminated groundwater volumes range from less than 100,000 cubic feet (ft^3) to 24,000,000 ft^3 at the Base. A fixed multi-system treatment facility could be appropriate for a large volume with several dissimilar COCs; whereas, a skid-mounted mobile unit would be appropriate for a small isolated area with similar COCs. The identification and screening of process options was focused on managing these variable conditions at the Base.

Other factors that affected the identification and screening of process options include the depth to groundwater and the geologic setting. The water table is shallow (approximately at a depth of 10 feet) at the 20 sites. In addition, low permeability alluvium and bedrock are dominant beneath the sites. Both conditions impact the applicability of in-situ soil treatment processes and processes that rely on a moderate flow of groundwater (e.g., vertical extraction wells) as well as containment strategies.

The regional geology impacts the choice of contaminant treatment options primarily due to the presence of naturally occurring metals in the alluvium and bedrock, and thus, dissolved in the groundwater. Although not necessarily hazardous, the selected treatment options must be compatible with the metals, and if needed, treat the metals to comply with applicable or relevant and appropriate requirements (ARARs) that regulate the discharge of treated water.

The seasonal rainfall patterns impact both the extraction rate of contaminated water and the discharge options for treated water. Normal winter rains can raise the water table significantly and will preclude the need to supply treated water for irrigation on the Base.

Options that could impact the ongoing Base mission were screened out. Options with limited effectiveness were also screened out. This selection process is displayed in Figure 3-2.

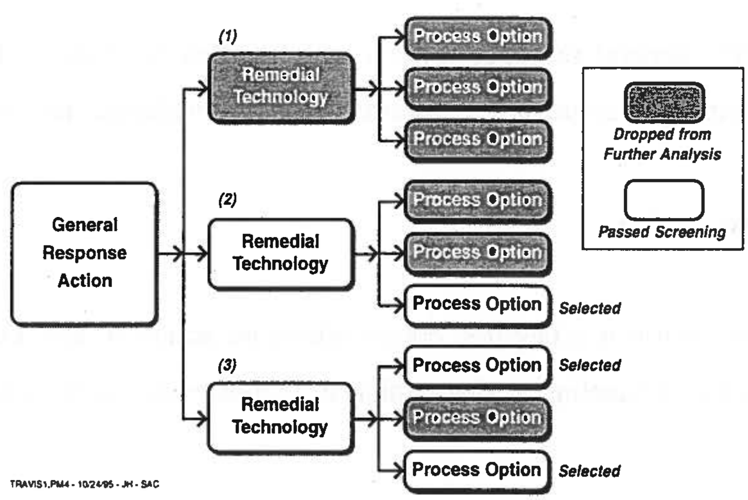

Figure 3-2. Technology and Process Option Screening

Figure 3-2 presents three possibilities. In #1, all process options were screened out due to their poor implementability or effectiveness. In this case, the associated technology also is screened out. In #2, only one option passes the screening and is, therefore, selected. In #3, two (or more) options pass the screening. In #3, at least one representative process option was selected for detailed evaluation. The selection was based on similar effectiveness, implementability, and cost attributes of the process options.

After the initial screening was complete, the response actions, technologies, and process options were combined into remedial alternatives. These alternatives address different media at the different sites within the NEWIOU. To identify general response actions, the site was divided into two media: water (groundwater and surface water) and soil (including sediment). Groundwater includes the unconfined aquifer beneath Travis AFB. Surface water includes Union Creek, ditches, and other depressions which contain surface water in landfill areas. Groundwater and surface water are addressed together because technologies and process options to remediate each are similar. Soil includes unconsolidated deposits from the ground surface to the water table as well as sediments associated with surface water within the geographic area of the site.

3.2 General Response Actions for Water

Five general response actions are identified for water. These are no action, institutional actions, containment, collection/treatment/discharge, and in-situ treatment.

3.2.1 No Action

No action is a baseline option where no action of any kind is taken at a site. No action is used as a baseline against which to compare the other options.

3.2.2 Institutional Actions

Institutional actions limit human and ecological exposure to the groundwater and surface water. Institutional actions could include access restrictions (i.e., fencing, warning signs), restrictions on groundwater and surface water use, and substituting other water supplies or habitat for lost or threatened water supplies and habitat. This response action relies solely on natural attenuation to reduce contaminant concentrations. Natural attenuation processes include degradation, adsorption, dispersion, and volatilization of COCs.

3.2.3 Containment

Containment prevents or minimizes the spread of contaminated water through the use of physical or hydraulic barriers. Hydraulic barriers are established by pumping or injecting water. The purpose of containment is not to reduce the toxicity or volume of contamination, but to prevent migration.

3.2.4 Collection/Treatment/Discharge

This response action consists of collecting contaminated water, treating the water at an aboveground facility, and discharging the water. Possible groundwater collection methods include use of vertical or horizontal wells and interceptor trenches. Surface water can also be collected by storm drains, trenches, and directly from Union Creek. The water is treated using physical, chemical, or biological methods prior to on-site or off-site discharge.

3.2.5 In-situ Treatment

Contaminated groundwater could be treated in-situ using chemical oxidation, air sparging, permeable treatment beds, vapor extraction, bioremediation, or steam stripping. These methods often also treat the soil in contact with the contaminated water.

3.3 General Response Actions for Soil and Sediment

The general response actions identified for soil and sediment ("soil" will be referred to throughout this section) are no action, institutional actions, excavation and disposal, containment, excavation/treatment/disposal, and in-situ treatment.

3.3.1 No Action

As with groundwater, this is a baseline option and includes no action of any kind.

3.3.2 Institutional Actions

Institutional actions include actions such as land use administrative controls and fencing. As with water, institutional actions are used to limit exposure to the COCs in the soil. This response action relies solely on natural degradation and involves no remedial response at the site. The term "degradation" is used for soils as opposed to "attenuation" used for water since the processes differ slightly. Contaminants in soils are degraded through adsorption and the biological destruction/oxidation capability of naturally occurring bacteria.

3.3.3 Excavation and Disposal

Contaminated soil is excavated and transported directly to an existing off-site or on-site landfill for disposal. This general response action would result in the removal of the contamination.

3.3.4 Containment

Containment prevents or minimizes the spread of contaminants to surrounding soil or groundwater by reducing infiltration of rainwater and reducing dust migration. Direct contact with contaminated soil is eliminated, and the contaminated soil is isolated from adjacent soil. The potential for migration of contaminants to surrounding soil by rainwater runoff and percolation is reduced. Containment methods include capping, vertical barriers, sediment control barriers, and lateral barriers.

3.3.5 Excavation/Treatment/Disposal

Contaminated soil can be excavated, treated, and disposed. Potential treatment methods include soil washing, low temperature thermal treatment, biopiling and incineration. Disposal options include reburial and disposal on-base or disposal in off-base landfills. The resulting holes can be backfilled, or treated soil could be used for general fill if the necessary cleanup level is achieved.

3.3.6 In-situ Treatment

In-situ treatment methods are implemented without excavating the contaminated soil. In-situ treatment includes stabilization, soil heating, soil vapor extraction with offgas treatment, in-situ vitrification, bioventing, and bioremediation. Additionally, combinations of these process options may be used (e.g., vapor extraction enhanced by steam injection).

3.4 Identification and Screening of Technology Types and Process Options

3.4.1 Identification of Technology Types and Process Options

For each media-specific general response action, remedial technologies and then process options were identified that are potentially applicable to the contamination at the Base. For instance, under the general response actions that include treatment, the technologies could include physical treatment, chemical treatment, biological treatment, and thermal treatment. Process options for chemical treatment could include precipitation and chemical oxidation, among others. The process options were selected using U.S. EPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and Air Force Center for Environmental Excellence (AFCEE) guidance documents and experience at numerous other CERCLA sites.

3.4.2 Screening of Technology Types and Process Options

An initial screening was performed to reduce the number of technology types and process options based on the effectiveness and implementability of the option. This screening process is discussed in the document *Feasibility Studies Conducted Under CERCLA* (U.S. EPA, 1988a). In this evaluation, effectiveness is a measure of: 1) the suitability of the process option for handling the estimated areas and volumes of media and for meeting the remediation goals; 2) the potential impacts to human health and the environment during the construction and implementation phase; and 3) the reliability of the process with respect to the contaminants and conditions at the site. Both short- and long-term effectiveness are considered.

Each process option was also evaluated for both technical and administrative implementability. Implementability considerations included the developmental state of the technology (e.g., commercial, bench scale); physical and environmental conditions at the Base (e.g., slopes, habitat, buildings, and infrastructure); potential negative impacts upon the mission of the Base (e.g., runway closure, hangar closure); the ability to obtain necessary permits (or satisfy the substantive requirements of a permit); the availability of treatment, storage, and disposal (TSD) facilities; and the availability of necessary equipment and skilled workers to implement the technology.

Tables 3-1 and 3-2 summarize the evaluation. The process options that are not shaded in Tables 3-1 and 3-2 are considered to be potentially implementable and effective at the site. The shaded options are dropped from further consideration because of difficulties in implementation or their marginal effectiveness. The specific reasons for eliminating process options are noted in the tables.

On Tables 3-1 and 3-2, the relative capital and operation and maintenance (O&M) costs are identified as high, moderate, or low, or a cost range compared to other process options. Costs are provided for comparative purposes and to identify the cost sensitivity of the option to site size or volume of contamination. Process options were not screened out based on cost. The cost factors are used when representative process options are selected to develop remedial alternatives. The cost variability, as influenced by the specific site conditions at Travis AFB, is considered when the alternatives are evaluated in detail for each site.

3.5 Formulation of Remediation Alternatives

The process options which passed the screening evaluation are identified on Tables 3-3 and 3-4 for water and soil, respectively. Potential remediation alternatives were developed by combining different groupings of the process options to formulate alternatives that are applicable to the different COCs found in soil, sediment, groundwater, and surface water. The number of potential alternatives would be very large if all potential combinations of process options were made. To reduce the number of alternatives to a manageable number for detailed analysis, representative process options were selected for each primary process (i.e., a representative process option was selected for each component of a potential

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
No Action	None	None	GW SW	Not applicable.	No effort required to implement.	None
Institutional Action	Access restrictions	Water use/water rights restrictions, fences, posting signs	GW SW	Effectiveness depends on continued future implementation. Does not reduce contamination.	Implementable for on-base contamination as long as base maintains control over land use. Implementability decreases for off-base contamination since coordination with private parties and legal issues can decrease likelihood for protective administrative controls such as deed restrictions.	Low
		Land purchase/eminent domain	GW	Effectiveness depends on continued future implementation. Does not reduce contamination.	Limited implementability. Purchase must be negotiated with current land owners. Further migration of contamination could require additional land acquisition.	Moderate
	Alternate water supply	Agricultural (no known domestic or industrial users). Provide alternate water supply for agricultural users.	GW	This technology is effective. No known agricultural users are immediately impacted.	Implementable. Alternate water supplies can be obtained.	Moderate

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Institutional Action (cont.)	Monitoring	Monitoring wells and surface water sampling	GW SW	Effectively monitors migration and degree of natural attenuation. Can be used to alert Travis AFB if a receptor is threatened.	Easily implemented.	Low
Containment	Vertical barrier	Slurry wall/grout curtain	GW	Man-made barriers are marginally effective at reducing lateral migration, because the low permeability soils limit migration. Even if migration is not limited by low permeability of soils, contaminated water will eventually migrate around or mound over man-made barriers.	Easy to implement in landfill sites and other isolated sites. More difficult to implement in industrial settings with significant surface obstructions.	Low to High
		Sheet pile wall	GW	Man-made barriers are marginally effective at reducing lateral migration, because the low permeability soils limit migration. Even if migration is not limited by low permeability of soils, contaminated water will eventually migrate around or mound over man-made barriers.	Easy to implement in landfill sites. More difficult to implement in industrial settings with significant surface obstructions.	Low to High

1 Media: Groundwater (GW) and Surface Water (SW).
2 Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Containment (cont.)	Vertical barrier (cont.)	Pump and treat extraction and injection wells (hydraulic barrier)	GW	Not effective on geohydrologic conditions at the site. Groundwater could migrate laterally around injection well. Extraction wells considered in collection/treatment/discharge.	Easily implemented. Restrictions are limited to access for drilling rig. Extensive areas of contamination would require large and complex well system. Also has detrimental effect on water balance.	Low to High
	Horizontal barrier	Grout injection (subsurface barrier) which creates a solidified horizontal barrier through the injection of a grout slurry that hardens.	GW	Marginally effective at Base, because the shallow aquifer has a thin saturated thickness and contamination has reached bedrock in most cases.	Difficult to implement. Collects water that must be removed.	High
	Storm sewer isolation	Slip-lining the storm sewers	SW	Effective at preventing migration from groundwater to surface water.	Implementable.	Low to High
		Storm sewer section repair	SW	Effective at preventing migration from groundwater to surface water.	Implementable.	Low to High
		Collar installation	SW	Effective at preventing migration of contaminated groundwater in sand surrounding installed storm sewer pipeline.	Implementable.	Low

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Collection/Treatment/Discharge						
Collection	Groundwater collectors	Vertical wells	GW	Technology is readily available and proven for removing contaminated groundwater. Because of low permeability of Travis AFB soil, vertical wells have a limited production rate. Two treatability studies at Monitoring Well 269 and Ragsdale and V have demonstrated that high vacuum enhanced extraction greatly expands wells' production rate.	Implementable. Both monitoring and extraction vertical wells have been installed at Travis AFB.	Low
		Horizontal wells	GW	Horizontal wells are effective at removing groundwater from a large area. The technology is currently being used at the Travis AFB TARA to remove contaminated groundwater.	Implementable. Horizontal wells are easily installed in the soil types found at Travis AFB. Obstructions found during drilling are easily avoided without damaging utilities.	Low
	Floating product recovery	Bioslurping	GW	Technology is proven for removal of floating product and promotes biodegradation of TPH-contaminated soils.	Implementable. Pilot testing has occurred at Travis AFB and other locations.	Low
		Vertical well and skimmer pump	GW	Technology is proven for removal of floating product.	Implementable.	Low
	Surface collectors	Sump	SW	Effective collection and diversion of surface water for treatment.	Implementable.	Low

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Collection (cont.)	Subsurface drains	Collection trenches (French drain)	GW SW	Effectively removes shallow groundwater by gravity drain to collection sump. Water is then transferred to treatment system using pumps.	Implementable, but limited to undeveloped areas. Requires disruption of land use (large area of land) during installation.	Low
Ex-Situ Treatment	Biological treatment (Aerobic)	Activated sludge	GW SW	Effective for TPH, less effective for halogenated compounds.	Extensive equipment and labor required to build and operate. System will not operate without the proper biomass population which likely cannot be sustained using groundwater only.	High
		Fixed film	GW SW	Effective for TPH, less effective for halogenated compounds.	Extensive equipment and labor required to build and operate. System will not operate without the proper biomass population which likely cannot be sustained using groundwater only.	High
	Biological treatment (Anaerobic)	Fixed bed reactor	GW SW	Effective for contaminants of concern.	Extensive equipment and labor required to build and operate. System will not operate without the proper biomass population which likely cannot be sustained using groundwater only.	High

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Ex-Situ Treatment (cont.)	Biological treatment (Anaerobic) (cont.)	Fluidized bed reactor	GW SW	Effective for contaminants of concern.	Difficult to implement. Extensive equipment and labor required to build and operate. System will not operate without the proper biomass population which likely cannot be sustained using groundwater only.	Moderate
	Physical treatment	Air stripping	GW SW	Effective and reliable for removal of volatile contaminants. Must be used in conjunction with other technologies to remove metals and semivolatiles.	Easily implemented. Effluent air stream must be treated prior to discharge using carbon adsorption or thermal/catalytic oxidation.	Moderate
		Steam stripping	GW SW	Effective and reliable for removal of volatile and semivolatile contaminants.	Implementable, but has high energy requirements and would require the construction of an extensive steam system with support facilities. Both energy and infrastructure requirements would interfere with Base operations.	High
		Carbon adsorption	GW SW	Effective and reliable for organics. Carbon adsorption is currently being effectively used in the TARA treatment system to remove organics from groundwater.	Easily implemented. Requires regeneration of carbon (on-site or off-site).	Low to High

1 Media: Groundwater (GW) and Surface Water (SW).
2 Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Ex-Situ Treatment (cont.)	Physical treatment (cont.)	Reverse osmosis	GW SW	Effective for removal of metals and salt compounds. Pretreatment of the waste stream will likely be required to prevent membrane fouling. Could be effectively used in a treatment system process train.	Implementable. Membrane must be selected to match the constituents and usage must be monitored carefully. Maintenance of membrane system requires periodic chemical cleaning. A concentrated waste reject stream is produced.	Low to Moderate
	Chemical treatment	Ion exchange	GW SW	Effective for the removal of anions and cations. Pretreatment is required to prevent fouling of resin. Depending on the waste stream constituents, more than one resin type may be required.	Easily Implementable. Resins can be regenerated on site or off-site by addition of the appropriate chemicals. Treatability test required to select resins. Possibly needed to satisfy NPDES limits.	Low to Moderate
		pH adjustment and precipitation	GW SW	Effective at reducing the solubility of heavy metals to facilitate precipitation and ultimate removal of metal hydroxides.	Easily implemented as a component of a process treatment train. Possibly needed to satisfy NPDES limits.	Low to Moderate
		Chemical oxidation promoted with ultraviolet light	GW SW	Effective destruction of organics.	Implementable. Requires treatability tests to select correct oxidizing agent and dosages. Oxidizing agents may be hazardous materials requiring special care. Possibly needed to satisfy NPDES limits.	Low to Moderate

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Ex-Situ Treatment (cont.)	Chemical treatment	Chemical dechlorination using zero valent metal treatment technology	GW SW	Largely effective destruction of chlorinated hydrocarbons. Partially dechlorinated hydrocarbon byproducts may be more hazardous than original contaminants. Precipitation in the reactor vessels is a limiting factor. Does not treat TPH which is commingled with solvent contamination at many Travis AFB sites.	Not a proven technology. It would need a "polishing" system to ensure effluent goals are attained. The polishing system cannot be activated carbon (which is relatively inexpensive and easy to implement) because a primary byproduct is vinyl chloride. Unproven nature of technology requires a six- to twelve-month pilot test.	Moderate
Discharge	On-site discharge	Direct discharge to storm drain	GW SW	Effective disposal of treated water during winter months when discharge would be small portion of total flow. May upset the water balance of the wetlands if water discharged to the creek creates wetland habitat and is then terminated.	Implementable. Discharge limits, monitoring, and reporting to the RWQCB are required. Applications to the RWQCB for each additional discharge are required and RWQCB approval must be obtained for each discharge.	Low
	On-site use	Industrial use	GW SW	Effective if used to replace an existing or planned use of potable water.	Implementable. Requires upgrading of infrastructure for delivery of treated water.	Low to Moderate
		Irrigation	GW SW	Effective if used to replace an existing or planned use of potable water.	Implementable. Requires upgrading of infrastructure for delivery of treated water. Cannot be used near runways, because attracting wildlife is not desirable.	Low to Moderate

1 Media: Groundwater (GW) and Surface Water (SW).
2 Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
Discharge (cont.)	On-site discharge	Shallow aquifer injection	GW SW	Marginally effective in limiting lateral contamination migration.	Difficult to implement. Discharge is limited by the permeability of the formations and the shallow water table.	Low
		Deep aquifer injection	GW SW	Marginally effective. Does not beneficially use treated water. Potential for discharge to other aquifers if deep aquifer is not completely hydrogeologically isolated.	Difficult to implement. Requires suitable aquifer. May require extensive piping to appropriate injection site. Well bore annulus must be monitored to ensure only deep aquifer receives discharged waste.	High
	Off-site discharge	Discharge to Publicly Owned Treatment Works (POTW)	GW SW	Effective disposal method. However approval from the POTW authority is required.	Implementable. Discharge limits and monitoring required. Surcharge for discharge.	High

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▨ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
In-Situ Treatment	Chemical treatment	Chemical dechlorination using zero valent metal treatment technology to abiotically degrade contaminants in an intercepting trench filled with zero valent metals.	GW	Partially effective technology for destruction of chlorinated hydrocarbons in hot spots. Hazardous partial decomposition products, such as vinyl chloride, are produced, and the technology is not effective with TPH and metals. More effective in shallow aquifers above continuous aquatards. Because the process is in-situ, system adjustments to address corrosion, fouling, and pH excursion are restricted. Also, it is not always effective because interception of all contaminated groundwater is uncertain.	Difficult to implement. Difficult to construct and monitor in active (paved) areas. Can only be applied where excavations would not affect Base mission. Unproven nature of technology requires 6 to 12 month pilot test.	Moderate
	Physical treatment	In-situ air stripping. Volatilize contaminants in well by percolating air within casing. Extract and treat vapor from casing.	GW	Not effective on metals. Limited effectiveness on VOCs in aquifers with multiple low-permeable layers. Limited radius of influence. Fluctuating water table could adversely affect performance.	Materials and technology available. In some cases, investigation wells can be converted to remediation wells. Pilot test would be required.	Low to Moderate

[1] Media: Groundwater (GW) and Surface Water (SW).
[2] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-1

Summary of Evaluation of Process Options for Groundwater and Surface Water (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Media[1]	Effectiveness	Implementability	Cost[2]
In-Situ Treatment (cont.)	Biological treatment	Air sparging	GW	Effective for destruction and volatilization of degradable organic contaminants. Effectiveness limited by low permeability soils, small vadose zone, and ability to contact all contaminated media.	Implementable. Shallow water table will make vapor recovery system construction difficult. If the vapor recovery system is too shallow, it will be short circuited by air from the surface. If it is too deep, it may be within the seasonal fluctuation of the water table.	Low
	Thermal treatment	In-situ steam stripping	GW	Effective for destruction and volatilization of volatile organic contaminants. Not effective for metals. Effectiveness limited by low permeability soils and ability to contact all contaminated media.	Shallow water table will make vapor recovery system construction difficult. (See above.) A steam source must be available and capable of heating the targeted area. (See Ex-Situ Steam Stripping.)	Moderate to High

1 Media: Groundwater (GW) and Surface Water (SW).
2 Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
No Action	None	None	Not applicable.	No effort required to implement.	None
Institutional Action	Access restrictions	Administrative controls (Active Base)	Effectiveness depends on continued future implementation. Does not reduce contamination, or prevent migration of contaminated material.	Implementable for on-base contamination as long as base maintains control over land use. Base Civil Engineering would manage land use restrictions and reflect administrative controls in base use plan. Implementability decreases for off-base contamination since coordination with private parties and legal issues can decrease likelihood for protective administrative controls.	Low
		Deed restrictions (Closed Base)	Effectiveness depends on continued future implementation. Does not reduce contamination, or prevent migration of contaminated material.	Implementable for on-base contamination. If base were to close, restricting land use by future private owners. Implementability decreases for off-base contamination since coordination with private parties and legal issues can decrease likelihood for protective deed restrictions.	Low
		Land purchase/eminent domain	Effectiveness depends on continued future implementation. Does not reduce contamination, or prevent migration of contaminated material.	Difficult to implement. Purchase must be negotiated with current land owners.	High

[1] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Institutional Action (cont.)	Access restrictions (cont.)	Fencing	Effective and reliable for human receptors. Not effective for ecological receptors.	Easily implemented. Base must maintain control over land use.	Low
	Monitoring	Soil gas monitoring	Does not directly measure soil contamination. Effective at monitoring migration and providing a warning that a receptor is threatened.	Easily implemented.	Low
		Borings for contamination monitoring.	Effective and reliable for monitoring migration and degree of natural attenuation as well as providing a warning that a receptor is threatened.	Easily implemented.	Low
Excavation/Disposal					
Excavation	Shallow excavation (less than 15 feet in depth) and backfilling	Backhoe, bulldozer, scraper, truck loader	Effective and reliable, but only for top 10–15 feet of soil. Use is limited to surface soils.	Easily implemented. Dewatering will be required at ± 10' below grade.	Low
Disposal	Off-site disposal	Class I RCRA landfill	Effective and reliable for all solid wastes.	Implementable if transportation requirements can be met. Nearest Class I landfills are located in Kettleman City and Lokem.	Up to $250/ton Low to High
		Class II landfill	Effective and reliable for non-RCRA, non-California hazardous wastes.	Implementable; several permitted Class II landfills exist in the area.	Up to $35-40/ton Low to Moderate
		Class III landfill	Effective and reliable for mildly contaminated soils.	Implementable if facilities' permit criteria allows them to accept material in question. One Class III facility is located within 10 miles of Travis AFB.	Up to $17/ton Low-Moderate

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
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Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Disposal (cont.)	On-site disposal	Foundation material in on-site landfill cap.	Effective and reliable for soil contaminated with low concentrations of COCs, such as TPH, assuming that environmental protectiveness can be maintained and the soil meets the engineering standards of a cap foundation material.	Implementable assuming the requirements of CCR, Title 23, Chapter 15 can be satisfied.	Low
Containment	Capping	Bentonite and soil	Effective at preventing surface contact and reducing migration of contaminants. Cracks are self-healing. Minimizes leaching of contaminants to groundwater by reducing infiltration of precipitation. Less effective at preventing contaminant migration by percolation if water table is near ground surface.	Implementable in landfill areas where ongoing industrial operations at Travis AFB would not be affected. Source of soil could be excavated soil from IRP sites, assuming environmental protectiveness could be maintained.	Low to High
		Clay	Effective at preventing surface contact and reducing migration of contaminants. Susceptible to weathering and cracking. Less effective at preventing migration from surface soils to groundwater if the water table is near ground surface.	Implementable in landfill areas where ongoing industrial operations at Travis AFB would not be affected.	Low to High

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Containment (cont.)	Capping (cont.)	Asphalt	Same comments as clay cap, with increased protection from weathering. Also can allow for contaminated areas to be used beneficially if structural integrity is adequate.	Implementable in landfill areas where ongoing industrial operations at Travis AFB would not be affected.	Low to High
		Concrete	(Same as for asphalt cap)	Implementable in landfill areas where ongoing industrial operations at Travis AFB would not be affected.	Low to High
		Multi-media (e.g., RCRA cap with layers of clay and synthetic liners).	Most effective cap at preventing migration.	Implementable in landfill areas where ongoing industrial operations at Travis AFB would not be affected.	Low to High
	Vertical barrier	Slurry wall	Effective in minimizing lateral migration. Not effective for vertical migration of contaminants in vadose zone.	Implementable. Sufficient space is available in the landfill area of the Base. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application.	Low to Moderate
		Grout curtain	Effective in minimizing lateral migration. Not effective for vertical migration of contaminants in vadose zone.	Implementable. Sufficient space is available in the landfill area of the Base. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application.	Low to Moderate

[1] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
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Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Containment (cont.)	Vertical barrier (cont.)	Vibrating beam	Effective in minimizing lateral migration. Not effective for vertical migration of contaminants in vadose zone.	Implementable. Sufficient space is available in the landfill area of the Base. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application.	Low to Moderate
		Sheet pile wall	Effective in minimizing lateral migration. Not effective for vertical migration of contaminants in vadose zone.	Implementable. Sufficient space is available in the landfill area of the Base. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application.	Low to Moderate
	Subsurface horizontal barrier	Grout injection (injected horizontal layer of grout)	Effectively minimizes vertical migration, if used in conjunction with other barriers, i.e., vertical barriers.	Sufficient space is available in the landfill area of the Base. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application. The shallow water table will make design more difficult.	Low to High
	Encapsulation	Total encapsulation. Horizontal barrier (described above) in addition to vertical barriers with a cap and minimal hydraulic control.	Effective in preventing clean groundwater from contacting contaminated soil and prevents potential receptors from directly contacting contaminated soil.	Sufficient space is available in the landfill area of the site. Other areas are adjacent or beneath active facilities on the base and are not suitable for this application. The shallow water table will make design more difficult.	Low to High

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Excavation/Treatment/Disposal					
Excavation	(See Excavation and Disposal)				
Ex-Situ Treatment	Physical treatment	Soil washing/solvent extraction	Effective removal of organic and inorganic contaminants. Effectiveness depends on selection of proper extraction solvent.	Extensive equipment and labor required to build and operate. Generates aqueous or solvent waste stream that must be treated.	Low to High
		Steam stripping	Effective removal of volatile and semivolatile contaminants.	Extensive equipment, labor, and energy required to build and operate. Generates vapor stream that generates condensate that must be treated. Energy and infrastructure requirements would interfere with Base operations.	Moderate
		Air stripping/vacuum extraction	Effective removal of volatile contaminants. Not effective on SVOCs and metals.	Implementable although requires much greater effort than in-situ extraction. Generates vapor stream that must be treated.	Low
		Low temperature thermal treatment	Effective removal of volatile and semivolatile contaminants. Not effective on metals. Requires treatment of resulting vapor phase.	Complex equipment and extensive labor required to operate. Generates vapor stream that must be treated.	Low to High

[1] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Ex-Situ Treatment (cont.)	Chemical treatment	Fixation/solidification	Effectively immobilizes most contaminants. Process can be reversible due to weathering.	Implementable, but not as effective in the presence of greater than 10% VOCs and SVOCs.	Low to Moderate
		Chemical dechlorination	Effectively destroys chlorinated organics. Does not treat non-chlorinated contaminants.	Implementable.	Low to Moderate
	Biological treatment	Slurry phase bioreactor	Effective destruction of degradable organic contaminants. Not effective on SVOCs and metals. The only sites with only degradable soil contaminants are subsurface soil sites where material would have to be excavated and transported. Limited effectiveness during winter months.	Extensive equipment and labor required to build and operate.	Low to Moderate
		Solid phase reactor	Effective destruction of degradable organic contaminants. Not effective on SVOCs and metals. The only sites with only degradable soil contaminants are subsurface soil sites where material would have to be excavated and transported. Limited effectiveness during winter months.	Extensive equipment and labor required to build and operate.	Low to Moderate

[1] Low = <\$1,500,000; Moderate = \$1,500,000 to \$5,000,000; High = >\$5,000,000.
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Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Ex-Situ Treatment (cont.)	Biological treatment (cont.)	Biopiling, with addition of air and bulking agent	Effective destruction of degradable organic contaminants. Not effective on SVOCs and metals. The only sites with only degradable soil contaminants are subsurface soil sites where material would have to be excavated and transported. Limited effectiveness during winter months.	Implementable. May require large effort to perform O&M, maintaining appropriate biological conditions for degradation to take place.	Low to Moderate
		Landfarming	Effective destruction of degradable organic contaminants. Not effective on SVOCs and metals. Most soil sites contain metals and SVOC. The only sites with only degradable soil contaminants are subsurface soil sites where material would have to be excavated and transported. Limited effectiveness during winter months.	Requires large areas of land and extensive monitoring.	Low to Moderate
		Two stage bioreactor	Effective destruction of degradable organic contaminants. Not effective on SVOCs and metals. The only sites with only degradable soil contaminants are subsurface soil sites where material would have to be excavated and transported. Limited effectiveness during winter months.	Extensive equipment and labor required to build and operate.	Moderate to High

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Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
Ex-Situ Treatment (cont.)	Thermal treatment	High temperature thermal treatment	Effective for VOCs and SVOCs. Some compounds, including metals, may not be amenable to this treatment/disposal option.	Implementable. At least two thermal treatment facilities are located in California. On-site treatment systems also available. Unlike landfilling, this option ends potential liability for Travis AFB.	Up to $40/ton Low to Moderate
		Co-disposal, (e.g., in a cement kiln)	Effective on VOCs and SVOCs.	Off-site option is technically implementable, although vendors and commercial facilities are limited.	Low to High
		Pyrolysis	Effective on VOCs and SVOCs, but more applicable to TPH where byproducts can be recycled.	Both on- and off-site options are technically implementable, although vendors and commercial facilities are limited.	Low to High
Disposal	On-site disposal	Use as fill capping material	Effective and reliable for non-hazardous waste or for treated soils.	Implementable. Soil could potentially be used as a cap. Storage of soil prior to use is difficult. The Base has limited area to store large volumes of soil.	Low
	(See Excavation and Disposal for additional technologies)				

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
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Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▒ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
In-Situ Treatment	Physical treatment	Soil vapor vacuum extraction	Effective for removal of volatile contaminants with minimal soil disturbance. Can be used in conjunction with (and to enhance) groundwater extraction technologies including two phase extraction and dual phase extraction.	Easily implemented. Proven technology.	Low
		In-situ electrochemical	Effective for removal of metallic salts. Less effective on hydrocarbons.	Implementable, although commercial experience is limited.	Low to Moderate
		In-situ air stripping	Effective for removal of volatile contaminants.	Difficult to implement, shallow water table will make vapor recovery difficult. If the vapor recovery system is too shallow, it will be short circuited by air from the surface. If it is too deep, it may be within the seasonal fluctuation of the water table.	Low to Moderate
		Soil flushing	Effective for removal of soluble contaminants.	Implementable. High potential for groundwater contamination due to shallow water table.	Low to Moderate
		Stabilization	Effectively prevents future migration. Effectiveness limited by organic content, valence state of metals, and water saturation. Also reversible.	Implementable.	Low to Moderate

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-2

Summary of Evaluation of Process Options for Soil and Sediment (Continued)

☐ Technologies and process options selected for further analysis.
▩ Technologies and process options dropped from further analysis.

General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost[1]
In-Situ Treatment (cont.)	Thermal treatment	In-situ vitrification	Effective removal of organics.	Difficult to implement. Technology in development stage; leaves a solid mass in the ground. Could affect future use of the land and could interfere with Base operations.	Moderate to High
		In-situ steam stripping	Effective removal of organics. Does not address metals.	Implementable. Energy and infrastructure requirements would interfere with Base operations. Would have to extract condensate. Limited commercial experience.	Moderate
	Biological treatment	Bioventing	Effective destruction of degradable organics such as TPH, although treatment can take several years. May be less effective in winter months. Produces less off gas than other vacuum extraction treatment options.	Implementable. Shallow groundwater table makes it difficult to ensure that contaminants will not be submerged in wet season.	Low
		Anaerobic	Effective on chlorinated compounds. TPH does not readily degrade anaerobically. Not effective on SVOCs and metals.	Implementable, but technology is unproven. Shallow groundwater table makes it difficult to ensure that contaminants will not be submerged in wet season or that anaerobic conditions can be maintained.	Low

[1] Low = <$1,500,000; Moderate = $1,500,000 to $5,000,000; High = >$5,000,000.
A cost range indicates that the cost is sensitive to the site size or volume.

Table 3-3

Possible Process Options for Groundwater and Surface Water

General Response Action	Possible Process Options
No Action	Not applicable
Institutional Action	Administrative controls to restrict water use Fences Natural attenuation with monitoring
Collection	Horizontal extraction wells Vertical wells Bioslurping Sump for surface water
VOC Treatment	Air stripping with catalytic oxidation UV oxidation (UV-OX) Carbon adsorption
Metals Treatment	Ion exchange Reverse osmosis pH adjustment and precipitation
Discharge	Irrigation water supply Industrial water supply Discharge to the storm drain Discharge to the Publicly Owned Treatment Works
Storm Sewer Isolation	Slip-lining the storm sewers Storm sewer section repair Installation of pipe collars

Table 3-4

Possible Process Options for Soil and Sediment

General Response Action	Possible Process Options
No Action	Not applicable
Institutional Action	Administrative controls to restrict land use Fences Natural degradation with monitoring
Excavation	Backhoe Bulldozer Scraper Truck loader
Disposal	On-site capping or fill material Existing off-site Class I landfill Existing off-site Class II landfill Existing off-site Class III landfill
Containment	Bentonite/soil cap Clay cap Asphalt cap Concrete cap Multimedia cap Encapsulation Sub-surface horizontal barrier
Excavate	Backhoe Bulldozer Scraper Truck loader
SVOC, VOC Treatment	High temperature thermal treatment Soil washing/solvent extraction Low temperature thermal treatment Co-disposal in cement kiln
Disposal	On-site capping or fill material Existing off-site Class I landfill Existing off-site Class II landfill Existing off-site Class III landfill
In-Situ Treatment	Soil vapor extraction (SVE) Bioventing

remedial action; general remedial action components are extraction, treatment, and disposal). Selecting a particular option as representative does not preclude the ultimate use of another similar process if the alternative process is ultimately determined to be preferable. Related process options are grouped because of the similarity in the effectiveness, implementability, and relative cost. For example, most groundwater alternatives include horizontal wells for groundwater extraction. However, at some sites vertical wells may be substituted for horizontal wells. By selecting one option as representative of the others, the conclusions of the detailed analysis will be applicable to the evaluated alternative as well to alternatives that could have been developed for other represented process options.

The key technical requirement for this streamlined approach is to have appropriate alternatives developed for the differing site conditions at Travis AFB. This requirement was met by formulating alternatives containing from one to several integrated process alternatives. The alternatives are formulated by medium. At a site with both soil and groundwater impacts, the remediation alternatives will be evaluated by the effectiveness, implementability, and cost of treating each medium separately. The synergistic benefits from treating both media will be considered in Section 10.0. The formulated remedial alternatives for each site at Travis AFB are shown for groundwater, surface water, and soil in Tables 3-5, 3-6, and 3-7, respectively. The logic for selecting the representative process options is given with each remedial alternative as discussed in Sections 3.6, 3.7, and 3.8.

3.6 Remedial Alternatives for Groundwater

The remedial alternatives for groundwater include no action, institutional controls, and several alternatives which involve collection, treatment, and discharge. The treatment options address VOC and metals contamination. In addition, a range of VOC control options are presented. Bioslurping, which primarily addresses floating (separate phase), biodegradable compounds, is discussed as a separate alternative.

Table 3-5

Potential Remediation Alternatives for Groundwater by Site[a]

IRP Designation	Alternative #1	Alternative #2	Alternative #3	Alternative #4	Alternative #5	Alternative #6	Alternative #7	Alternative #8	Alternative #9
North Operable Unit									
LF006 (Area A)	●	●	●	c	●	c	●	c	d
LF007 (Area B)	●	●	●	c	●	c	●	c	d
LF007 (Area C)	●	●	●	c	●	c	●	c	d
LF007 (Area D)	●	●	●	c	●	c	●	c	d
East Industrial Operable Unit									
FT004	●	●	●	c	●	c	●	c	d
FT005	●	●	●	c	●	c	●	c	d
SS015	●	●	●	c	●	c	●	c	d
SS016	●	●	●	c	●	c	●	c	d
SS029	●	●	b	●	b	●	b	●	d

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Offgas Catalytic Oxidation

● = is a potential remedial alternative
a = media of interest is not contaminated at LF007 (Area E), SD001, FT002, FT003, OT010, and WP017
b = metals are not COCs in media of interest
c = alternative does not address metals contamination
d = floating TPH is not a COC in the media of interest

Table 3-5

Potential Remediation Alternatives for Groundwater by Site[a] (Continued)

IRP Designation	Alternative #1	Alternative #2	Alternative #3	Alternative #4	Alternative #5	Alternative #6	Alternative #7	Alternative #8	Alternative #9
East Industrial Operable Unit (cont'd)									
SS030	●	●	●	c	●	c	●	c	d
SD031	●	●	●	c	●	c	●	c	d
ST032	●	●	●	c	●	c	●	c	●
West Industrial Operable Unit									
SD033	●	●	●	c	●	c	●	c	d
SD034	●	●	●	c	●	c	●	c	●
SS035	●	●	b	●	b	●	b	●	d
SD036	●	●	●	c	●	c	●	c	d
SD037	●	●	●	c	●	c	●	c	d

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Offgas Catalytic Oxidation

● = is a potential remedial alternative
a = media of interest is not contaminated at LF007 (Area E), SD001, FT002, FT003, OT010, and WP017
b = metals are not COCs in media of interest
c = alternative does not address metals contamination
d = floating TPH is not a COC in the media of interest

Table 3-6

Potential Remediation Alternatives for Surface Water by Site[a]

IRP Designation	Alternative #10	Alternative #11	Alternative #12	Alternative #13	Alternative #14	Alternative #15
East Industrial Operable Unit						
SD001	●	●	●	●	●	b
West Industrial Operable Unit						
SD033	●	●	●	●	●	c

Alternative #10: No Action
Alternative #11: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek
Alternative #13: Collection Sump, Activated Carbon, Discharge to Union Creek
Alternative #14: Slip-lining and Collaring Storm Sewer
Alternative #15: Source Control

● = is a potential remedial alternative
a = Only Sites SD033 and SD001 have surface water contamination
b = Main Branch of Union Creek is a receptor, not a source
c = West Branch of Union Creek is a receptor, not a source

Table 3-7

Potential Remediation Alternatives for Soil and Sediment by Site[a]

IRP Designation	Alternative #16	Alternative #17	Alternative #18	Alternative #19	Alternative #20	Alternative #21	Alternative #22
North Operable Unit							
LF007 (Area B)	●	●	●	●	●	c	d
LF007 (Area D)	●	●	●	●	●	c	d
LF007 (Area E)	●	●	●	●	●	c	d
LF007	●	●	●	●	●	c	d
East Industrial Operable Unit							
SD001	●	●	●	b	●	c	d
FT002	●	●	●	●	●	c	d
FT003	●	●	●	●	●	c	d
FT004	●	●	●	●	●	c	d
FT005	●	●	●	●	●	c	d
OT010	●	●	●	●	●	c	d

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-situ Soil Vapor Extraction (SVE), Offgas Catalytic Oxidation
Alternative #22: In-situ Bioventing

● = is a potential remedial alternative
a = media of interest is not contaminated at LF006, LF007 (Area C), and SD031
b = capping not implementable at this site
c = a large volume of soil gas is not present at this site
d large volume of TPH-contaminated soil is not present at this site

Table 3-7

Potential Remediation Alternatives for Soil and Sediment by Site[a] (Continued)

IRP Designation	Alternative #16	Alternative #17	Alternative #18	Alternative #19	Alternative #20	Alternative #21	Alternative #22
East Industrial Operable Unit (cont'd)							
SS015	●	●	●	b	●	c	d
SS016	●	●	●	b	●	c	d
WP017	●	●	●	●	●	c	d
SS029	●	●	●	●	●	c	d
SS030	●	●	●	●	●	c	d
ST032	●	●	●	●	●	●	●
West Industrial Operable Unit							
SD033	●	●	●	●	●	●	●
SD034	●	●	●	●	●	●	●
SS035	●	●	●	●	●	c	d
SD036	●	●	●	●	●	●	●
SD037	●	●	●	●	●	●	●

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-situ Soil Vapor Extraction (SVE), Offgas Catalytic Oxidation
Alternative #22: In-situ Bioventing

● = is a potential remedial alternative
a = media of interest is not contaminated at LF006, LF007 (Area C), and SD031
b = capping not implementable at this site
c = a large volume of soil gas is not present at this site
d = a large volume of TPH-contaminated soil is not present at this site

Alternative 1: No Action

"No Action" is used as a baseline option for all sites. Under this remedial action, the Base undertakes no activity toward cleanup or risk mitigation.

Alternative 2: Institutional Actions

The institutional actions alternative for groundwater consists of administrative controls and monitoring. Administrative controls would be placed on the use of on-base groundwater from contaminated areas. Administrative controls also would be placed on areas with groundwater contamination, restricting excavation and subsurface work where the excavation worker will encounter groundwater or vapors emitted from the groundwater. Excavation and work would be allowed when environmental and worker safety control measures were implemented. For off-base contaminated groundwater, deed restrictions could be placed on property not owned by the Air Force.

Monitoring would be performed to track the migration of impacted groundwater and to provide an early warning if receptors such as agricultural wells or ecological receptors were threatened. Monitoring would also track the decline in concentrations resulting from natural attenuation processes.

Land purchase and alternative water supplies were not formulated into an alternative because the distance that plumes have migrated off-base has not affected current uses of the land and has not created an imminent threat to the water supplies. These options are open to the Air Force if the monitoring identifies a potential threat to the water supplies or to the productive use of the adjacent property.

Alternative 3: Horizontal Wells, Air Stripping/Catalytic Oxidation, Ion Exchange, Activated Carbon, Irrigation Supply, and Surface Water (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of VOCs, metals treatment, and treated water discharge. This remedial alternative applies to sites with concentrations of both VOC and metals in the groundwater that exceed the IRGs.

Groundwater Collection

Horizontal wells are representative of groundwater collection processes and are presently being used at the Base. Under proper hydrologic and land utilization conditions, vertical wells would also be viable and possess similar costs. Vertical wells with skimmer pumps could also be used for floating product recovery.

VOC Treatment

Air stripping followed by vapor phase catalytic oxidation and liquid phase activated carbon is the representative process for VOC treatment. Although air stripping is not currently in use at Travis AFB, this technology is commonly used for bulk VOC removal. Catalytic oxidation of the air effluent stream is used to ultimately destroy the VOCs by converting them to carbon dioxide, water, and hydrochloric acid (HCl).

Vapor phase carbon could be used as an alternative process option to catalytic oxidation with equal effectiveness and implementability. Total costs for the two options are estimated to be approximately equal. With vapor phase carbon, the VOCs would be adsorbed from the air stream, and the carbon filter would eventually need replacement or regeneration. The adsorptive capacity of activated carbon significantly increases when it is used with vapor phase rather than with aqueous phase contaminants. Vapor phase carbon has been used to remove VOCs from soil vapor extraction (SVE) system effluent at Travis AFB.

Activated carbon will be used on the stripper effluent water stream to act as a polishing system for final removal of VOCs. Activated carbon is currently in use at Travis AFB and is effective in meeting discharge requirements for streams with initial moderate VOC concentration (1,000 ppb). The activated carbon will need to be replaced or regenerated once the adsorbent is saturated. However, the replacement/regeneration frequency will be significantly reduced due to the upstream bulk VOC removal process.

Metals Treatment

As the representative technology for metals removal, an ion exchange system will be installed upstream of the activated carbon and downstream of the air stripper. This technology is advantageous because specific polymeric resins (or inorganic media) can be used to sorb specific suites of cations and anions. In addition, ion exchange affords some operating flexibility because regeneration of the resin can occur either on- or off-site.

Reverse osmosis (RO) and pH adjustment with precipitation are the other viable technologies for treatment of inorganic constituents in the water. RO produces one deionized water stream and one concentrated brine stream as a result of separation across a membrane. The brine stream (as much as 50% of the inlet water volume) would require further treatment. The RO system also requires periodic backwashing of the membrane with acidic and basic solutions. Metal hydroxide precipitation is used following a pH adjustment step. This process could be used singularly or to treat the brine discharge from an RO system. These processes are both approximately equal in effectiveness and implementability relative to ion exchange.

The capital and operating costs of ion exchange, RO, and hydroxide precipitation processes are all equally sensitive to the initial contaminant volume and concentration. Consumable materials can vary, but the effect on O&M costs is anticipated to be similar. For example, ion exchange could be operated so that regeneration occurs off-site. This would result in a recurring charge for replacement of resin. Metals precipitation would result in a regular charge for caustic chemicals and for disposal of hydroxide metal sludge.

Process Integration

An advantage of this configuration for combined VOC and metals removal is that the treatment of groundwater is staged. This allows for insertion of a metals-treating system within the process train where it will be most advantageous. For example, VOCs can be removed with air stripping so that the ion exchange resin is not impacted. Then metals are removed so that the activated carbon performance will not be degraded.

Groundwater Disposal

The most representative process options for treated groundwater disposal are discharge to Travis AFB's non-potable water irrigation system and direct discharge to NPDES-permitted bodies of water, such as Union Creek and the storm drain system. These options are currently exercised on Base. In accordance with the *Treated Groundwater Use Plan for Travis AFB* (Radian, 1995c) and all applicable permits and regulations, these options provide for maximum beneficial use of produced groundwater. Discharge to the storm drain system or other NPDES-permitted bodies would occur only during the wet weather period when irrigation is not required. As such, the impacts on the existing habitat in Union Creek are minimized.

Alternative 4: Horizontal Wells, Air Stripping/Catalytic Oxidation, Activated Carbon, Irrigation Supply, and Surface Water Discharge (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of VOCs, and treated water discharge. This remedial alternative applies to sites with concentrations of VOCs in the groundwater that exceed the IRGs. This alternative differs from Alternative 3 in that no metals treatment is performed. The rationale for selection of the process options which constitute this alternative is provided with Alternative 3.

Alternative 5: Horizontal Wells, Ultraviolet Oxidation, Ion Exchange, Activated Carbon, Irrigation Supply, and Surface Water Discharge (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of both VOCs and metals, and treated water discharge. This remedial alternative applies to sites with concentrations of both VOC and metals in the groundwater that exceed the IRGs. The rationale for selection of the process options which allow for groundwater collection and discharge and metals treating is provided with Alternative 3. The rationale for the VOC treatment method is provided below.

VOC Treatment

Another viable technology for VOC destruction is UV-OX. This is a liquid phase process and requires chemical reagents, such as hydrogen peroxide, promoted with UV light to destroy VOCs. Relative to an integrated system with an air stripper and catalytic oxidizer, this method is equally effective and implementable, and the estimated costs are comparable. However, this process option is substantially different from an air stripper because there is no generation (and required subsequent treatment) of an offgas stream. As with the air stripper/catalytic oxidation system, an ion exchange unit followed by activated carbon will be placed downstream of the UV-OX to provide for metals removal and final VOC treatment, respectively.

Alternative 6: Horizontal Wells, UV-OX, Activated Carbon, Irrigation Supply, and Surface Water Discharge (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of VOCs, and treated water discharge. This remedial alternative applies to sites with concentrations of VOC in the groundwater that exceed the IRGs. This alternative differs from Alternative 5 in that no metals treatment is performed. The rationale for selection of the process options which allow for groundwater collection and discharge is provided with Alternative 3. The rationale for the VOC treatment method is provided with Alternative 5.

Alternative 7: Horizontal Wells, Ion Exchange, Activated Carbon, Irrigation Supply, and Surface Water Discharge (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of both VOCs and metals, and treated water discharge. This remedial alternative applies to sites with concentrations of both VOC and metals in the groundwater that exceed the IRGs. The rationale for selection of the process options which allow for groundwater collection and discharge as well as VOC and metals treating is provided with Alternative 3.

Alternative 8: Horizontal Wells, Activated Carbon, Irrigation Supply, and Surface Water Discharge (NPDES)

This remedial alternative includes process options for groundwater extraction, treatment of VOCs, and treated water discharge. This remedial alternative applies to sites with concentrations of VOC in the groundwater that exceed the IRGs. This alternative differs from Alternative 5 in that no metals treatment is performed. The rationale for selection of the process options which allow for groundwater collection and discharge and VOC treating is provided with Alternative 3.

Alternative 9: Vertical Well, Bioslurping, Recovered Product Recycling, Offgas Catalytic Oxidation

Free hydrocarbon floating on the water table has been identified as a contaminant of concern (COC) at Sites SD034 and ST032. Alternative 9 incorporates bioslurping to address this contaminant. Bioslurping is a vacuum extraction technique which can result in the removal of soil gas, vadose zone contamination, floating product, and groundwater. During bioslurping, the suction line from a blower located on the surface is placed inside a vertical well and positioned near or within the floating product lens. When a vacuum (approximately 15 inches of mercury) is established at the air-water-hydrocarbon interface, contaminant is withdrawn from the three phases. In addition, biodegradation of TPH-contaminated soil is enhanced (if oxygen is rate limiting) as the blower pulls air through the formation. The offgas from the bioslurper will be treated with a catalytic oxidation system prior to release to the atmosphere if emission limits are otherwise exceeded. Extracted water and hydrocarbon are separated in an oil-water separator. Water is then pumped to the proposed groundwater treatment system for the site, and recovered hydrocarbon is stored for subsequent disposal or possible reuse. The design basis for the bioslurper, taken from the treatability study performed at Travis AFB (Battelle, 1995), is an air flow rate of 20 scfm, a hydrocarbon flow rate of 4 gallons per day (gpd), and a water flow rate of 400 gpd. Since bioslurping primarily addresses floating product, it would be implemented with remedial technologies specifically targeted at dissolved constituents in the groundwater, if needed.

3.7 Remedial Alternatives for Surface Water

Remedial alternatives for surface water include no action; institutional actions; two alternatives which involve collection, treatment, and discharge; contaminant migration barriers; and contaminant source control. Treatment and containment alternatives address both organic compounds and metals contamination.

Alternative 10: No Action

"No Action" is used as a baseline option for all sites. Under this remedial action, the Base undertakes no activity toward cleanup or risk mitigation.

Alternative 11: Institutional Actions

The institutional actions alternative for surface water consists of administrative controls, fences, and monitoring. Administrative controls would be placed on the use of surface water from contaminated areas. Administrative controls also would be placed on areas with surface water contamination, restricting activities which would encounter surface water or vapors emitted from the surface water. Activities would be allowed when environmental and worker safety control measures were implemented. Deed restrictions could be appropriate administrative controls for property not owned by the Air Force.

Monitoring would be performed to track the migration of impacted surface water and to provide an early warning if ecological receptors were threatened. Monitoring would also track the decline in concentrations resulting from natural attenuation processes.

Alternative 12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek

This remedial alternative includes process options for surface water collection, treatment of VOCs, metals treatment, and treated water discharge. This remedial alternative applies to sites with concentrations of both VOC and metals in the surface water that exceed the IRGs. The rationale for selection of the process options for VOC treatment and metals treatment is provided with Alternative 3.

Surface Water Collection

Sumps are representative of surface water collection processes and are presently being used at the Base. Sumps can be used to collect surface water as well as discharges to surface water prior to treatment and discharge.

Surface Water Disposal

The most representative process option for treated surface water disposal is direct discharge to NPDES-permitted bodies of water, such as Union Creek. This option is currently exercised at Travis AFB.

Alternative 13: Collection Sump, Activated Carbon, Discharge to Union Creek

This remedial alternative includes process options for surface water collection, treatment of VOCs, and treated water discharge. This remedial alternative applies to sites with concentrations of VOC in the surface water that exceed the IRGs. The rationale for selection of the process options which constitute this alternative is provided with Alternative 12.

Alternative 14: Slip-lining and Collaring Storm Sewers

This remedial alternative includes process options for containment. This remedial alternative applies to sites with concentrations of both VOC and metals in the groundwater that exceed the IRGs and could migrate into the storm sewers. The slip-lining and collaring alternative allows for isolation of the storm sewers from contaminated groundwater by inserting a plastic pipe liner in existing storm sewer lines. This alternative could also include external barriers, such as pipe collars, installed at several locations throughout the storm sewer system. The collars would minimize migration of contaminants through the disturbed soil associated with the pipe trench.

Storm sewer section repair could be used as an alternative process option to slip-lining with equal effectiveness and implementability. Total costs for the two options are estimated to be approximately equal. With storm sewer section repair, only portions of the storm sewer systems in disrepair would be addressed. As with slip-lining, barriers such as pipe collars could be installed at several locations throughout the storm drain system. The collars would extend into the pipe trench fill, thereby limiting migration of contaminated groundwater via this pathway.

Finally, this alternative also incorporates storm sewer system maintenance activities to minimize contaminant transport through the system. These activities would include periodic cleaning of sediments from the storm sewers as well as from associated sumps.

Alternative 15: Source Control

This remedial alternative incorporates the process options previously discussed for groundwater and surface water as well as the process options for soil (discussed in Section 3.8). This remedial alternative applies to all source sites. Union Creek is a potential receptor for contamination from any site with existing or potential groundwater contamination. The Union Creek water quality can be improved and protected by preventing discharge of contaminated soil, sediments, and water into the creek.

3.8 Remedial Alternatives for Soil

Remedial alternatives for soil include no action; institutional actions; excavation and disposal; contaminant; excavate, treatment, and disposal: and in-situ treatment. Treatment and migration control alternatives address both organic compounds and metals contamination.

Alternative 16: No Action

"No Action" is used as a baseline option for all sites. Under this remedial action, the Base undertakes no activity toward cleanup or risk mitigation.

Alternative 17: Institutional Actions

The institutional actions for soil and sediment consist of administrative controls, fencing, and monitoring. Administrative controls would be placed on the long-term use of land in contaminated areas, as well as on excavation and subsurface work where the excavation will encounter contamination or vapors emitted from the contamination. Excavation and work would be allowed when environmental and worker safety control measures were implemented. These controls would be managed by the base Civil Engineering Office, who would ensure that specified land use restrictions are followed and are reflected in the base plan. For off-base contamination, deed restrictions could be placed on property not owned by the Air Force as well as portions of adjacent property.

Monitoring would be performed to track the migration of contaminants and to provide an early warning if ecological receptors were threatened. Monitoring would also track the decline in concentrations resulting from natural degradation processes.

Alternative 18: Backhoe, Landfill

This remedial alternative includes excavation of contaminated soils or sediments with a backhoe and off-site or on-site disposal at an appropriate landfill. This remedial alternative applies to soils and sediments which contain organic or metal contaminants.

Excavation

Backhoe excavation was selected as the representative process option because most soil contamination at Travis AFB is limited to 1-2 feet from the surface, and the shallow groundwater table hampers other modes of excavation. Other types of excavation equipment, such as bulldozers, and scrapers, could generally be used. These additional types of equipment may be employed with backhoes at sites with contamination at greater depth or with greater areal extent.

Landfill

Landfill disposal was selected because it offers the most conventional, accepted approach to soil disposal. Disposal options for excavated contaminated soil are off-site disposal in a Class I, Class II or Class III landfill, or on-site disposal. Most soil encountered during remediation is expected to be non-hazardous. Contaminated soil exceeding local disposal requirements, such as oil-stained soil and non-RCRA hazardous waste, may be disposed of off-site in an industrial (Class II) landfill. Several facilities near Travis AFB accept contaminated soils. Soils which contain RCRA hazardous wastes would need to be disposed in a Class I landfill. There are two Class I landfills located in the state.

On-site disposal of contaminated soils could also be an option for excavated soils, assuming adequate environmental protectiveness could be maintained, and the requirements of California Code of Regulations (CCR), Title 23, Chapter 15 could be satisfied. An example of such disposal could be the use of soil contaminated with low levels of TPH as a foundation material in the preparation of a cap for Site LF007.

Alternative 19: Soil and Bentonite Cap

This remedial alternative uses a soil and bentonite cap to contain the soil contamination. This alternative is effective for soil which contains organic or metal contamination.

Infiltration of rainwater is the primary means by which soil contaminants are mobilized. By implementing this process option, soil contaminant migration is minimized. Capping with soil and bentonite was selected as the representative process option because it presents installation and operational characteristics which are typical of the other viable containment strategies. In addition, the opportunity to reuse uncontaminated soil is available. Another option could be the use of contaminated soil from other Travis AFB IRP sites as part of the foundation material in the cap. However, use of such soils would have to maintain environmental protectiveness and meet the requirements of CCR, Title 23, Chapter 15.

Several other containment strategies present themselves as equally effective, implementable, and cost sensitive to the areal extent of the contamination. These are capping with other impermeable materials, including clay, asphalt, or multi-media; installation of a subsurface horizontal barrier; and total encapsulation with a series of horizontal and vertical barriers. Common to all containment strategies, including a soil and bentonite cap, are the need for surface runoff control and design strategies to mitigate the potential deleterious effects of the shallow water table. Existing vernal pools that could be disturbed by a cap would have to be mitigated.

Alternative 20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Landfill

This remedial alternative includes process options for excavation, treatment of VOCs and SVOCs, and disposal. This remedial alternative applies to sites with concentrations of VOCs and SVOCs and metals in the soil and sediment that exceed the IRGs. The rationale for the selection of the process option for soil excavation is provided with Alternative 18.

Treatment

High temperature thermal treatment is the representative process option for destruction of organic contaminants in soil. Rotary kiln incinerators are the most commonly used devices for the treatment of contaminated soil and debris. Although they can be used for all organic contaminants, this technology is especially appropriate for soil contaminants which have a high British thermal unit (Btu) content (such as petroleum hydrocarbons) or which are hard to degrade by other technologies (such as PCBs, pesticides, and dioxins). As a result of high temperature thermal treatment, organic contaminants are destroyed through conversion to carbon dioxide, water, and HCl. Metallic contaminants are converted to the highest oxidation state and are concentrated in the slag and ash. Disadvantages of high temperature thermal treatment include gaseous and particulate emissions that may require control and unremoved metals that may require landfilling at a RCRA permitted facility.

Co-disposal, low temperature thermal treatment, and soil washing/solvent extraction are the other viable process options for ex-situ treatment of contaminated soil. These process options are as effective and implementable as high temperature thermal treatment and have comparable costs.

Co-disposal consists of incinerating the soil in an industrial production process, most commonly in a cement kiln. The soil may be incorporated into the final product, such as the cement, or exit as part of the ash or slag from fuels such as coal. Metals may be concentrated in the slag and ash and may prevent incorporation of the soil in the final product. This process is otherwise similar to high temperature thermal treatment.

Low temperature thermal treatment, or thermal stripping, involves heating the soil in an enclosed vessel to drive off VOCs and SVOCs. The vapor stream containing the VOCs and SVOCs must be treated by incineration or adsorption. Disposal of the soil must accommodate the initial metal contamination since this process does not remove metals.

Soil washing/solvent extraction can be used to separate the organic and inorganic contaminants from the soil. The effectiveness of this process is dependent on the selection of extraction solvents. Several solvents may be required to remove all contaminants from the soil. The process can produce concentrated aqueous and organic waste streams which must be treated prior to disposal.

Disposal

Landfill disposal is the representative process option for disposal as discussed in Alternative 18. Another potentially effective process option for disposal of treated soils would be on-site use, such as landfill capping, backfill, and grading material. Landfill capping is discussed in Alternative 19.

Alternative 21: In-situ Soil Vapor Extraction

This remedial alternative applies to sites with concentrations of VOCs in the soil gas, soil, and sediment that exceed the IRGs or present a significant risk to human health or the environment. SVE may have limited effectiveness when used alone in the vadose zone during times when the water table is high. SVE has been proven effective when combined with groundwater extraction at Travis AFB.

The process consists of extraction of soil vapors through wells completed in the contaminated vadose zone aquifer. The process can involve injection of supplemental air into the formation to aid in stripping VOCs from the soil and groundwater. The recovered soil gas is treated via adsorption or oxidation.

Alternative 22: In-situ Bioventing

Bioventing has been identified as a viable treatment option for soils which contain total petroleum hydrocarbons (TPH) at a depth greater than 5 feet. Bioventing involves increasing the amount of oxygen available to naturally occurring microorganisms to improve the rate of in-situ biodegradation. With typical bioventing installations, a blower at the surface injects air (up to 50 scfm per well) through a vertical well located in the zone of highest contamination. The injected air then exits as a surface flux. Because of the relatively low air flow rate and biological degradation of the contaminants, air exhaust treatment is not normally required. However, extraction wells or air extraction may be used as needed to prevent intrusion of soil gas into nearby buildings. A treatability study has been performed using bioventing at Travis AFB (Engineering-Science, 1993). The study indicated that the general conditions at the Base are amenable to bioventing. Sites SD037, SD036, SD034, SD033, and ST032 have been identified as suitable for bioventing.

4.0 STRATEGY FOR PERFORMING THE DETAILED ANALYSIS OF ALTERNATIVES

The purpose of the detailed analysis of alternatives (DAA) is to evaluate remedial alternatives identified in the initial screening of alternatives (ISA) (Section 3.0) according to evaluation criteria specified in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This will provide a basis for selecting alternatives for remediating sites within the North/East/West Industrial Operable Unit (NEWIOU). Alternatives for the media of groundwater, surface water, and soil are discussed in Sections 5.0, 6.0, and 7.0, respectively.

A "Goals-To-Metrics" analysis, specifying the goal, objectives, actions, uncertainties, and metrics for the DAA, is presented in Table 4-1. Such an analysis is useful for defining the approach to the DAA, and for ensuring that objectives are achieved and uncertainties addressed.

4.1 Strategy

The DAA is being conducted for all sites evaluated in this Feasibility Study (FS). The alternatives evaluated for each site are those summarized in Section 3.0. Because many of the sites have similar characteristics (e.g., contaminant type, medium impacted, plume size, geographic location), a detailed analysis of each site would be redundant: no differences would exist in the conclusions drawn for each evaluation criterion at similar sites. Sites were therefore grouped by similar characteristics and a detailed analysis performed of a representative site in each group. Representative sites were selected at random, although, in some cases, increased availability of site data was a criterion for selection. Sites that could not be logically grouped according to specified criteria were individually analyzed. The conclusions drawn from the detailed analysis are then applied to each site in the group analyzed, to the extent that site similarities exist and are representative of each other.

Table 4-1

Travis AFB DAA Goals-To-Metrics Analysis

GOAL	OBJECTIVES	ACTIONS	UNCERTAINTIES	METRICS
• Analyze and compare alternatives that have the potential to remediate groundwater, surface water, and soil to cleanup levels at all identified NEWIOU sites	• Eliminate duplication through the establishment of groups of sites based on similar media, COCs, locations, and site characteristics • Develop basic design criteria and cost estimates for alternatives at a representative site within each group • Evaluate compliance with each CERCLA criterion • Perform comparative analysis of alternatives for each representative site • Perform sensitivity analysis to determine how each alternative analysis would be affected by changes in assumptions • Determine synergies of strategically located treatment plant(s) to remediate more than one site, as opposed to a separate plant for each site (Section 10.0) • Determine synergies of remediating one or more affected media upon the others. For example, cleanup of groundwater and soil contamination would eliminate sources of surface water and sediment contamination	• Establish evaluation criteria and ranking system • Establish design assumptions for each representative site, including volumes, flow rates, and conceptual extraction system, treatment system, and discharge design • Present site characteristics and conceptual designs for each site in a figure, with supporting justification • Estimate cost to implement each alternative, using RACER™ and site-specific information • Provide a table, with supporting text, that scores each alternative against each of the CERCLA criterion • Quantitatively compare alternatives, using total scores and benefit/cost ratios • Qualitatively compare alternatives for CERCLA compliance at each site • Perform sensitivity analysis by varying cleanup times, discount rate, cleanup goals, and O&M contingency	• A single site may not precisely represent all sites within a group • Designs are preliminary and could change when the remedial design is performed • Cleanup levels could vary from those presented as IRGs • Cleanup times could vary from the estimated values to changes in cleanup levels or the influence of site-specific factors • Cost estimates are accurate to within -30% to +50% given the current cleanup levels and estimated cleanup times	• Information provided to make reasonable conclusions, for each site, as to which alternatives will best meet CERCLA requirements to the extent practicable, at an achievable cost • Approved Records of Decision(s) and Proposed Plan(s) for site remediation

COCs = Contaminants of Concern
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
D = Detailed Analysis of Alternatives
NEWIOU = North/East/West Industrial Operable Unit
O&M = Operation & Maintenance
RACER™ = Remedial Action Cost Engineering and Requirements System

A figure is presented for each representative site, which displays key site information such as extent of contamination, contaminant type, geology, applicable remediation alternatives, and physical characteristics. For alternatives that have on-site design aspects, such as groundwater pump and treat alternatives, a conceptual design is also provided on the figure that identifies such factors as the number of wells, flow rates, contaminant loading, and an estimate of the time to achieve the interim remediation goals.

The term "contaminants of concern" is used in the following chapters to include both the analytes identified in the Remedial Investigations as contaminants of concern and other chemicals that could affect remedial design. This broader use of the term "contaminants of concern" in the following chapters is not intended to change the findings of the Remedial Investigation Reports with respect to which chemicals exceed cleanup levels or pose a risk to human health or the environment.

The performance of each alternative at each representative site is analyzed using U.S. Environmental Protection Agency (U.S. EPA) evaluation criteria (U.S. EPA, 1988a). A scoring system is applied which specifies values that evaluate how completely an alternative meets the evaluation criteria. Costs are estimated for applicable alternatives at each representative site applying a specified set of assumptions. Both capital and operation and maintenance costs are evaluated.

A comparative analysis of the alternatives for each representative site is provided. The comparative analysis discusses how the different alternatives rank relative to each other with regard to effectiveness, implementability, and cost. A sensitivity analysis (Section 8.0) is provided that varies key variables such as cleanup times and discount rate, and discusses the sensitivity of an alternative to such changes in key variables. A comparative analysis summary section (Section 9.0) is presented which draws media-specific conclusions. Section 10.0 presents considerations to take into account when combining media-specific alternatives into an integrated plan for each site. Appendix A contains an ARARs Appendix. Appendix B presents the cost summaries and figures for both representative and non-representative sites, organized by site group. Appendix C presents a discussion of the procedures used to calculate the estimated time to clean up contaminants in groundwater.

4.2 Site Groupings

The DAA addresses the applicability of a large number of alternatives (i.e., 9 for groundwater, 6 for surface water, and 7 for soils) at a large number of sites (i.e., 15 for groundwater, 2 for surface water, and 19 for soils). If sites were not grouped, over 200 detailed analyses would need to be performed. If analyzed site by site, the analysis would become very repetitive and difficult to follow. Combining sites into groups eliminates this repetition without compromising the DAA. Thus, care must be taken to ensure that the CERCLA criteria for an alternative apply to every site within the group identically, such that the group conclusions are representative for each site.

The criteria for site grouping are as follows:

1. **Media** — Sites must fall within the same medium of soil, groundwater, or surface water. The groundwater basin with which each groundwater site is associated was not a criterion in the grouping since similar remediation alternatives would not necessarily apply to all sites in each basin. Sites which have contamination in more than one medium would appear in a different group for each medium.

2. **Applicable Alternatives** — The remedial alternatives applicable to each site within each group, based on the analysis in Section 3.0, must be identical.

3. **Contaminant Types and Concentrations** — Similar contaminant types and concentrations would be remediated with similar effectiveness by each alternative.

4. **Location** — Sites located close to each other at Travis AFB would have similar implementability issues such as water discharge locations and treatment plant locations.

5. **CERCLA Criteria Evaluation** — Sites would all have scored the same for each CERCLA criterion (except cost), if scored individually.

Table 4-2 presents the site groupings and the rationale for each site grouping. The representative site is listed first and is bolded. It should be noted that in many cases, sites could not be grouped because the above criteria could not be met. For these cases, the table states why only one site is included in a group. Table 4-3 presents the same site group information, organized by site number. In addition, this table indicates the total media and site group(s) associated with each site.

4.2.1 Assignment of Alternatives to Groups

Tables 4-4, 4-5, and 4-6 summarize the alternatives that are applicable to the site groups specified in Table 4-2 for groundwater, surface water, and soil, respectively. These are the same alternatives that were specified in Tables 3-5, 3-6, and 3-7, respectively. The alternatives will be analyzed in Sections 5.0, 6.0, and 7.0, respectively.

4.3 Evaluation Criteria and Scoring System

4.3.1 Criteria

The nine evaluation criteria of CERCLA can be divided into three categories: threshold factors, balancing factors, and modifying considerations. Threshold factors are those conditions that must be met for the alternative to be viable and relate directly to statutory findings that will be identified in the Record of Decision(s) (ROD); these criteria must be met. Balancing factors comprise the primary basis for comparing alternatives by relating the alternatives to the site-specific conditions. Finally, modifying considerations consider agency and community concerns: an alternative could be effective and technically

Table 4-2

Site Groupings

Media	Group	Sites[1]	Rationale for Grouping
Groundwater	A	**FT004**, LF006, LF007, SD031	• Similar location in northeast part of Travis AFB. • Similar COCs (chlorinated hydrocarbons and TPH). • Metals treatment required for all sites.
	B	**SD036**, SS015, SD033	• Similar location west of the flightline. • Similar COCs (chlorinated hydrocarbons and TPH). • Metals treatment required for all sites.
	C	**FT005**	• Low COC concentration (120 ppb TCE maximum) relative to other sites in the southeast area of Travis AFB. • Some off-base migration of groundwater. • Metals treatment required.
	D	**SS016**	• High COC concentration (32,000 ppb TCE maximum) relative to other sites in NEWIOU. • Metals treatment required.
	E	**SS029**	• Unlike most other groundwater sites, no metals treatment is required. • Maximum TCE concentration of 1,300 ppb. • Geographically isolated location south of the flightline.
	F	**SS030**	• Small groundwater volume relative to other sites in the southeast area of Travis AFB. • Some off-base migration of groundwater. • Maximum TCE concentration of 3,860 ppm. • Metals treatment required.
	G	**SD034**, ST032	• Contains free product layer. • Significant TPH concentrations (maximum TPH concentrations of 10.5×10^6 and 29×10^6 ppb, respectively) relative to other sites. • Metals treatment required for both sites.

Table 4-2

(Continued)

Media	Group	Sites[1]	Rationale for Grouping
Groundwater (cont'd)	H	**SS035**	• Low COC concentrations (21 ppb TCE maximum and 160 ppb TPH maximum) relative to other nearby sites. • Unlike most other groundwater sites, no metals treatment is required.
	I	**SD037**	• Large groundwater volume relative to other sites west of the flightline. • Consists of many commingled contaminant plumes of various origins. • Maximum TCE concentration of 6,990 ppb. • Metals treatment required.
Surface Water	J	**SD033**, SD001	• Both surface water sites impact Union Creek. • Surface water COCs (TCE, TPH, and metals) are similar for both sites. • Groundwater source control or downstream treatment could be used for both sites.
Soil	K	**FT003**, FT002, FT004, FT005	• Similar COCs (PCBs, PAHs, and dioxins/furans). • Includes all former fire training areas in the NEWIOU.
	L	**LF007**	• Geographically isolated location in northeast corner of Travis AFB. • Subject to remediation to mitigate ecological risk. • COCs (PCBs, PAHs, and metals) derived from landfill operations. • Unique heterogeneous nature of subsurface soil.
	M	**WP017**, OT010, SS029, SS030	• Sites located close together southeast of the runway. • Similar COCs (PAHs and metals). • Soil volumes are similar for both sites.

Table 4-2

(Continued)

Media	Group	Sites[1]	Rationale for Grouping
Soil (cont'd)	N	**SS035**, SS015, SS016	• Similar COCs (PAHs). • Sites located close to each other near center of Travis AFB.
	O	**SD036**	• Soil gas COCs (TPH, chlorinated organics) are a primary concern. • Major soil contaminant is TPH.
	P	**SD037**, SD033	• Much of contamination is associated with storm and sanitary sewers. • Contains isolated pockets of soil gas (contaminated with TPH, benzene, and TCE) and TPH. • Site contains PAHs in surface soils and TPH and SVOCs in subsurface soils.
	Q	**SD034**, ST032	• Free product above water table. • Major soil contaminant is TPH. • Soil gas contaminated with TPH and TCE.
	R	**SD001**, SD033	• Sediments associated with surface water are media of concern, rather than soils. • Similar COCs (metals and PAHs).

[1] The representative site for each group is listed first and bolded.

COC = Contaminant of Concern
NEWIOU = North/East/West Industrial Operable Unit
PAHs = Polycyclic Aromatic Hydrocarbons
PCB = Polychlorinated Biphenyl
ppb = parts per billion
pg = picogram
SVOCs = Semi-volatile Organic Compounds
TCE = Trichloroethene
TPH = Total Petroleum Hydrocarbon

Table 4-3

NEWIOU Site Groupings[a]

Site	Groundwater	Surface Water	Soil	Sediment
SD001	—	J	—	R
FT002	—	—	K	—
FT003	—	—	K	—
FT004	A	—	K	—
FT005	C	—	K	—
LF006	A	—	—	—
LF007	A	—	L	—
OT010	—	—	M	—
SS015	B	—	N	—
SS016	D	—	N	—
WP017	—	—	M	—
SS029	E	—	M	—
SS030	F	—	M	—
SD031	A	—	—	—
ST032	G	—	Q	—
SD033	B	J	P	R
SD034	G	—	Q	—
SS035	H	—	N	—
SD036	B	—	O	—
SD037	I	—	P	—

[a] For each site, this table indicates which media are impacted and the associated site group for each impacted medium. The site group is shown in bold where the associated site is the representative site for that group.

Table 4-4

Potential Remediation Alternatives for Groundwater by Group[1]

Group	Alternative #1	Alternative #2	Alternative #3	Alternative #4	Alternative #5	Alternative #6	Alternative #7	Alternative #8	Alternative #9
A	X	X	X	a	X	a	X	a	c
B	X	X	X	a	X	a	X	a	c
C	X	X	X	a	X	a	X	a	c
D	X	X	X	a	X	a	X	a	c
E	X	X	b	X	b	X	b	X	c
F	X	X	X	a	X	a	X	a	c
G	X	X	X	a	X	a	X	a	X
H	X	X	b	X	b	X	b	X	c
I	X	X	X	a	X	a	X	a	c

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Off Gas Catalytic Oxidation

[1] The applicable alternatives for each groundwater site group are indicated with an "X" in the boxes. These are evaluated in Section 5.0. The other boxes, which have an "a", "b", or "c" indicated, are not applicable alternatives for the reasons indicated below:

a = Not applicable since a metals treatment train, i.e., ion exchange, is not included for treatment of metals exceeding discharge limits.
b = Not applicable since ion exchange is not required for treatment of metals.
c = Not applicable since bioslurping is only applicable to sites which have a significant free product layer.

Table 4-5

Potential Remediation Alternatives for Surface Water by Group[1]

Group	Alternative #10	Alternative #11	Alternative #12	Alternative #13	Alternative #14	Alternative #15
J	X	X	X	X	X	X

Alternative #10: No Action
Alternative #11: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek
Alternative #13: Collection Sump, Activated Carbon, Discharge to Union Creek
Alternative #14: Slip-lining and Collaring Storm Sewer
Alternative #15: Source Control

[1] The applicable alternatives are indicated with an "X" in the boxes. These are evaluated in Section 6.0.

Table 4-6

Potential Remediation Alternatives for Soil by Group[1]

Group	Alternative #16	Alternative #17	Alternative #18	Alternative #19	Alternative #20	Alternative #21	Alternative #22
K	X	X	X	X	X	a	b
L	X	X	X	X	X	a	b
M	X	X	X	X	X	a	b
N	X	X	X	X	X	a	b
O	X	X	X	X	X	X	X
P	X	X	X	X	X	X	X
Q	X	X	X	X	X	X	X
R	X	X	X	c	X	a	b

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
Alternative #22: In-Situ Bioventing

1 The applicable alternatives for each soil site group are indicated with an "X" in the boxes. These are evaluated in Section 7.0. The other boxes, which have an "a", "b", or "c" indicated, are not applicable alternatives for the reasons indicated below:

a = Not applicable since significant levels of VOCs are not present in the soil gas.
b = Not applicable since bioventing is best applied at sites where TPH is the primary COC.
c = Not applicable since capping of Union Creek is not a viable alternative.

implementable, but not viable based on these modifying considerations. The nine evaluation criteria used in the detailed analyses -- including brief definitions of each -- are shown in Table 4-7. The detailed evaluations focus on the threshold and balancing factors. Costs are calculated to an accuracy of -30% to +50%, per CERCLA guidance (U.S. EPA, 1988a). Modifying considerations (agency and community acceptance) will be evaluated in the Proposed Plan(s) and ROD(s), after the agencies and public have had an opportunity to review all relevant documents.

4.3.2 Scoring System

A relative numerical rating system was used to measure the degree to which an alternative fulfills each evaluation criterion. Subjective factors and numerical values in a rating system evaluate how completely an alternative meets the evaluation criteria (Table 4-8). All criteria, with the exception of cost, were rated with a three number system of 5, 3, or 0. The cost criterion includes a four number system including 5, 3, 1, and -1. The addition of a fourth score for the cost criterion is included to provide for a wider range of cost scores. These values are not absolute and serve as a subjective ranking method for the purpose of performing the comparative analysis.

The selection of an alternative in the ROD(s) is based on an evaluation of the trade-offs between the costs, benefits, and impacts of any remedial response. The scoring system is designed to numerically represent the trade-offs between the different alternatives. This rating system also assumes that each of the CERCLA criteria are equally important, since each are numerically weighted the same. This may not always be representative in that certain criteria can have more importance, depending on site-specific circumstances. For example, threshold factors must be achieved and therefore might be seen as more important than a balancing factor, such as implementability, that might be of less importance. Despite these factors, this unbiased scoring system was selected as the best method to consistently evaluate all alternatives. The comparative analysis section considers site-specific circumstances that may cause more importance to be placed on certain factors.

Table 4-7

Remedial Alternative Evaluation Criteria

Criterion Type	Evaluation Criterion	Definition
Threshold Factors	Protective of human health and the environment[a]	Protects human health and the environment through the elimination, reduction, or control of contaminated media. All migration pathways must be addressed.
	Compliance with appropriate ARARs[a]	Complies with applicable or relevant and appropriate requirements of RCRA, CWA, SDWA, TSCA, state and local regulations and codes, and TBCs.
Balancing Factors	Long-term effectiveness and permanence[a]	Protects human health and the environment after the remedial objectives have been met.
	Reduction in toxicity, mobility, and volume through treatment[a]	Treats the media and reduces the toxicity, mobility, and/or volume of the contaminated media.
	Short-term effectiveness[a]	Protects human health and the environment during construction and implementation. Degree of threat and the time period to achieve remedial action objectives are also considered.
	Implementability	There are no administrative barriers (no permits, zoning limitations). The availability of materials and personnel, site features such as available space and topography, and impacts upon on-going operations are considered. The technical status of alternatives is also considered; theoretical technologies with only limited bench-scale evaluation are considered less implementable than fully proven processes.
	Cost	Costs include design, construction, start-up, monitoring, and maintenance. Accuracy to within -30% and +50%.
Modifying Considerations	State acceptance	The state's (or other regulatory agency's) preference among or concern about alternatives.
	Community acceptance	The community's apparent preferences among or concerns about alternatives.

[a] Effectiveness criterion used to determine the benefit/cost ratio.

ARARs = Applicable or Relevant and Appropriate Requirements
CWA = Clean Water Act
RCRA = Resource Conservation and Recovery Act
SDWA = Safe Drinking Water Act
TBC = To Be Considered
TSCA = Toxic Substance Control Act

Table 4-8

Remedial Alternative Evaluation Criteria Rating System

Evaluation Criterion	Condition	Value
Protective of human health and the environment	Is protective	5
	Potentially or contingent protection	3
	Is not protective	0
Compliance with appropriate ARARs	Complies with appropriate ARARs	5
	Complies with most appropriate ARARs or waivers needed	3
	Does not comply	0
Long-term effectiveness and permanence	Once cleanup is completed, there is no recurrence potential	5
	Contaminants transferred, future re-release possible	3
	Contaminants not removed or destroyed	0
Reduction in toxicity, mobility, and volume through treatment	Eliminates toxicity, mobility, and volume	5
	Reduces toxicity, mobility, and volume	3
	No reduction or no treatment	0
Short-term effectiveness	Short-term environmental improvement protects human health and the environment. No risks (or only insignificant risks) created by implementation	5
	Limited short-term improvement in environment. Minor risks created by implementation of alternative	3
	No short-term improvement in environment. Significant risks created by implementation	0
Implementability	Alternative proven, all materials and personnel available, permitting available or in place, little effect on operations	5
	Alternative requires significant space, raises some action-specific ARAR compliance issues, has some effect on operations	3
	Uncertain permitting, major impact on operations	0
Cost	<$1.5 million	5
	$1.5 to 5 million	3
	$5 to 10 million	1
	>$10 million	-1
State acceptance[a]	To be determined (in the ROD[s])	NA
Community acceptance[a]	To be determined (in the ROD[s])	NA

a These final two criteria are typically evaluated following comment on the RI/FS report and the proposed plan; they will be addressed when the ROD(s) is prepared.

ARARs = Applicable or Relevant and Appropriate Requirements
NA = Not Applicable
ROD = Record of Decision

For the comparative analysis, two methods of quantitatively totaling the scores are presented. The "Total Score" sums the seven criterion scores (i.e., all criteria except for the two modifying considerations). The "Benefit/Cost Ratio" sums the scores of the five effectiveness criteria (first five criteria on the left side of the tables) and divides by the estimated cost, in millions of dollars. While the total score measures overall compliance with the CERCLA criteria, the benefit/cost ratio better quantifies the degree to which CERCLA criteria are satisfied per unit cost expenditure.

4.4 Cost Estimating Procedures and Assumptions

While the other eight CERCLA criteria provide a qualitative means of evaluating the attractiveness of a particular remedial alternative, these criteria cannot be evaluated alone to determine the "best" alternative. Factoring cost, the seventh CERCLA criterion, into this analysis adds an important quantitative measure since funding is often a limiting factor in selecting a remedial alternative.

Order-of-magnitude costs were estimated for each alternative applicable of each representative site. Both capital costs and operation and maintenance (O&M) costs were considered. Costs are estimated to be accurate to -30% to +50%, per U.S. EPA CERCLA Guidance (U.S. EPA, 1988a). A discount rate of 5%, including the effects of inflation, is assumed for present worth analysis, again based on the CERCLA Guidance (U.S. EPA, 1988a). Costs are rounded to two significant figures, which is based on the order-of-magnitude nature of the estimates. Costs are estimated only for the purposes of comparing alternatives according to the CERCLA Guidance. Actual remediation costs could vary significantly from those in this FS and will be determined in the remedial design phase.

4.4.1 Capital Costs

Capital costs for each alternative were calculated as separate components and then assembled as appropriate for each remedial alternative. Component construction costs were calculated using the RACER/ENVEST™ cost estimating model (version 3.1) (U.S. Air Force, 1993) as shown in the individual cost estimate summary sheets, organized by group (Appendix B). The RACER/ENVEST™ model was developed by the U.S. Air Force specifically for estimating costs of remediation approaches for CERCLA documents, including FSs. The model was supplemented with site-specific and literature cost information, where available. Appendix B also includes costs for the non-representative sites.

Additional contingency costs were added to the construction costs, applying the assumptions in Table 4-9. Cost modifiers, which are additional costs related to the basic construction cost, were applied to the combined construction costs for each alternative as shown in Table 4-10. Cost modifiers were varied for some of the alternatives, based on alternative-specific factors. For example, the modifying assumption for Field and Laboratory Testing was reduced from 5% to 0% for the three institutional actions alternatives (Alternatives 2, 11, and 17) and the Slip-Lining Storm Sewer alternative (Alternative 14), as these alternatives would not have geotechnical testing associated with construction of remedial actions.

Table 4-9

Construction Contingency Cost Assumptions

Item	Percentage	Justification	Exceptions
Bid Contingencies	15%	These contingency items were added to the construction costs due to the uncertainty associated with estimating costs in the absence of detailed designs for the proposed remedial alternatives.	None
Scope Contingencies	20%		None
	25%		For Alternatives 18, 19, and 20 at LF007, the scope contingency was increased to 25% to account for increased health and safety expenditures expected for excavation work at this former landfill.

Table 4-10

Construction Cost Modifying Assumptions

Item	Percentage	Justification	Exceptions
Engineering Design	10%	Standard cost estimating practice	5% for Alternatives 18 and 20
Permitting and Legal	5%	Funding to obtain necessary permits for waste discharge/disposal, air permitting	10% for Alternatives 20 and 21
System Startup and Optimization	10%	Funding to "fine tune" remedial systems due to changing and unanticipated field conditions revealed during design implementation	0% for Alternatives 2, 11, 14, 17, 18, and 19
Bonding and Insurance	3%	Standard cost estimating practice	None
Construction Oversight	5%	Standard cost estimating practice	None
Field and Laboratory Testing	5%	Funding to provide geotechnical sampling and testing during remedial system installation	0% for Alternatives 2, 11, 14, and 17
Reporting	10%	Funding to provide regulatory-required *Remedial Action Report* after system installation	0% for Alternatives 2, 11, and 17
Escalation	15%	Assumes that construction will commence mid-1998.	None

4.4.2 Operation and Maintenance Costs

Operation and maintenance costs for each process option were calculated separately and then added as required for each remedial alternative. Present worth O&M costs were computed by applying the appropriate present worth factor to the annual O&M costs for each remedial process option, except the activated carbon only process option. The present worth costs for the activated carbon only alternatives were computed by applying the appropriate present worth factor to the gradient O&M costs. Straight-line functions were used to calculate annual O&M costs based on monthly carbon exchange of all vessels in the first year and quarterly carbon exchange in one vessel in the final year. Use of a straight line function may estimate costs conservatively since contaminant concentrations may decrease more rapidly in earlier years, resulting in a more rapid dropoff in carbon usage rate. However, changes in O&M costs in later years have minimal impact on present worth when brought back to the present. Also, pumping existing sources may either cause a temporary increase or prevent a rapid decrease in contaminant concentrations. Use of a straight line function is believed to be a realistic, conservative approach to estimating annual O&M costs.

The present worth factors are based on estimated operating times to achieve cleanup levels (presumed at this time to be Maximum Contaminant Levels [MCLs]), and a discount rate of 5.0% per annum, which is the recommended discount rate found in the CERCLA Guidance (U.S. EPA, 1988a). The calculated time to clean up groundwater to MCLs were used for costing instead of the standard 30 year cleanup time suggested by the CERCLA Guidance to provide for a more realistic estimate of cleanup costs. Table 4-11 summarizes the cost modifying assumptions used to calculate O&M costs for each process option. Again, some of these factors were changed based on alternative-specific factors (e.g., O&M Reporting costs were reduced from 5% to 0% for alternatives such as off-site disposal which have no need for ongoing O&M reporting).

Table 4-11

Operation and Maintenance Cost Modifying Assumptions

Item	Percentage	Justification	Exceptions
Insurance	1% of Total Capital Costs	Standard cost estimating practice	None
Reserve	1% of Total Capital Costs	Funding to cover unanticipated costs during system operation and maintenance	None
O&M Reporting	5% of Annual O&M	Funding to document system operation, cost, and performance data	0% for Alternatives 11, 14, 18, and 20
Project Administration	5% of Annual O&M	Funding to cover costs associated with project management	None
5-Year Review	1% of Annual O&M	Funding to provide required regulatory review of remedial actions at 5-year intervals	None
Contingencies	10% of Annual O&M	Funding to account for unforeseen operational difficulties	None

4.5 Implementation Analysis

The DAA uses a representative site for each group, and each alternative is addressed singularly. Travis AFB could benefit from the economies of scale if certain sites were combined for remedial action. For example, if aqueous phase granular activated carbon (GAC) is the selected alternative for a group of five sites, the DAA cost estimate assumes that a carbon treatment system is constructed at each site. By combining sites in close proximity to one another for execution, only one power source, treatment, and discharge system would be utilized, possibly resulting in cost savings. As a further permutation, it is possible that a centralized treatment facility would prove more economic if treatment alternatives were combined. For example, UV-OX could be used to treat a stream with a high VOC concentration, and GAC could be used to treat a stream with a low VOC concentration as well as the UV-OX effluent stream. The implementation analysis (Section 10.0) identifies an example implementation scenario considering geographic location of sites, and presents a cost savings analysis of the example sites if they were to be combined for execution. However, while it is mainly an economic analysis, centralized treatment facilities may also have some variations in effectiveness and implementability. For example, a single centralized treatment system may be somewhat easier to construct and operate than a number of smaller systems.

Other implementation elements are also discussed in Section 10.0. These include:

- The effects of a combined action to address soil contamination at several sites;
- The impacts of basewide groundwater and soil remediation upon contaminated surface water and sediments;
- Phasing in of alternatives as contaminant concentrations vary over time; and
- A methodology for selecting the combination of technologies and alternatives to be implemented at a single site or group of sites.

5.0 DETAILED ANALYSIS OF ALTERNATIVES FOR GROUNDWATER GROUPS

The alternatives identified in Section 3.0 that are applicable to the groups with groundwater contamination at Travis Air Force Base (AFB) are:

- Alternative #1: No Action
- Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
- Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #5: Horizontal Well Extraction, Ultraviolet Oxidation (UV-OX), Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #6: Horizontal Well Extraction, UV-OX, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain
- Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Off Gas Catalytic Oxidation

The applicable alternatives and the groups with groundwater contamination are presented in Table 5-1.

The conceptual designs for each representative site of a group and the estimated costs to implement the designs are for cost comparison only; actual sizing and location of the components of the extraction, treatment, and discharge systems will be determined in the detailed remedial design phase.

Table 5-1

Potential Remediation Alternatives for Groundwater by Group[1]

Group	Alternative #1	Alternative #2	Alternative #3	Alternative #4	Alternative #5	Alternative #6	Alternative #7	Alternative #8	Alternative #9
A	X	X	X	a	X	a	X	a	c
B	X	X	X	a	X	a	X	a	c
C	X	X	X	a	X	a	X	a	c
D	X	X	X	a	X	a	X	a	c
E	X	X	b	X	b	X	b	X	c
F	X	X	X	a	X	a	X	a	c
G	X	X	X	a	X	a	X	a	X
H	X	X	b	X	b	X	b	X	c
I	X	X	X	a	X	a	X	a	c

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Off Gas Catalytic Oxidation

[1] The applicable alternatives for each groundwater site group are indicated with an "X" in the boxes. The other boxes, which have an "a", "b", or "c" indicated, are not applicable alternatives for the reasons indicated below:

a = Not applicable since a metals treatment train, i.e., ion exchange, is not included for treatment of metals exceeding discharge limits.
b = Not applicable since ion exchange is not required for treatment of metals.
c = Not applicable since bioslurping is only applicable to sites which have a significant free product layer.

5.1 General DAA Elements

This section includes general discussion concerning conceptual design, evaluation of alternatives, and comparative analysis of alternatives. Following the general discussion, a detailed analysis of alternatives is presented for each group in Sections 5.2 through 5.10. The analysis for each group addresses specific issues concerning conceptual design, evaluation of alternatives, and comparative analysis of alternatives.

5.1.1 Description of Alternatives and Conceptual Design for Groundwater Groups

The strategy for locating the extraction wells serves to remove the sources and hotspots, control migration of the contaminated groundwater, and reduce plume contaminant levels down to designated cleanup standards. As reflected in the *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Guidance on Remedial Actions for Contaminated Groundwater* (U.S. EPA, 1988b), this approach protects human health and the environment, meets Applicable or Relevant and Appropriate Requirements (ARARs), and reflects an effective remedial solution that considers both short- and long-term costs. In areas where contaminated groundwater has migrated off-base, the extraction well layouts were designed to maximize the rate of cleanup to protect potential downgradient users of groundwater. Actual layout of the wells for each site may differ from the approach used to compare treatment alternatives. The layout could focus on source control, remediation and/or migration control depending on the type and concentration of contamination, and location of the contaminated groundwater. Factors to consider in determining the strategy (i.e., layout of the wells) is presented in Section 10.

The conceptual design includes a layout of the horizontal wells, which were located to remove sources and hotspots (areas where groundwater concentrations are greater than 3,000 parts per billion [ppb]) and on the downgradient edge of the contaminated groundwater (the approximate concentration isopleth corresponding to the maximum contaminant level [MCL]). Based on this layout of wells, the time to cleanup to MCLs was estimated under pumping conditions and considering the contaminant concentrations. Appendix C provides a sample calculation and method for determining cleanup times. The time to cleanup was then used to estimate the cost of the treatment alternatives. While the CERCLA Guidance suggests a 30 year period to estimate costs, the calculated time for cleanup to MCLs was used to provide a more rigorous estimate of the present worth cost of each alternative. The sensitivity analysis presented in Section 8.0 estimates the impact on cost due to changing the cleanup goal from MCL.

The installation of additional extraction wells would increase the gradient, groundwater velocity, and production rate, but the recovery rate of contaminant would probably not show a corresponding increase. Increased production rates would flush the most permeable zones of the aquifer. However, removal of contaminants in the saturated zone is limited by release from the dissolved, immiscible, and sorbed phases in the less permeable zones. Dissolution of the immiscible contaminant trapped in fine materials, desorption from fine materials, and advection/diffusion of dissolved contaminants in the fine materials are all comparatively slow processes relative to groundwater velocities enhanced by pumping. Therefore, the cleanup time is controlled by those slower processes, not the pumping rate.

A consistent approach -- applicable to all of the sites -- has been used for determination of cleanup times. Plume migration is estimated from basewide hydrogeologic conditions, types of contaminants, and movement of contaminants in both the vadose and saturated zones. Some site-specific data, such as hydraulic conductivity, effective porosity, and influence from pumping, are not available in all cases, so the use of a standardized set of hydraulic assumptions is warranted. The estimated horizontal extraction well production rate is based on the horizontal well treatability study conducted for TARA (Radian 1995e, Radian 1996c, and Radian 1996e). Other data, such as groundwater sample analyses, are available for all sites and are used to develop site plumes. This approach is appropriate for purposes of providing input into the cost estimates presented in Appendix B. Actual cleanup times may vary from those estimated in Appendix C.

Model plumes are generated with the program "SOLUTE" by the International Groundwater Modeling Center at the Colorado School of Mines (International Groundwater Modeling Center, 1993). The source concentration and duration are varied to match the model to the actual site plume. Once the model matches the site plume, the model is run into the future to determine the time to cleanup for a specific cleanup goal. The effects of NAPLs are not accounted for in this model. Appendix C contains a sample model procedure, the input values with ranges, and a table of results for the sites.

The program "SOLUTE" develops a solution for one-dimensional advection and dispersion with retardation and first-order decay assuming a constant source concentration boundary condition.

The general one-dimensional groundwater contaminant transport equation is as follows:

$$\frac{R\,\partial C}{\partial t}+v\frac{\partial C}{\partial x}+R\lambda C=D\frac{\partial^2 C}{\partial x^2}$$

where:

C	=	Concentration
t	=	Time
v	=	Average Linear Velocity
x	=	Distance
R	=	Retardation Factor
λ	=	First-Order Decay Constant (Biodegradation)
D	=	Combined Mechanical Dispersion and Diffusion Coefficient

This equation accounts for advection, dispersion, retardation, and first-order biodegradation in one dimension.

For each group, the description of alternatives and conceptual design is presented with corresponding figure of the representative site and key site characteristics that will help the reader understand the applicability of the remedial alternatives. The treatment alternatives and design assumptions are also displayed on the figure. Additional text describes the conceptual design and unique site characteristics. Conceptual design figures are provided for all sites in Appendix B.

The conceptual layout of the extraction, treatment, and discharge systems is the same for Alternatives 3, 4, 5, 6, 7, and 8. Each of these alternatives is a pump and treat technology, and they differ only in the specific treatment process options used. For each group, the components of the conceptual design were standardized to allow comparison of costs between alternatives and between groups. The components included one or more horizontal extraction well(s) with an estimated 15 gallons per minute [gpm] flow rate per 300 foot well, based on studies conducted at TARA, (Radian 1995e, Radian 1996c, and Radian 1996e), treatment system, power line from source to treatment system, untreated water piping from each well to the treatment system, and discharge piping from the treatment system to the discharge point. The untreated water piping is shown as a single line from the center of each well (connected via a vertical vault) to the treatment system. The actual remedial design may include manifolded untreated water piping. The conceptual design provided is consistent and conservative.

The groundwater treated by Alternatives 3, 4, 5, 6, 7, and 8 would be discharged either to Travis AFB's non-potable irrigation/industrial water system or to storm drains and Union Creek. Beneficial use of the treated groundwater is the preferable option, although discharge to storm drains must be considered during wet weather when less or no irrigation is required. Because of this required flexibility in discharge methods, treatment of groundwater must adequately reduce metals concentration levels to meet National Pollutant

Discharge Elimination System (NPDES) standards. This is why a number of the groups (i.e., Groups A, B, C, D, F, G, and I) have conceptual designs presented which include a metals treatment train (ion exchange). The sites in these groups include metals treatment because the maximum concentration for at least one metal exceeded the current NPDES discharge standards. This is a conservative assumption. Actual groundwater extracted from these sites may not require such metals treatment. The other two groups (i.e., Groups E and H) did not have any maximum concentration values for metals reported which exceeded NPDES standards, and, hence, would not likely require metals treatment.

Free hydrocarbon floating on the water table has been identified as a contaminant of concern (COC) at Sites SD034 and ST032 (Group G). Alternative 9 incorporates bioslurping to address this contaminant. Since bioslurping primarily addresses floating product (with secondary beneficial effect on TPH-contaminated soil), it would be implemented with remedial technologies specifically targeted at dissolved constituents in the groundwater, if needed.

5.1.2 Evaluation of Alternatives Against the CERCLA Criteria

The criteria of effectiveness, implementability, and cost were used to evaluate the alternatives of no action; institutional actions; and the three applicable collection, treatment, and discharge options for each group. The applicable alternatives were evaluated against each of the seven CERCLA criterion for Groups A through I, respectively, and the results are tabulated. This table employs the scoring system presented in Section 4.0. For each alternative, two quantitative measures, total score and benefit/cost ratio, are presented. The total score is the sum of each of the individual criterion scores. The benefit/cost ratio is the sum of the five effectiveness scores (first five criteria) divided by the estimated cost. Text is then presented, organized by each criterion, that describes the rationale for the scoring of each alternative. Capital, present worth operation and maintenance (O&M), and total present worth costs are tabulated for each group. The following discussion applies to all groundwater groups unless specifically noted.

Overall Protection of Human Health and the Environment

Alternative 1 was rated 0 because no protection to either human health or the environment would be provided under no action. Contaminants would not be eliminated or reduced, and migration pathways would not be affected. Alternative 2 was rated 3 because some limited protection would be provided. Access restrictions, such as administrative controls and posting signs, would reduce the chance of people coming in contact with contaminants at the site. Contaminant concentrations would not be actively reduced, although monitoring would assess the extent of contaminant reduction due to natural attenuation.

For groundwater contaminant remediation, Alternatives 3 through 8 each were rated 5 because these options should successfully achieve remediation levels that would provide adequate protection of human health and the environment. All treatment alternatives employ technologies that, based on experience, have been shown to be capable of achieving the Interim Remediation Goals (IRGs). Alternative 9 was rated 3 because removal of floating product and enhancing biodegradation (bioventing) of TPH-contaminated soil would be only partially protective of human health and the environment. Alternative 9 would not address dissolved halogenated hydrocarbons.

Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives 1 and 2 were rated 0 because no ARARs would be met under the no action scenario while under institutional actions, only some ARARs would be met. In both cases, achieving the IRG of cleaning groundwater to MCLs would be unlikely.

Alternatives 3 through 8 each were rated 5 because implementation of each alternative would achieve compliance with chemical-, location-, and action-specific ARARs. In particular, the treatment technologies described would all have the potential to achieve the IRGs of MCLs. The active treatment alternatives also involve treated water discharge to

Union Creek, the storm drain, or the irrigation system. Under any of these scenarios, the treatment system discharge would meet all applicable NPDES requirements. Alternative 9 was rated 3 because free product removal and treatment alone would not meet all NPDES requirements, though this technology would aid in overall compliance with groundwater discharge limits.

All treatment technologies (Alternatives 3 through 9) would likely emit some potentially regulated constituents to the air during operation. However, in all cases, the concentrations would likely be below the substantive standards of the Bay Area Air Quality Management District (BAAQMD), based on previous experience with these technologies and specific experience at Travis AFB (e.g., at the Tower Area Removal Action [TARA] facility.) A permit would not likely be required from the BAAQMD for individual sites, and use of these technologies would not violate air emission ARARs. For the alternatives including air strippers, an important "To Be Considered" (TBC) is CERCLA Guidance OSWER Directive 9355.0-28, "Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites," which recommends a limit of 15 pounds per day for VOC emissions.

All treatment technologies would produce solid waste streams that would have to be transported and disposed according to applicable requirements. These waste streams would include sludges, free products, and spent carbon filter. Some of these materials (e.g., the spent carbon) would need to be manifested and managed as a hazardous waste, based on experience at TARA. However, compliance with these action-specific ARARs should be readily achievable.

Long-term Effectiveness and Permanence

Alternative 1 was rated 0 because the no action scenario would provide no contaminant control, and the long-term remedial action objectives are unlikely to be achieved. Alternative 2 was rated 3 because some protection and cleanup would be provided due to access limitations and natural attenuation. Alternatives 3 through 8 each were rated 5 because these options would each provide for groundwater contaminant removal. For most groups, it is unlikely that a continuous source is present that would cause groundwater COC concentrations to increase above cleanup levels once the cleanup objectives were achieved. The monitoring program, which would track the quality of groundwater both during and after execution of the alternative, would detect such a situation. Alternative 9 was rated 3 because floating product removal only would not completely eliminate the potential for recurrent groundwater contamination.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 1 and 2 were rated 0 because no reduction of toxicity, mobility, or volume would occur under no action and institutional actions. The definition of this criterion requires that active treatment occur for a positive score to be achieved. Alternatives 3 through 8 each were rated 5 because implementation of any one of these alternatives would achieve reduction of toxicity, mobility, and volume of the groundwater COCs to meet cleanup objectives. The greatest effect of the treatment would be to reduce the toxicity of the COCs, through degradation or transformation to other, less harmful constituents. With respect to the scoring of the alternatives using activated carbon, it is assumed that the carbon would be regenerated off-site, and the sorbed products would be destroyed in accordance with all applicable permit requirements. UV-OX and Cat Ox affect on-site destruction of the contaminants. Volume would be reduced as groundwater is removed from the zone of contamination and either used on Base or discharged to the storm drain, under applicable NPDES permit requirements. Mobility would also be reduced since the pumping of groundwater would have a containment effect on contaminated groundwater in the vicinity of the extraction wells. Alternative 9 was rated 3 because removal of floating product and biodegradation (bioventing) of TPH-contaminated soil would reduce (but would not eliminate) toxicity, mobility, and volume at the affected sites. Alternative 9 would not address dissolved halogenated hydrocarbons.

Short-term Effectiveness

Alternatives 1 and 2 were rated 0 because their implementation would not provide short-term environmental improvement. While natural attenuation would be expected to occur under Alternative 2, this process would occur over many years and would have minimal short-term benefits. Alternatives 3 through 9 each were rated 5 because implementation of these options would immediately promote protection of human health and the environment. The activities associated with these alternatives should not pose a significant risk to human health or the environment during construction and startup. The extraction wells would have to be placed so as to prevent a release of contamination and the treatment system constructed so as to not endanger the safety of site workers.

Implementability

The no action and institutional action alternatives were rated 5 for implementability because, if adopted, no difficulty with process implementation would exist. Access restrictions and groundwater monitoring systems could also be easily implemented. In addition, implementation would not impact Base operations. Alternatives 3 through 9 were rated 3 for implementability. The technologies are well understood and the materials for construction would be readily available. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of the Base for most groups, and only the substantive requirements of permitting would have to be followed. However, a full 5 score is not given because there would be some effect on future Base operations: effort would be required to maintain optimal system performance and meet air and water discharge standards.

The alternatives would be slightly less implementable for groups (or sites) that are either close to the Base boundary or in active areas of the Base. For example, the conceptual designs for FT005 (Group C) and SS030 (Group F) indicate the installation of off-base horizontal wells. This would require the permission of the landowner, which could hinder implementation. Similarly, sites located in active, or more difficult to access, areas of the Base, such as SD036, SS016, ST032, SS035, and SD037, could require more effort and coordination to construct and operate an extraction and treatment system. However, none of the above affects on implementation are believed to be insurmountable, or would cause a change in scoring for any site from a "3".

Cost

For the representative site in each group, the estimated present worth costs for each alternative, broken out by capital and O&M costs, are tabulated with accompanying text. Costs for the other sites are given in Appendix B. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.3 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative and site.

For all groups, the no action alternative has a cost of $0 and a cost score of 5. The cost of institutional actions (groundwater monitoring) varies for each group with the time to clean up. The institutional action alternative has a capital cost of $19,000 because the same number of monitoring wells is used for all sites. The present worth O&M cost ranges from $200,000 to $1,400,000, and the total present worth cost ranges from $210,000 to $1,500,000. The cost score for institutional action is 5.

5.1.3 Comparative Analysis of Groundwater Alternatives

A comparative analysis is provided for each group, which summarizes the two qualitative analysis scores and provides conclusions comparing the alternatives to each other based on the CERCLA criteria evaluation. The discussion in this section applies to all groups. The no action alternative and the institutional actions alternative have the lowest total scores of 10 and 16, respectively. This is primarily because they provide for little or no remediation of the groundwater. The benefit/cost ratio for the institutional actions alternative is the highest for any alternative for several groups, ranging from 4.0 to 29. This would seemingly indicate a favorable option; however, because the threshold criteria of Overall Protection of Human Health and the Environment and Compliance with ARARs are not met, the institutional actions alternative (as well as the no action alternative) may not be adequate unless coupled with a treatment alternative.

In general, the UV-OX and air stripping alternatives have total present worth costs within 10% of one another for a given site. However, the total present worth cost of the activated carbon only alternative can vary significantly from the other two treatment schemes as contaminant concentration and speciation vary.

Since the activated carbon only alternative (Alternatives 7 and 8) is strongly influenced by O&M costs, shorter cleanup times favor carbon. A major capital cost for carbon only is the initial carbon load. For example, Alternative 8 is the most cost-effective option for Site SS035 because the estimated cleanup time (3 years) and the average TCE concentration (21 μg/L) are both relatively low. TCE is also more amenable to treatment with activated carbon relative to a more volatile substance, such as vinyl chloride, because the TCE is more readily adsorbed.

5.2 Detailed Analysis of Alternatives for Group A

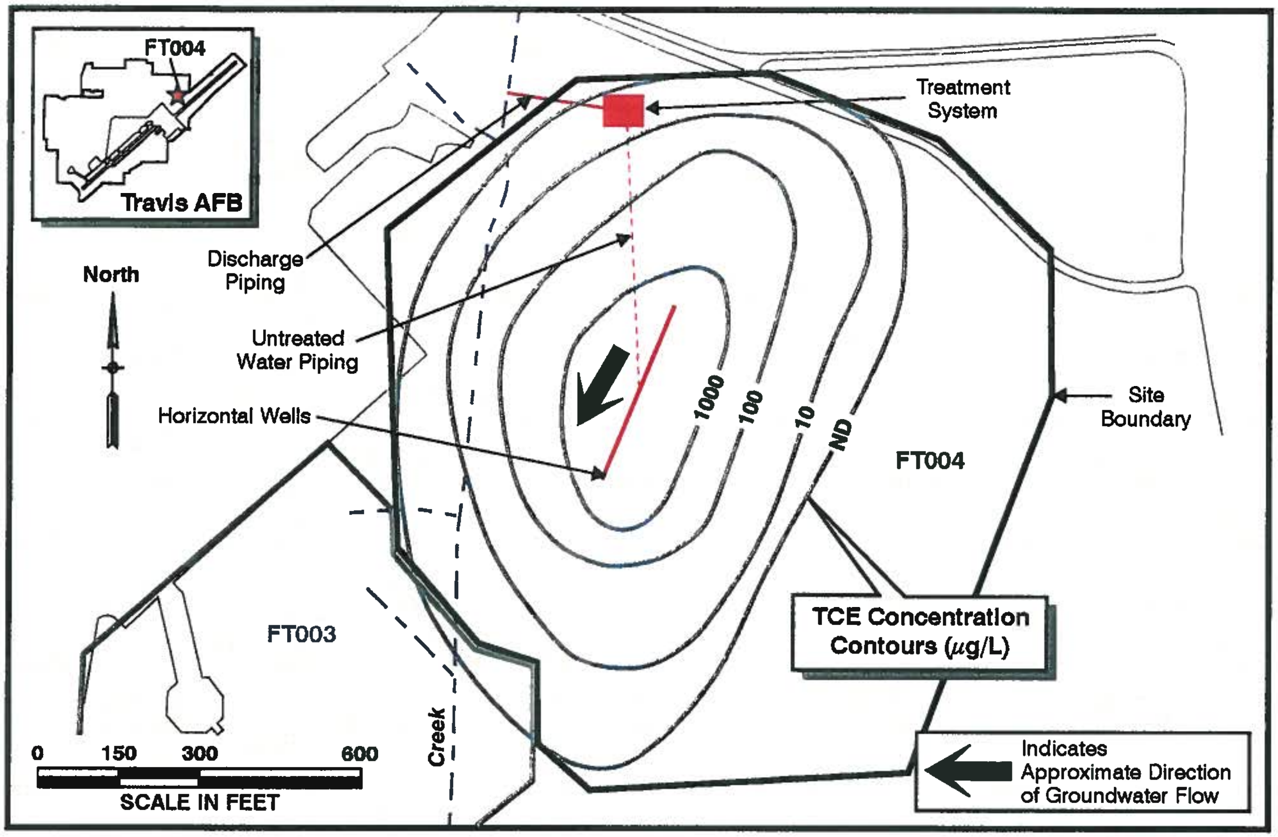
5.2.1 Description of Alternatives and Conceptual Design for Group A

The groundwater sites included in Group A are FT004, LF006, LF007 (Areas B, C, and D), and SD031. In the discussion below, FT004 serves as the representative site for describing alternatives and the conceptual design at Group A sites. The contaminants driving selection of the treatment technology are various chlorinated hydrocarbons, including trichloroethylene (TCE), arsenic, chromium, copper, selenium, silver, total petroleum hydrocarbons (TPH), and dissolved metals. The metals include nickel and lead at concentrations that may exceed the NPDES discharge limits. Alternatives 1, 2, 3, 5, and 7 are applicable to this group.

The conceptual design of the extraction, treatment, and discharge systems for FT004, shown in Figure 5-1, includes the targeted contaminant area, three extraction wells, a treatment system, and the untreated water and discharge lines. The targeted contaminant area is predominantly unpaved and located beneath an open field in the northeast quadrant of Travis AFB. Installation of the horizontal wells, therefore, should not interfere with current Base activities. Three horizontal wells are included in the conceptual design to contain the source area and to prevent any further migration of the groundwater plume. The treatment system is located south of the paved access road and east of Union Creek. Discharge of treated water is to the storm drain.

5.2.2 Evaluation of Alternatives for Group A

The results of the evaluation of alternatives for Group A are given in Table 5-2.



Site Characteristics

- Open field, less than 10% paved area
- TCE in groundwater — 830 µg/L average, 3,700 µg/L maximum
- TPH in groundwater — 1,000 µg/L average, 7,700 µg/L maximum
- Estimated mass of dissolved VOCs equals 230 lb; DNAPL may be present
- Ni in groundwater — 2,540 µg/L maximum
- Ar, Cr, Cu, Pb, Se, and Ag were measured at concentrations greater than NPDES discharge limits in some monitoring wells
- Depth to groundwater — 10 feet
- Depth to bedrock — 30 feet
- Silt and clay to 10 feet bgs
- Silty sand with minor gravel from 10 to 40 feet bgs
- Site also included in Group K for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- Three horizontal wells, 300 feet in screened length each
- Extraction rate 45 gpm total, 15 gpm from each well
- 2,250 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 500 feet of discharge piping (to creek) — 2 inch ID, sch 80 PVC
- 300 feet from treatment system to existing power line
- 95 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-1.
Conceptual Design for FT004 (Group A) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: A
Sites: FT004 (representative site), LF006, LF007, SD031

Table 5-2

CERCLA Criteria Evaluation for Group A

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.4M)	16	4.3
Alternative #3	5	5	5	5	5	3	1 ($6.5M)	29	3.8
Alternative #5	5	5	5	5	5	3	1 ($7.1M)	29	3.5
Alternative #7	5	5	5	5	5	3	-1 ($63.0M)	27	0.40

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-3

Cost Summary for Group A Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,400,000
#3	$910,000	$5,600,000	$6,500,000
#5	$960,000	$6,200,000	$7,100,000
#7	$3,000,000	$60,000,000	$63,000,000

Based on the present worth costs shown in Table 5-3, Alternatives 3 and 5 were rated 1, and Alternative 7 was rated -1 for cost. The highest capital and O&M costs are associated with Alternative 7 and are $3,000,000 and $60,000,000, respectively. The higher costs associated with Alternative 7 are due to the high rate of carbon changeout, which is an O&M cost component.

5.2.3 Comparative Analysis of Group A Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-2. Alternatives 3 and 5 evaluate similarly, and Alternative 7 is the most expensive. The three treatment alternatives have total scores ranging from 29 to 31, and Alternative 3 has the highest benefit/cost ratio of 3.8.

Alternatives 3, 5, and 7 have total scores of 29, 29, and 27, respectively. This is because they would be equally effective and implementable. However, they have dissimilar total present worth costs and the benefit/cost ratios for Alternatives 3, 5, and 7 are 3.8, 3.5, and 0.40, respectively. For this group, the benefit/cost ratio is a more clear indicator of the differences between alternatives. Alternative 3 has the highest benefit/cost ratio because it has the lowest present worth cost. The low benefit/cost ratio associated with Alternative 7 is due to the high rate of carbon changeout, which is an O&M expense.

5.3 Detailed Analysis of Alternatives for Group B

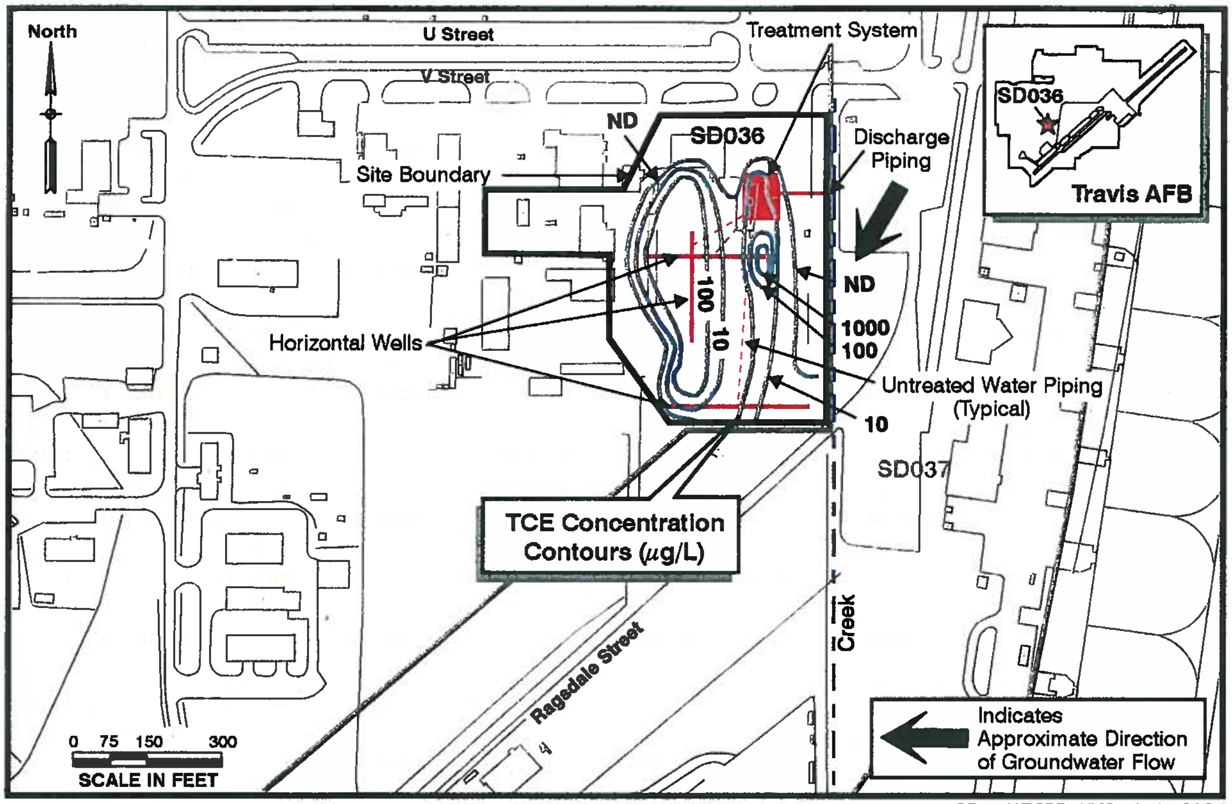
5.3.1 Description of Alternatives and Conceptual Design for Group B

The groundwater sites included in Group B are SS015, SD033, and SD036. In the discussion below, SD036 serves as the representative site for describing alternatives and conceptual design at Group B sites. The contaminants driving selection of the treatment technology are various chlorinated hydrocarbons, including TCE and dichloroethylene (DCE), TPH, and dissolved metals in groundwater. Dissolved metals include mercury and copper, and concentrations of these metals may exceed the NPDES discharge limits. In addition, volatile organic compounds (VOCs) have been detected in soil gas. Alternatives 1, 2, 3, 5, and 7 are applicable to this group.

The conceptual design of the extraction and treatment system for SD036, shown in Figure 5-2, includes the targeted contaminant area, three extraction wells, a treatment system, and the untreated water and discharge lines. The targeted contaminant area is surrounded by buildings, in an active area of the Base. Installation of the horizontal wells, therefore, will have to be coordinated with Base activities to minimize disruption. Three horizontal wells are included in the conceptual design to contain the source area and to prevent any further migration of the contaminants. The treatment system is located southeast of Building 872 and west of Ragsdale Street. Treated water is discharged to the West Branch of Union Creek.

5.3.2 Evaluation of Alternatives for Group B

The results of the evaluation of alternatives for Group B are given in Table 5-4.



Site Characteristics

- The site is paved and is surrounded by buildings
- The site is active
- Site is adjacent to SD037 — groundwater plumes are mixed
- VOCs also detected in soil gas
- TCE and 1,2-DCE in groundwater — 2,900 µg/L average TCE and DCE, 3,800 µg/L maximum 1,2-DCE
- TPH in groundwater — 4,400 µg/L maximum
- Estimated mass of dissolved VOCs equals 140 lb; DNAPL may be present
- Cu and Hg were measured at concentrations greater than NPDES discharge limits in some monitoring wells
- Depth to groundwater — 10 feet
- Depth to bedrock — >30 feet
- Two to four feet of asphalt and road base material
- Low permeability alluvium (clay) from 4 to 9.5 feet bgs
- Moderate permeability alluvium (clayey sand) from 8 to 18 feet bgs
- Thick, discontinuous sand units
- Site also included in Group O for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- 3 horizontal wells, 300 feet in screened length each
- Extraction rate 45 gpm total, 15 gpm from each well
- 550 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 70 feet of discharge piping (to west branch of Union Creek) — 2 inch ID, sch 80 PVC
- 70 feet from treatment system to existing power line
- 60 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-2.
Conceptual Design for SD036 (Group B) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: B
Sites: SD036 (representative site), SS015, SD033

Table 5-4

CERCLA Criteria Evaluation for Group B

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.4M)	16	4.3
Alternative #3	5	5	5	5	5	3	3 ($2.9M)	31	8.6
Alternative #5	5	5	5	5	5	3	3 ($3.6M)	31	6.9
Alternative #7	5	5	5	5	5	3	-1 ($38.0M)	27	0.66

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-5

Cost Summary for Group B Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,400,000
#3	$800,000	$2,100,000	$2,900,000
#5	$860,000	$2,700,000	$3,600,000
#7	$2,300,000	$36,000,000	$38,000,000

Based on the present worth costs shown in Table 5-5, Alternative 3 and Alternative 5 were rated 3, and Alternative 7 was rated -1 for cost. The highest capital and O&M costs are associated with Alternative 7 and are $2,300,000 and $36,000,000, respectively.

5.3.3 Comparative Analysis of Group B Alternatives

The alternatives are compared by assessing the total cost, total score, and the benefit/cost ratio as shown in Table 5-4. Based on effectiveness, implementability, and total present worth cost, Alternatives 3 and 5 are similar. Alternative 7 is the most expensive. The three treatment alternatives have total scores ranging from 27 to 31, and Alternative 3 has the highest benefit/cost ratio of 8.6.

The total scores for Alternatives 3, 5, and 7 are 31, 31, and 27, respectively. The benefit/cost ratios for Alternatives 3, 5, and 7 are 8.6, 6.9, and 0.66, respectively. Alternative 3 has the highest benefit/cost ratio because it has the lowest present worth cost. The three treatment alternatives are similarly effective and implementable with total present worth cost distinguishing the alternatives. Alternative 7 has a benefit/cost ratio of 0.66 due to high O&M costs associated with carbon use.

5.4 Detailed Analysis of Alternatives for Group C

5.4.1 Description of Alternatives and Conceptual Design for Group C

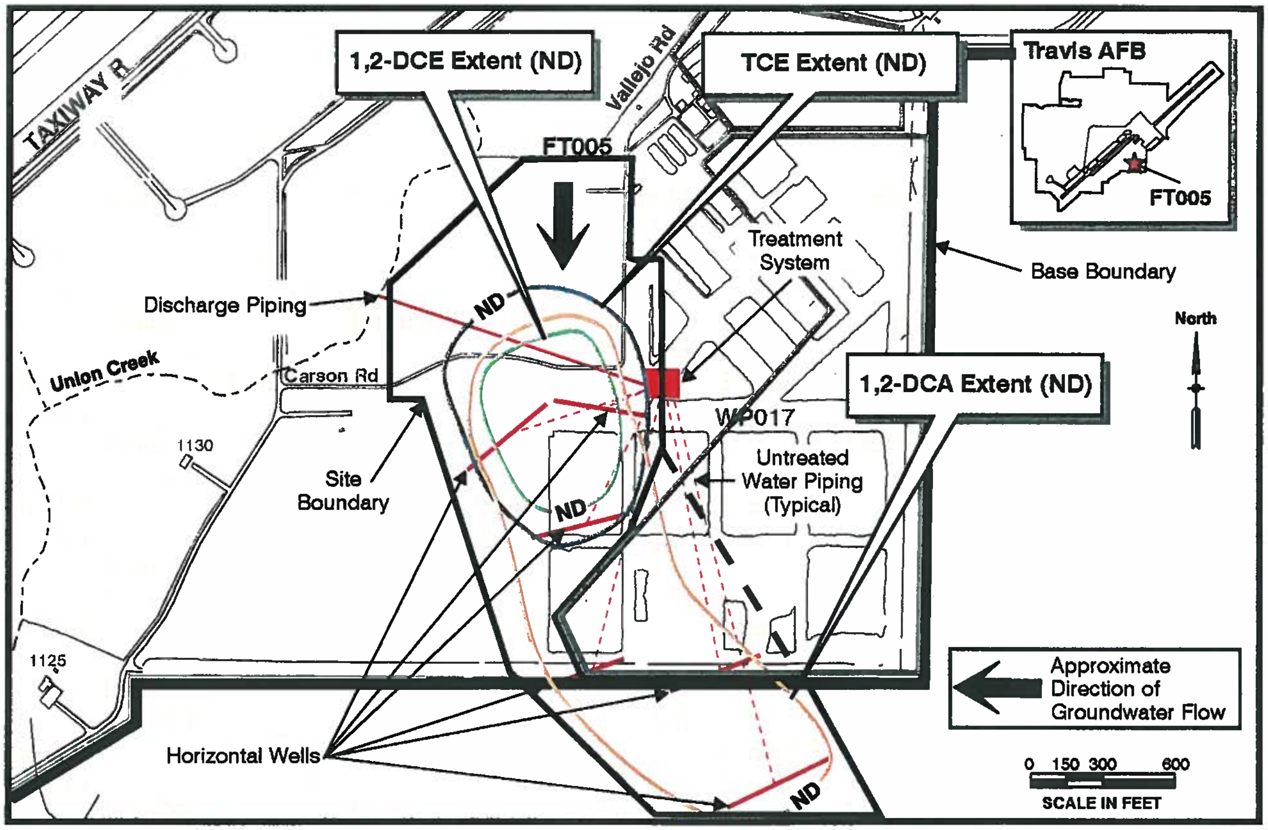
The groundwater site included in Group C is FT005, which is located along the southeast boundary of Travis AFB. The contaminants driving selection of the treatment technology are various chlorinated hydrocarbons, including DCE, 1,2-dichloroethane (1,2-DCA), and TCE, TPH, and metals in groundwater. The metals of concern include chromium, copper, mercury, and nickel; concentrations of these metals may exceed the NPDES discharge limits. Alternatives 1, 2, 3, 5, and 7 are applicable to FT005.

The conceptual design of the extraction and treatment system for FT005, shown in Figure 5-3, includes the targeted contaminant area, six extraction wells, a treatment system, and the untreated water and discharge lines. The targeted contaminant area is located adjacent to wastewater evaporation ponds, in an inactive area of the Base. Installation of the horizontal wells, therefore, should not disrupt Base activities. Six horizontal wells are included in the conceptual design to contain the source area and to prevent any further migration of the contaminants off-base. The treatment system is located along the western edge of WP017. Treated water discharge is to Union Creek.

At least one horizontal well may be installed off-base to intercept the groundwater contamination. Installation and O&M of the well would require permission from the landowner.

5.4.2 Evaluation of Alternatives for Group C

The results of the evaluation of alternatives for Group C are given in Table 5-6.



FT005ALT.CDR - VMG 7/25/96 SAC 1

Site Characteristics

- Site is located in an area of Travis AFB that is inactive except for explosives detonation
- TCE in groundwater — 3.3 µg/L average, 120 µg/L maximum
- TPH in groundwater — 200 µg/L average, 820 µg/L maximum
- Estimated mass of dissolved VOCs equals 3.9 lb
- Ni in groundwater — 370 µg/L maximum
- Cr, Cu, and Hg were measured at concentrations greater than NPDES discharge limits in some monitoring wells
- Depth to groundwater — 10 feet
- Depth to bedrock — 50 feet
- Permeable materials (sand and silt) occur through depths of 20 to 40 feet bgs
- Some low permeability soils (clay and silt) occur between 10 and 30 feet bgs
- Site also included in Group K for soil contamination
- The bold dashed line indicates where the FT005 groundwater contamination overlaps the soil site WP017

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- 6 horizontal wells, 300 feet in screened length
- Extraction rate 90 gpm total, 15 gpm from each well
- 5,100 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 1,200 feet of discharge piping (to Union Creek) — 3 inch ID, sch 80 PVC
- 1,000 feet from treatment system to existing power line
- 15 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumption shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-3.
Conceptual Design for FT005 (Group C) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: C
Sites: FT005

Table 5-6

CERCLA Criteria Evaluation for Group C

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.1M)	16	5.5
Alternative #3	5	5	5	5	5	3	3 ($4.5M)	31	5.6
Alternative #5	5	5	5	5	5	3	3 ($4.9M)	31	5.1
Alternative #7	5	5	5	5	5	3	1 ($5.5M)	29	4.5

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-7

Cost Summary for Group C Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,100,000	$1,100,000
#3	$1,800,000	$2,700,000	$4,500,000
#5	$1,900,000	$3,100,000	$4,900,000
#7	$1,700,000	$3,800,000	$5,500,000

Based on the present worth costs shown in Table 5-7, Alternatives 3, 5, and 7 were rated 1 for cost. Alternative 5 has the highest associated capital costs of $1,900,000, and Alternative 7 has the highest associated O&M cost of $3,800,000.

5.4.3 Comparative Analysis of Group C Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-6. For the group, Alternatives 3, 5, and 7 are effectively equivalent. Alternatives 3 and 5 have the highest total score of 31, and Alternative 3 has the highest benefit/cost ratio of 5.6.

The active treatment alternatives all have similar scores of 29 or 31. This is because they would be equally effective and implementable and would have similar total present worth costs. In addition, for this group, capital and operating costs are essentially equal for the three treatment alternatives. The benefit/cost ratios for Alternatives 3, 5, and 7 are 5.6, 5.1, and 4.5, respectively. Alternative 3 has the highest benefit/cost ratio because it has the lowest present worth cost.

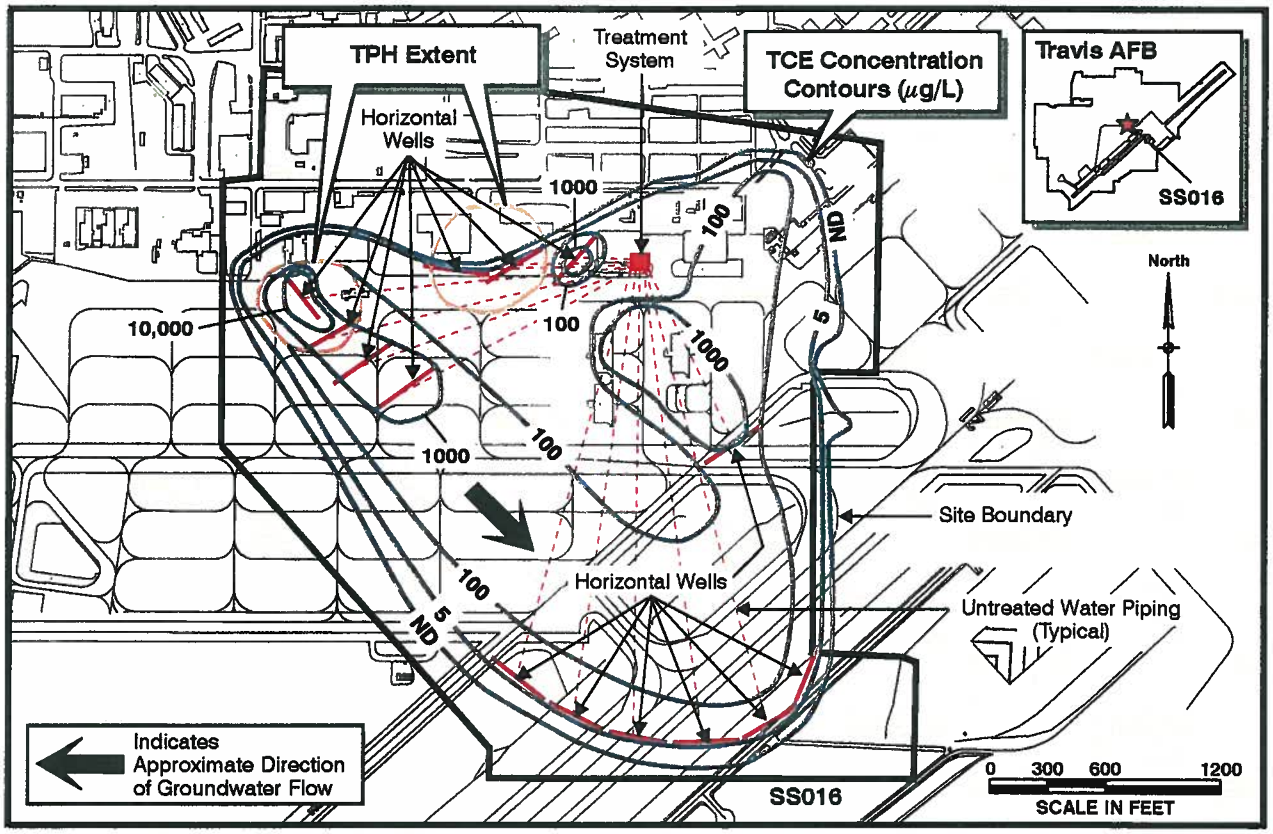
5.5 Detailed Analysis of Alternatives for Group D

5.5.1 Description of Alternatives and Conceptual Design for Group D

The groundwater site included in Group D is SS016 (Oil Spill Area [OSA]) and is located adjacent to the runways. The contaminants driving selection of the treatment technology are chloroform, DCE, TCE, and dissolved metals. Vinyl chloride may also be present. The metals include cadmium, chromium, copper, lead, silver, nickel, and zinc at concentrations that may exceed the NPDES discharge limits. Alternatives 1, 2, 3, 5, and 7 are the applicable alternatives for this group.

The conceptual design of the extraction and treatment system for SS016, shown in Figure 5-4, includes the targeted contaminant area, 14 extraction wells, the treatment system, and the untreated water and discharge lines. Four horizontal wells are included in the conceptual design to contain the source area, and ten wells are included to intercept lower levels of contamination in the remainder of the plume. The treatment system is located adjacent to the existing TARA site, and treated water is discharged to the irrigation system.

The contaminated area is located largely beneath the tarmac. Care must be exercised during the detailed design phase to ensure that Base operations are not unduly impacted. Groundwater treatment for this group would likely use two concurrent treatment stages to optimize treatment efficiency: one for the low volume, high concentration source area, and one for the higher volume, low concentration remainder of the plume. The TARA facility is currently extracting and treating groundwater from the low concentration area. Activated carbon is used to remove primarily TCE. The proposed Source Area Treatment Facility would use UV-OX with polishing carbon to treat the much higher concentrations of dissolved chlorinated hydrocarbons. Facility descriptions as well as the effectiveness and costs associated with the TARA Facility are provided in Section 1.3.1.



SS016ALT.CDR - VMG 9/10/96 SAC 1

Site Characteristics

- Approximately 100% of the area is covered by pavement and buildings
- Site located in an active area of Travis AFB (maintenance facilities and aircraft parking apron)
- TCE in groundwater in northwest portion of site — 10,000 µg/L average, 32,000 µg/L maximum (recent CPT data has detected TCE levels up to 180,000 µg/L, but results may not be representative; see Table 1-3)
- TCE in groundwater in the rest of the plume — 600 µg/L average, 5,000 µg/L maximum
- TPH in groundwater source areas — 4,000 µg/L average, 8,500 µg/L maximum
- Estimated mass of dissolved VOCs equals 1,200 lb; DNAPL may be present
- Ni in groundwater — 460 mg/L maximum
- Cd, Cr, Cu, Pb, Ag, and Zn were measured at concentrations greater than NPDES discharge limits in some monitoring wells
- Depth to groundwater — 10 feet
- Depth to bedrock — 30 feet
- Low permeability soils (clay and silt) to a depth of between 15 and 25 feet bgs
- More permeable material (sands and silts) below 15 to 25 feet bgs
- Site also included in Group N for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- 14 horizontal wells, 300 feet in screened length — 4 OSA wells and 10 wells for the rest of the plume
- Extraction rate 210 gpm total, 15 gpm from each well
- 27,300 feet of untreated water piping (from wells to treatment system) — 1 inch ID, sch 80 PVC
- 50 feet of discharge piping (to existing irrigation system) — 3 inch ID, sch 80 PVC
- 10 feet from treatment system to existing power line
- 193 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-4.
Conceptual Design for SS016 (Group D) Groundwater Treatment Alternatives, Travis AFB

5.5.2 Evaluation of Alternatives for Group D

The results of the evaluation of alternatives for Group D are given in Table 5-8.

Media: Groundwater
Group: D
Sites: SS016

Table 5-8

CERCLA Criteria Evaluation for Group D

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.5M)	16	4.0
Alternative #3	5	5	5	5	5	3	-1 ($27.0M)	27	0.93
Alternative #5	5	5	5	5	5	3	-1 ($29.0M)	27	0.86
Alternative #7	5	5	5	5	5	3	-1 ($230.0M)	27	0.11

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-9

Cost Summary for Group D Source Area Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#3	$2,900,000	$5,500,000	$8,400,000
#5	$3,000,000	$6,200,000	$9,200,000
#7	$7,100,000	$120,000,000	$130,000,000

Table 5-10

Cost Summary for Group D Remainder of Plume Area Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,500,000
#3	$6,500,000	$13,000,000	$19,000,000
#5	$6,500,000	$13,000,000	$20,000,000
#7	$9,300,000	$91,000,000	$100,000,000

As an example of two concurrent treatment stages, costs are itemized above by "source" (high concentration) and "remainder of plume" (low concentration) areas. Costs for Alternatives 1 and 2 are tabulated only for the "remainder of plume" area to prevent duplication for the single site. The total present worth costs shown on Table 5-8 are the sums of the two total values shown in Tables 5-9 and 5-10. Alternatives 3, 5, and 7 were rated -1 for cost. The highest capital and O&M costs are associated with Alternative 7 and total to $16,000,000 and $210,000,000, respectively.

5.5.3 Comparative Analysis of Group D Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-8. Alternatives 3 and 5 are similar, while Alternative 7 is the most expensive. The three treatment alternatives have the highest total score of 27, and Alternative 3 has the highest benefit/cost ratio of 0.93.

The active treatment alternatives all have a total score of 27. This is because they would be equally effective and implementable and would have total present worth costs in excess of $10,000,000. The benefit/cost ratios for Alternatives 3, 5, and 7 are 0.93, 0.86, and 0.11, respectively. Alternative 3 has the highest benefit/cost ratio because it has the lowest present worth cost. Alternative 7 is the most expensive due to O&M costs stemming from carbon changeout.

5.6 Detailed Analysis of Alternatives for Group E

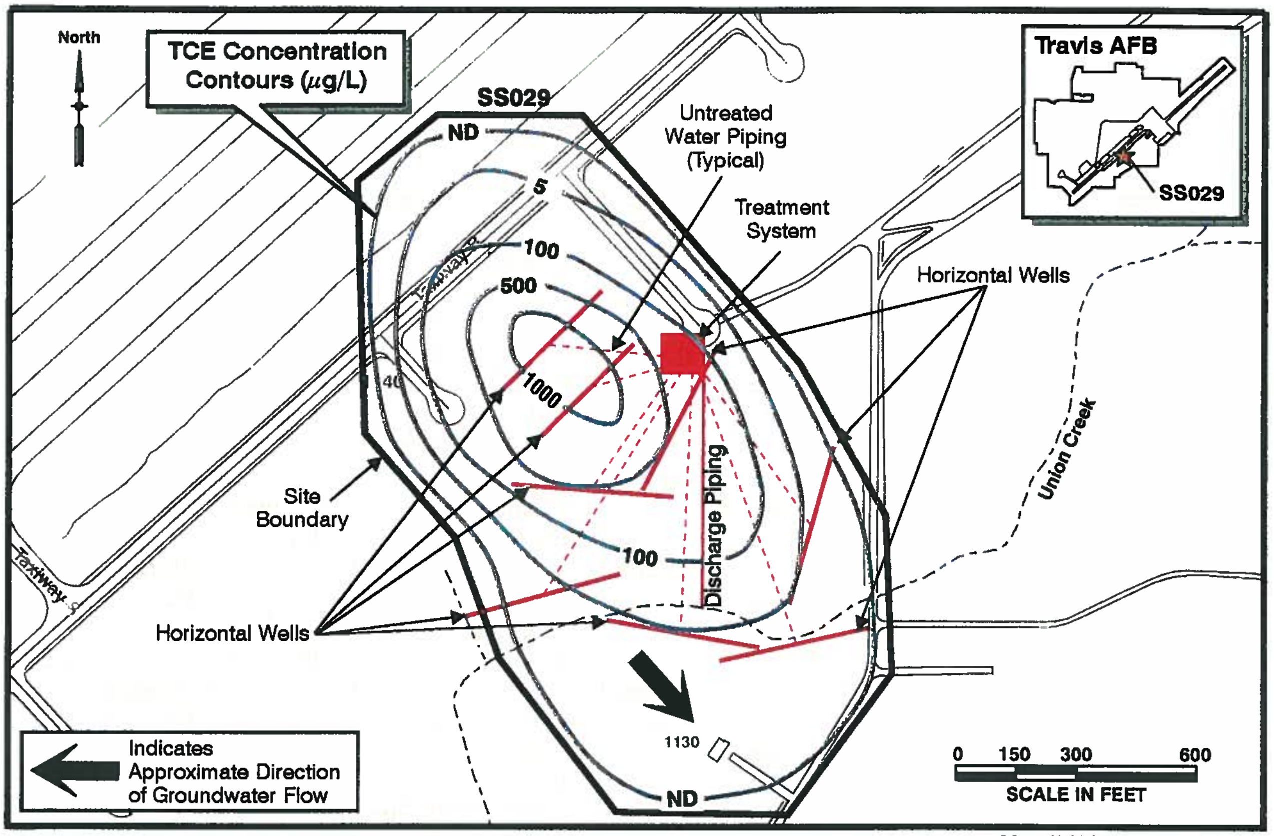
5.6.1 Description of Alternatives and Conceptual Design for Group E

The groundwater site included in Group E is SS029 (MW-329 Area), which is located near the southern boundary of Travis AFB. The contaminants driving selection of the treatment technology are TCE and DCE. No significant concentrations of TPH or dissolved metals were detected. Alternatives 1, 2, 4, 6, and 8 are applicable to this group.

The conceptual design of the extraction and treatment system for SS029, shown in Figure 5-5, includes the targeted contaminant area, eight extraction wells, a treatment system, and the untreated water and discharge lines. Eight horizontal wells are included in the conceptual design to contain the source area. The treatment system is located along the side of an old access road for Taxiway R, and treated water discharge is to Union Creek.

5.6.2 Evaluation of Alternatives for Group E

The results of the evaluation of alternatives for Group E are given in Table 5-11.



Site Characteristics

- Open field is located between abandoned taxiway and Union Creek
- TCE in groundwater — 315 µg/L average, 1,300 µg/L maximum
- Estimated mass of dissolved VOCs equals 100 lb
- Depth to groundwater — 10 feet
- Depth to bedrock — 30 feet
- Top 10 feet of saturated alluvium is composed of clays and other low permeability material
- Bottom 10 feet of saturated alluvium is composed of sands and other moderate permeability material
- Site also included in Group M for soil contamination

Treatment Alternatives

- Alternative #4: Air Stripper/Catalytic Oxidation, Activated Carbon
- Alternative #6: UV Oxidation, Activated Carbon
- Alternative #8: Activated Carbon

Design Assumptions

- 8 horizontal wells, 300 feet in screened length
- Extraction rate 120 gpm total, 15 gpm from each well
- 3,550 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 600 feet of discharge piping (to Union Creek) — 3 inch ID, sch 80 PVC
- 350 feet from treatment system to existing power line
- 149 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-5. Conceptual Design for SS029 (MW-329 Area) (Group E) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: E
Sites: SS029

Table 5-11

CERCLA Criteria Evaluation for Group E

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.5M)	16	4.0
Alternative #4	5	5	5	5	5	3	1 ($5.1M)	29	4.9
Alternative #6	5	5	5	5	5	3	1 ($5.9M)	29	4.2
Alternative #8	5	5	5	5	5	3	-1 ($15.0M)	27	1.7

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-12

Cost Summary for Group E Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,500,000
#4	$1,600,000	$3,400,000	$5,100,000
#6	$1,700,000	$4,200,000	$5,900,000
#8	$1,700,000	$13,000,000	$15,000,000

Based on the present worth costs shown in Table 5-12, Alternatives 4 and 6 were rated 1 and Alternative 8 was rated -1 for cost. Alternative 8 has the highest associated capital and O&M costs of $1,700,000 and $13,000,000, respectively.

5.6.3 Comparative Analysis of Group E Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-11. Alternatives 4 and 6 evaluate as essentially equivalent, and Alternative 8 is the most expensive. Alternative 4 has the highest benefit/cost ratio of 4.9.

Alternatives 4 and 6 have total scores of 29. This is because they would be equally effective and implementable and have similar total present worth costs. Alternative 8 has a lower total score of 27 since it has a much higher cost. For this group, the benefit/cost ratio is a more clear indicator of the differences between alternatives. The benefit/cost ratios for Alternatives 4, 6, and 8 are 4.9, 4.2, and 1.7, respectively. Alternatives 4 and 6 have the higher benefit/cost ratios because they have the lowest present worth cost. Alternative 8 is the most expensive due to O&M costs associated with carbon replacement.

5.7 Detailed Analysis of Alternatives for Group F

5.7.1 Description of Alternatives and Conceptual Design for Group F

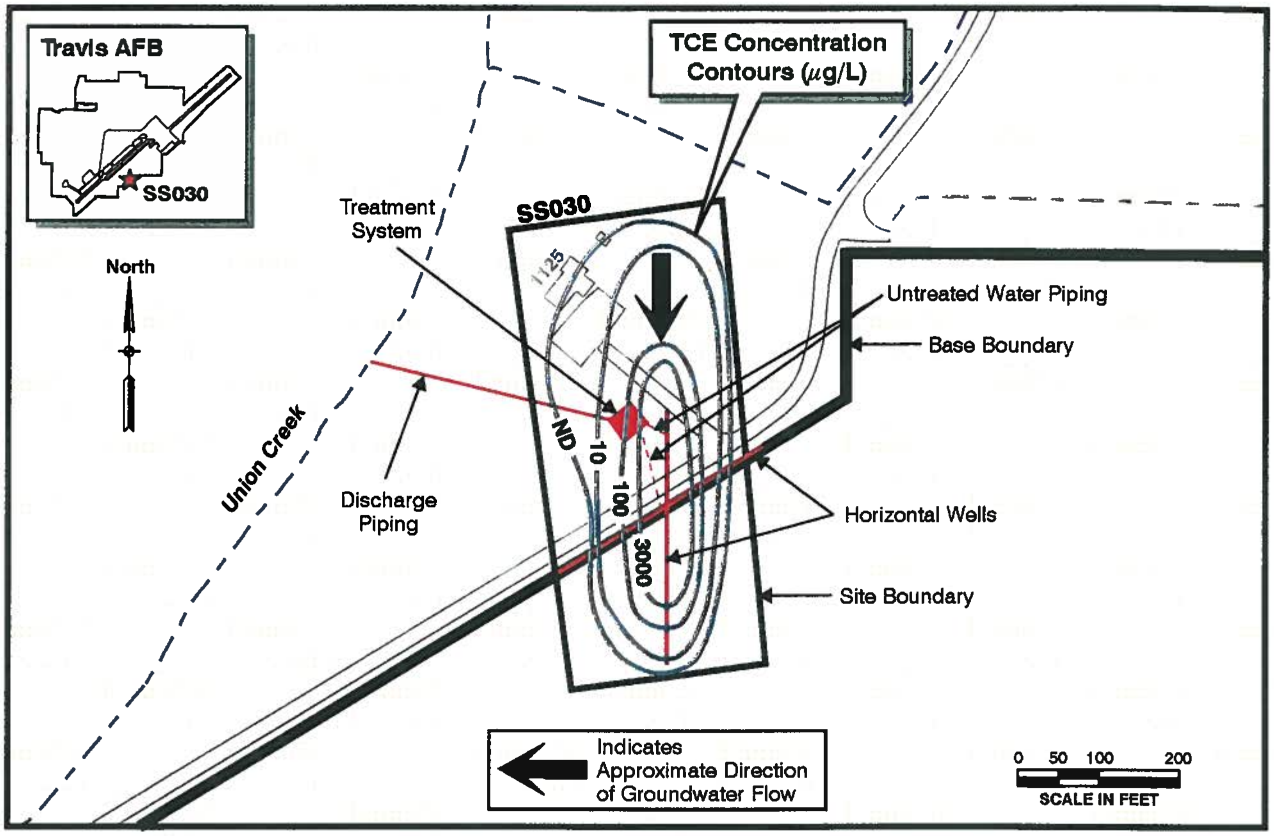
The groundwater site included in Group F is SS030 (MW-269 Area), which is located at the southern boundary of Travis AFB. The contaminants driving selection of the treatment technology are TCE (methylene chloride may also be present) and dissolved metals. The metals include nickel, selenium, and silver at concentrations that may exceed the NPDES discharge limits. Alternatives 1, 2, 3, 5, and 7 are applicable to this group.

The conceptual design of the extraction and treatment system for SS030 (MW-269 Area), shown in Figure 5-6, includes the targeted contaminant area, two extraction wells, a treatment system, and the untreated water and discharge lines. The figure also summarizes site characteristics, design assumptions, and applicable alternatives. The contaminant area is located both on- and off-base. Two horizontal wells are included in the conceptual design to contain the source area and to prevent any additional migration off-base. The treatment system is located adjacent to the road to Building 1125, and discharge of treated water is to Union Creek.

Installation and O&M of the off-base horizontal well will require permission of the landowner.

5.7.2 Evaluation of Alternatives for Group F

The results of the evaluation of alternatives for Group F are given in Table 5-13.



SS030ALT.CDR - VMG 7/25/96 SAC 1

Site Characteristics

- Approximately 25% of the area is covered by pavement or buildings
- TCE in groundwater — 958 µg/L average, 3,860 µg/L maximum
- Estimated mass of dissolved VOCs equals 18 lb; DNAPL may be present
- Nickel in groundwater — 903 µg/L maximum
- Se and Ag were measured at concentrations greater than NPDES discharge limits in some monitoring wells
- Low permeability soils (clay and silt) to a depth of between 15 and 25 feet bgs
- More permeable materials (sands and silts) below 15 to 25 feet bgs
- Depth to groundwater — 10 feet
- Depth to bedrock — 25 feet
- Well pumping rates — MW-269 conventional pumping at 0.8 gpm, Two Phase Extraction at 3.7 gpm
- Site also included in Group M for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- Two horizontal wells, 300 feet in screened length each
- Extraction rate 30 gpm total, 15 gpm from each well
- 150 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 350 feet of discharge piping (to Union Creek) — 1-½ inch ID, sch 80 PVC
- 100 feet from treatment system to existing power line
- 77 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-6. Conceptual Design for SS030 (MW-269 Area) (Group F) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: F
Sites: SS030

Table 5-13

CERCLA Criteria Evaluation for Group F

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.4M)	16	4.3
Alternative #3	5	5	5	5	5	3	3 ($2.7M)	31	9.3
Alternative #5	5	5	5	5	5	3	3 ($3.3M)	31	7.6
Alternative #7	5	5	5	5	5	3	3 ($2.0M)	31	13

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-14

Cost Summary for Group F Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,400,000
#3	$660,000	$2,100,000	$2,700,000
#5	$730,000	$2,600,000	$3,300,000
#7	$490,000	$1,500,000	$2,000,000

Based on the present worth costs shown in Table 5-14, Alternatives 3, 5, and 7 were rated 3 for cost. The highest capital and O&M costs are associated with Alternative 5 and are $730,000 and $2,600,000, respectively.

5.7.3 Comparative Analysis of Group F Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-13. Alternative 7 evaluates as the most cost-effective alternative and has the highest benefit/cost ratio of 13.

Alternatives 3, 5, and 7 all have total scores of 31. This is because they would be equally effective and implementable and would have similar total present worth costs. The benefit/cost ratios for Alternatives 3, 5, and 7 are 9.3, 7.6, and 13, respectively. Alternative 7 has the highest benefit/cost ratio because it has the lowest present worth cost.

5.8 Detailed Analysis of Alternatives for Group G

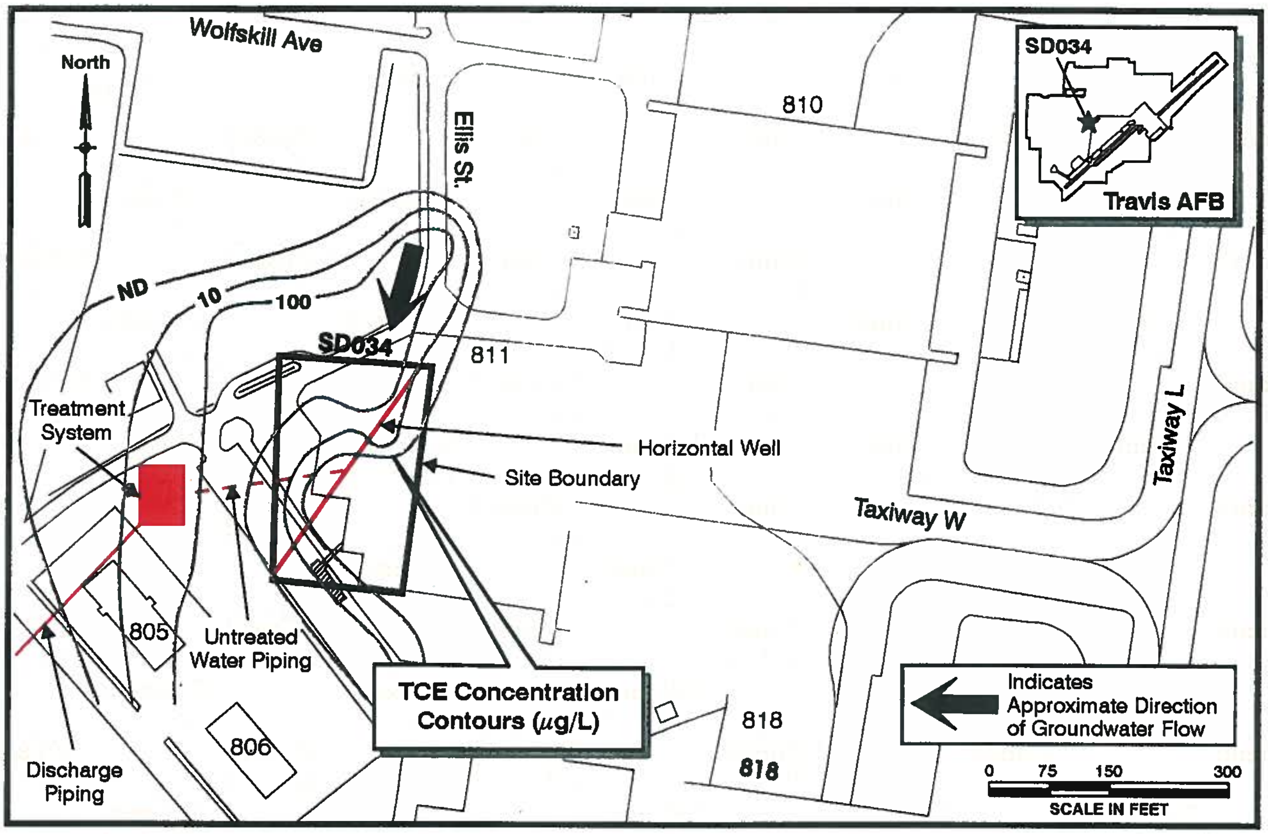
5.8.1 Description of Alternatives and Conceptual Design for Group G

The groundwater sites included in Group G are SD034 and ST032. Site SD034, which is located west of the tarmac, serves as the representative site for describing alternatives and the conceptual design for Group G sites. The contaminants driving selection of the treatment technology are TPH (floating and dissolved), dissolved TCE, and dissolved metals. The metals include chromium and mercury at concentrations that may exceed the NPDES discharge limits. Alternatives 1, 2, 3, 5, 7, and 9 are applicable to Group G.

The conceptual design of the extraction and treatment system for SD034, shown in Figure 5-7, includes the targeted contaminant area, one extraction well, a treatment system, and the untreated water and discharge lines. The horizontal well is included in the conceptual design to contain the source area and to prevent any further migration of the contaminants. The treatment system is located north of Building 805. The groundwater contamination includes free floating or emulsified hydrocarbon (PD680 solvent). The water must be pretreated to remove the TPH phase prior to treatment for dissolved TCE and metals. Treated water is discharged to Union Creek.

5.8.2 Evaluation of Alternatives for Group G

The results of the evaluation of alternatives for Group G are given in Table 5-15.



Site Characteristics

- Includes an indoor washrack, an oil/water separator, and a concrete-lined overflow pond
- Approximately 75% of the area is covered with roadbase and asphalt
- cis 1,2-DCE in groundwater — 80 μg/L average, 496 μg/L maximum
- TCE in groundwater — 120 μg/L average, 740 μg/L maximum
- TPH in groundwater — 5,000,000 μg/L average, 10,500,000 μg/L maximum, floating product (PD680) is present
- Estimated mass of dissolved VOCs equals 9.6 lb
- Chromium and mercury were measured at concentrations greater than NPDES limits
- Site is adjacent to SD037 — groundwater plumes are mixed
- Depth to groundwater — 13 feet
- Depth to bedrock — 16 feet
- Site also included in Group Q for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon
- Alternative #9: Bioslurping, Recovered Product Recycling, Off-gas Catalytic Oxidation

Design Assumptions

- 1 horizontal well, 300 feet in screened length
- Extraction rate 15 gpm
- 210 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 240 feet of discharge piping — 1 inch ID, sch 80 PVC
- 100 feet from treatment system to existing power line
- 60 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C
- Bioslurping: 1 vertical well, 400 gpd water, 4 gpd TPH, 20 scfm air

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-7.
Conceptual Design for SD034 (Group G) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: G
Sites: SD034

Table 5-15

CERCLA Criteria Evaluation for Group G

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.4M)	16	4.3
Alternative #3	5	5	5	5	5	3	3 ($2.1M)	31	12
Alternative #5	5	5	5	5	5	3	3 ($2.6M)	31	9.6
Alternative #7	5	5	5	5	5	3	3 ($1.9M)	31	13
Alternative #9	3	3	3	3	5	3	5 ($0.34M)	25	50

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #9: Vertical Well Extraction, Bioslurping, Recovered Product Recycling, Off Gas Catalytic Oxidation

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-16

Cost Summary for Group G Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,400,000
#3	$490,000	$1,600,000	$2,100,000
#5	$570,000	$2,100,000	$2,600,000
#7	$380,000	$1,500,000	$1,900,000
#9	$270,000	$74,000	$340,000

Based on the present worth costs shown in Table 5-16, Alternatives 3 and 5 were rated 3 for cost. Alternative 7 was rated 1 for cost. The highest capital cost is $570,000 (Alternative 5), and the highest O&M cost is $2,100,000 (Alternative 7). Alternative 9 was rated 5 for cost and has a total present worth cost of $340,000.

5.8.3 Comparative Analysis of Group G Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-15. Alternatives 3, 5, and 7 evaluate as essentially equivalent. These three dissolved phase treatment alternatives have the highest total score of 31, and within these options, Alternative 7 has the highest benefit/cost ratio of 13.

The active dissolved phase treatment alternatives have similar total scores because they would be equally effective and implementable and would have similar total present worth costs. The benefit/cost ratios for Alternatives 3, 5, and 7 are 12, 9.6, and 13, respectively. Alternative 7 has the highest benefit/cost ratio because it has the lowest present worth cost, but the slightly lower cost for Alternative 7 may not be significant given the level of detail of the cost estimate.

Among all alternatives, bioslurping (Alternative 9) has the highest benefit/cost ratio. However, because bioslurping primarily addresses floating product recovery, Alternative 9 would need to be combined with another groundwater remediation option to fully treat all contamination at the site.

5.9 Detailed Analysis of Alternatives for Group H

5.9.1 Description of Alternatives and Conceptual Design for Group H

The groundwater site included in Group H is SS035, which is located in the central portion of Travis AFB. The contaminants driving selection of the treatment technology are TCE and TPH in groundwater. No significant concentrations of dissolved metals were found. In addition, TCE was detected in soil gas. Alternatives 1, 2, 4, 6, and 8 are applicable to SS035.

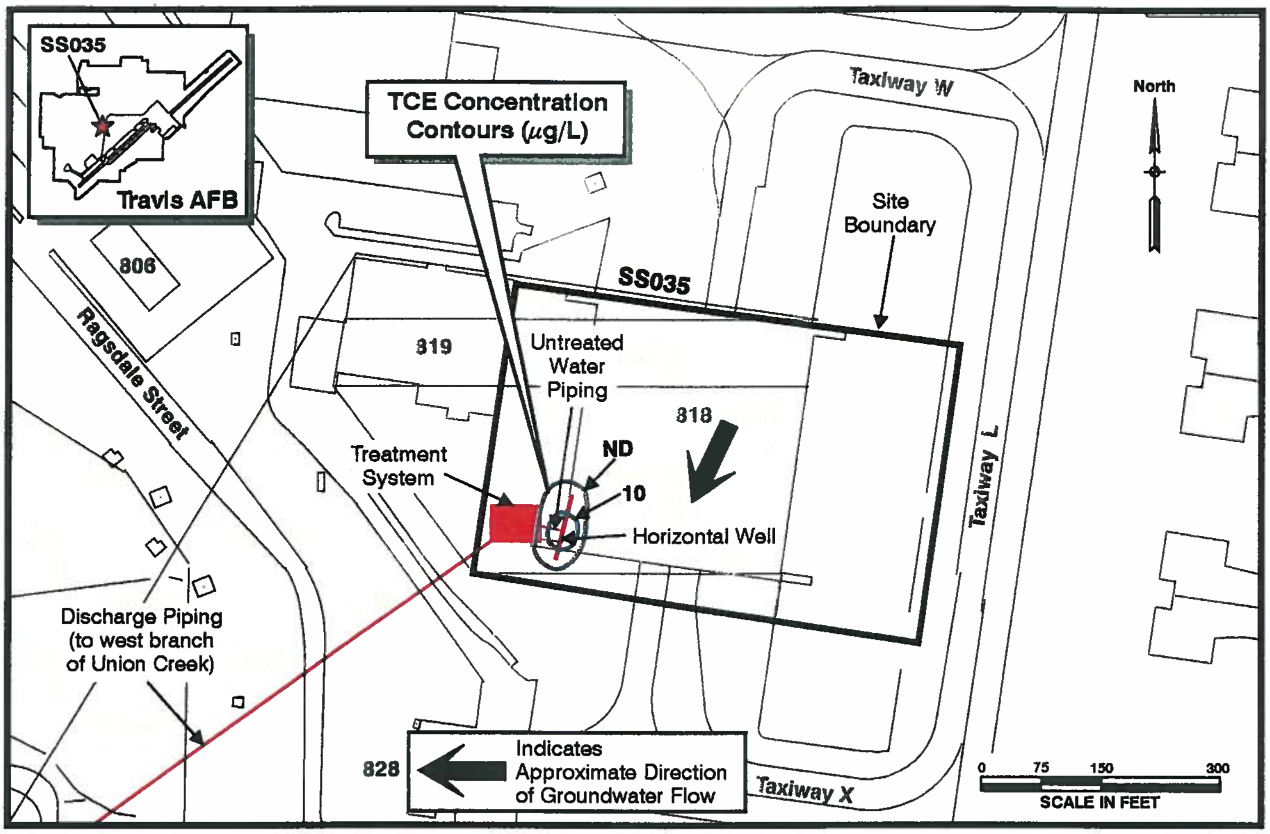
The conceptual design of the extraction and treatment system for SS035, shown in Figure 5-8, includes the targeted contaminant area, one extraction well, the treatment system, and the untreated water and discharge lines. The targeted contaminant area is located at the southwest corner of Facility 818, in an active area of the Base. One horizontal well is included in the conceptual design to contain the source area and to prevent any further migration of the contaminants. The treatment system is located west of Facility 818. Treated water discharge is to the West Branch of Union Creek.

Placement, installation, and maintenance of the well should be coordinated with Base activities to minimize disruption.

One 75-foot horizontal well is indicated with the conceptual design. In practice, vertical wells would most likely be used. However, to be consistent with the costing basis, the horizontal well was specified at this time.

5.9.2 Evaluation of Alternatives for Group H

The results of the evaluation of alternatives for Group H are given in Table 5-17.



Site Characteristics

- Asphalt and roadbase covers most of the site
- Facility 818/819 includes a wash area, oil/water separator and sump, hydraulic lift storage area, and hazardous material accumulation area
- Site is adjacent to SD037, plumes overlap
- TCE in soil gas detected @ 1,100 ppbv
- TCE in groundwater — 5 μg/L average, 21 μg/L maximum
- TPH in groundwater — 160 μg/L maximum
- Estimated mass of dissolved VOCs equals 0.007 lb
- Depth to groundwater — 15 feet
- Depth to bedrock — 14 feet
- Low permeability soils (clay and silt) to about 15 feet bgs
- More permeable material (sand lens) encountered at boring 818-B07
- Site also included in Group N for soil contamination

Treatment Alternatives

- Alternative #4: Air Stripper/Catalytic Oxidation, Activated Carbon
- Alternative #6: UV Oxidation, Activated Carbon
- Alternative #8: Activated Carbon

Design Assumptions

- ¼ of a horizontal well, 75 feet in screened length
- Extraction rate 4 gpm total
- 50 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 650 feet of discharge piping (to west branch of Union Creek) — 3 inch ID, sch 80 PVC
- 50 feet from treatment system to existing power line
- 3 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-8.
Conceptual Design for SS035 (Group H) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: H
Sites: SS035

Table 5-17

CERCLA Criteria Evaluation for Group H

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($0.21M)	16	29
Alternative #4	5	5	5	5	5	3	5 ($0.52M)	33	48
Alternative #6	5	5	5	5	5	3	5 ($0.65M)	33	38
Alternative #8	5	5	5	5	5	3	5 ($0.34M)	33	74

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #4: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #6: Horizontal Well Extraction, UV Oxidation, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #8: Horizontal Well Extraction, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-18

Cost Summary for Group H Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$200,000	$210,000
#4	$310,000	$210,000	$520,000
#6	$380,000	$270,000	$650,000
#8	$190,000	$150,000	$340,000

Based on the present worth costs shown in Table 5-18, Alternatives 4, 6, and 8 were rated 5 for cost. The highest capital and O&M costs are associated with Alternative 6 and are $380,000 and $270,000, respectively.

5.9.3 Comparative Analysis of Group H Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-17. For this group, Alternatives 4, 6, and 8 are rated the same for effectiveness and implementability; differences stem from the total present worth cost. The three treatment alternatives all have total scores of 33. Alternative 8 has the highest benefit/cost ratio of 74.

The active treatment alternatives all have total scores of 33. This is because they would be effective and implementable and would have total present worth costs below $1,500,000. The benefit/cost ratios for Alternatives 4, 6, and 8 are 48, 38, and 74, respectively. Alternative 8 has the highest benefit/cost ratio because it has the lowest present worth cost.

5.10 Detailed Analysis of Alternatives for Group I

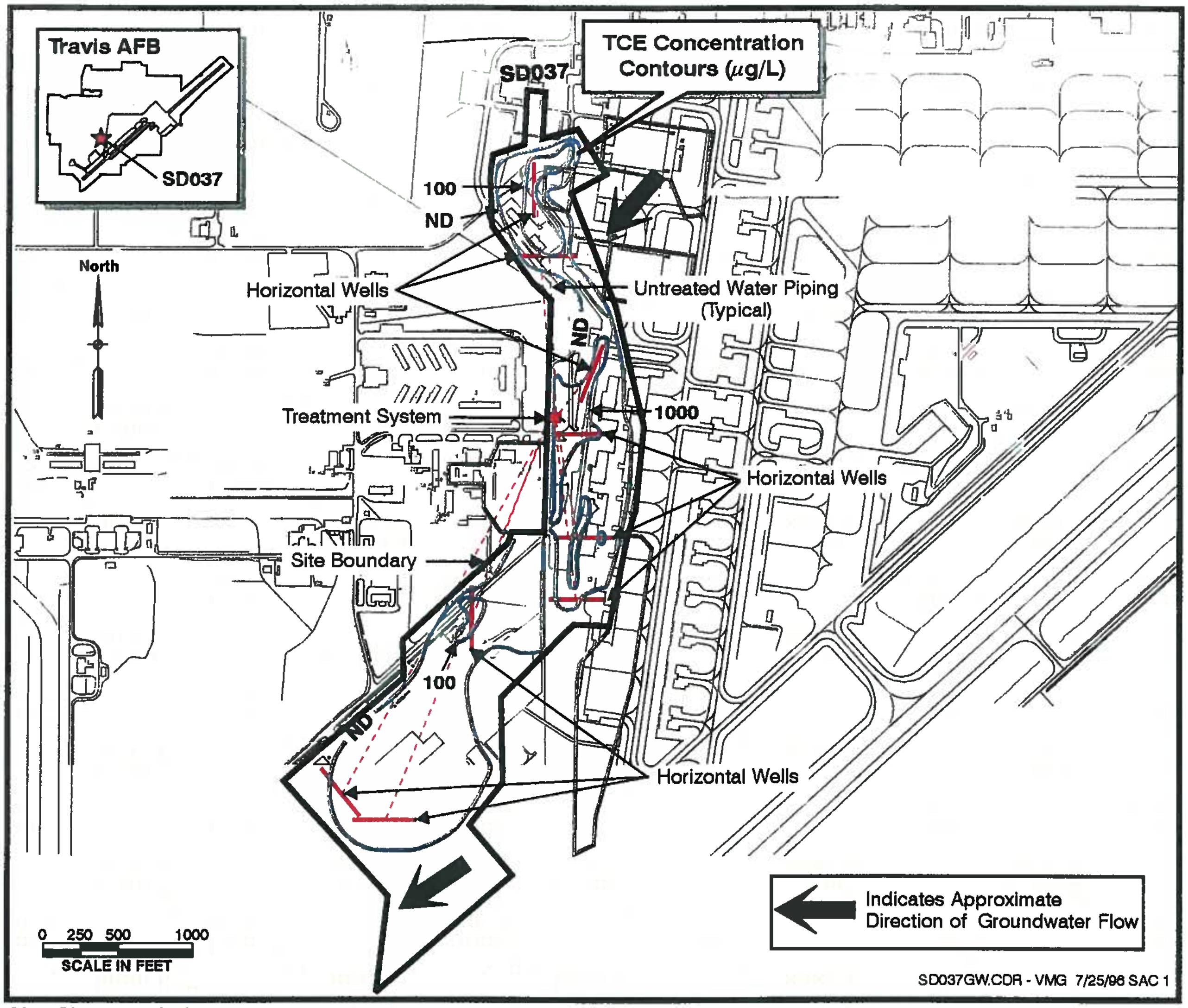
5.10.1 Description of Alternatives and Conceptual Design for Group I

The groundwater site included in Group I is SD037, which is located at the western edge of the tarmac. The contaminants driving selection of the treatment technology are TCE, DCE, TPH, copper, and silver. Alternatives 1, 2, 3, 5, and 7 are applicable to the group.

The conceptual design of the extraction and treatment system for SD037, shown in Figure 5-9, includes the targeted contaminant area, nine extraction wells, a treatment system, and the untreated water and discharge lines. The treatment system is located near the center of the site. Discharge of treated water is to the West Branch of Union Creek.

5.10.2 Evaluation of Alternatives for Group I

The results of the evaluation of alternatives for Group I are given in Table 5-19.



Site Characteristics

- The sanitary sewer system includes approximately 22,000 feet of piping, as well as associated oil water separators, sumps, and wash racks
- TCE in groundwater — 1,220 µg/L average, 6,990 µg/L maximum, DNAPL may be present
- TPH in groundwater — 100 µg/L average
- Estimated mass of dissolved VOCs equals 390 lb
- Copper and silver were measured at concentrations greater than NPDES levels in some monitoring wells
- Depth to groundwater — 10 feet
- Depth to bedrock — 30 feet
- Subsurface geology beneath the sanitary sewer system varies
- In general, low permeability alluvium underlies the area with discontinuous permeable layers
- Weathered sandstone and shale interbed to form bedrock layer beneath the alluvium
- Site also included in Group P for soil contamination

Treatment Alternatives

- Alternative #3: Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon
- Alternative #5: UV Oxidation, Ion Exchange, Activated Carbon
- Alternative #7: Ion Exchange, Activated Carbon

Design Assumptions

- 9 horizontal wells, 300 feet in screened length
- Extraction rate 135 gpm total, 15 gpm from each well
- 7,050 feet of untreated water piping (from well to treatment system) — 1 inch ID, sch 80 PVC
- 50 feet of discharge piping (to west branch of Union Creek) — 3 inch ID, sch 80 PVC
- 100 feet from treatment system to existing power line
- 111 years to clean groundwater to MCLs, calculated using a contaminant transport model based on assumptions shown in Appendix C

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 5-9. Conceptual Design for SD037 (Group I) Groundwater Treatment Alternatives, Travis AFB

Media: Groundwater
Group: I
Sites: SD037

Table 5-19

CERCLA Criteria Evaluation for Group I

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #1	0	0	0	0	0	5	5 ($0)	10	0
Alternative #2	3	0	3	0	0	5	5 ($1.5M)	16	4.0
Alternative #3	5	5	5	5	5	3	1 ($6.7M)	29	3.7
Alternative #5	5	5	5	5	5	3	1 ($7.8M)	29	3.2
Alternative #7	5	5	5	5	5	3	-1 ($30.0M)	27	0.83

Alternative #1: No Action
Alternative #2: Institutional Actions: Access Restrictions, Monitoring, Natural Attenuation
Alternative #3: Horizontal Well Extraction, Air Stripper/Catalytic Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #5: Horizontal Well Extraction, UV Oxidation, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain
Alternative #7: Horizontal Well Extraction, Ion Exchange, Activated Carbon, Discharge to Irrigation and/or Storm Drain

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Table 5-20

Cost Summary for Group I Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#1	$0	$0	$0
#2	$19,000	$1,400,000	$1,500,000
#3	$2,600,000	$4,100,000	$6,700,000
#5	$2,700,000	$5,100,000	$7,800,000
#7	$3,200,000	$26,000,000	$30,000,000

Based on the present worth costs shown in Table 5-20, Alternatives 3 and 5 were rated 1, and Alternative 7 was rated -1 for cost. The highest capital and O&M costs are associated with Alternative 7 and are $3,200,000 and $26,000,000, respectively.

5.10.3 Comparative Analysis of Group I Alternatives

The alternatives are compared by assessing the total score and the benefit/cost ratio as shown in Table 5-19. Alternatives 3 and 5 evaluate similarly, and Alternative 7 is the most expensive. Alternative 3 has the highest benefit/cost ratio of 3.7.

Alternatives 3 and 5 have total scores of 29 and Alternative 7 has a total score of 27. The benefit/cost ratios for Alternatives 3, 5, and 7 are 3.7, 3.2, and 0.83, respectively. Alternative 3 has the highest benefit/cost ratio because it has the lowest present worth cost. Alternative 7 is the most expensive due to higher O&M costs stemming from carbon replacement.

6.0 DETAILED ANALYSIS OF SURFACE WATER SITES

The six alternatives identified in Section 3.0 that are applicable to sites with surface water contamination are:

- Alternative #10: No Action;
- Alternative #11: Institutional Actions;
- Alternative #12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek;
- Alternative #13: Collection Sump, Activated Carbon, Discharge to Union Creek;
- Alternative #14: Slip-lining and Collaring Storm Sewer System; and
- Alternative #15: Source Control

The two sites with surface water contamination, SD001 and SD033, are combined into Group J because application of the treatment technologies are similar. The treatment technologies can be applied to control the contamination upstream in the source areas as discussed in Sections 5.0 and 7.0 or the specific alternative denoted may be used at outfall locations downstream of all the sources contributing to the surface water contamination. The conceptual design and the evaluation of the technologies according to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) criteria are presented below.

6.1 Detailed Analysis of Group J Alternatives

The representative site for discussion of the alternatives and the conceptual design is SD033 which includes the Storm Sewer System within the West Industrial Operable Unit (WIOU) and the West Branch of Union Creek. Identified contaminants of concern

(COCs) detected in the surface water are total petroleum hydrocarbon (TPH), trichloroethene (TCE), pesticides, and metals. To evaluate the institutional actions alternative against the CERCLA criteria, no control or only limited control of the sources was assumed, distinguishing this alternative from Alternative 15, Source Control.

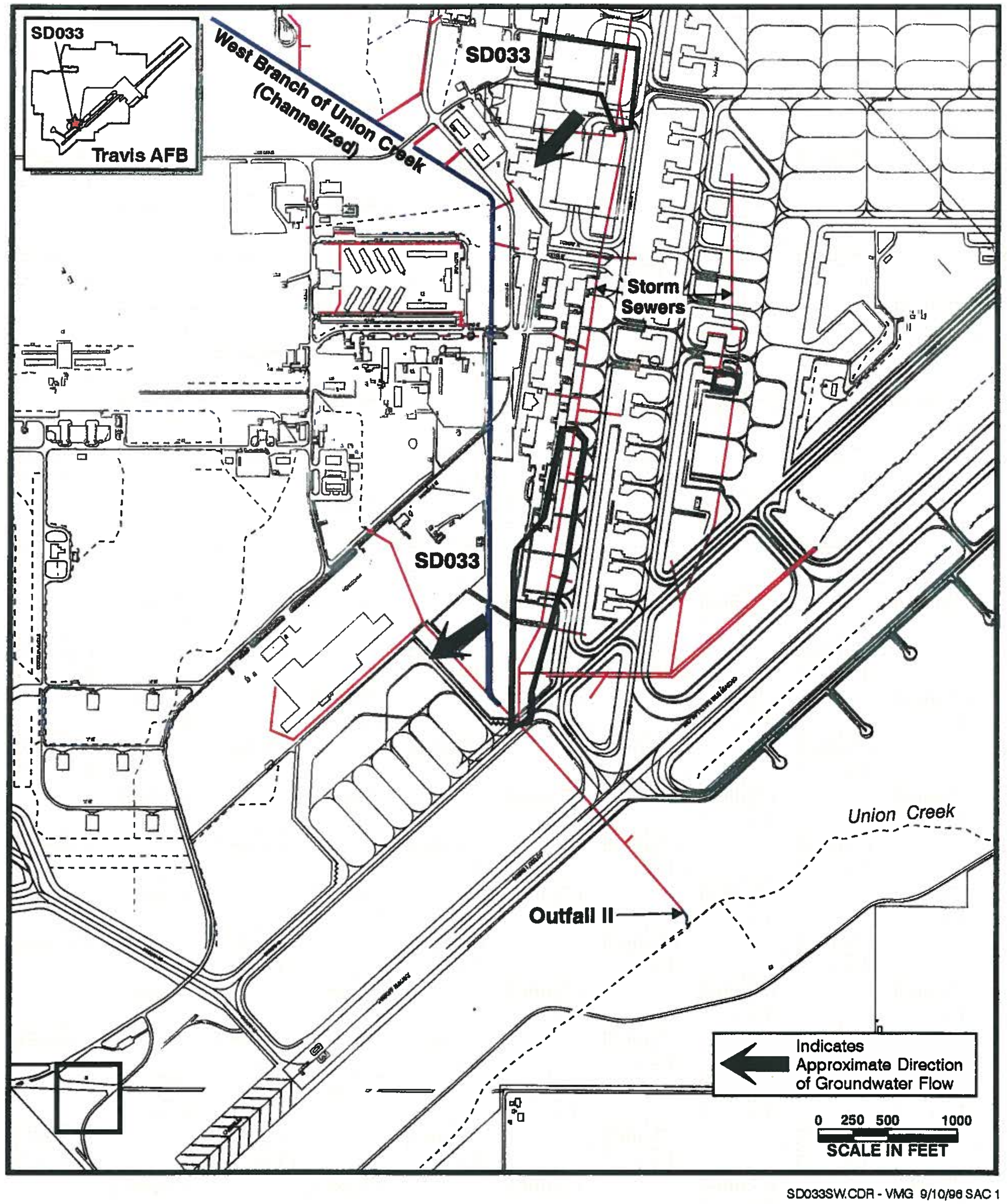
6.1.1 Description of Alternatives and Conceptual Design

The conceptual design of the Alternatives 12 and 13 for SD033 includes a collection sump and treatment at the Outfall II. Discharge of the treated water would be to Union Creek. Alternative 14 involves slip-lining and/or collaring portions of the storm sewer within the WIOU to prevent infiltration of contaminated groundwater into the storm sewer and subsequently into the West Branch of Union Creek and Union Creek. This alternative also includes maintenance activities such as periodic cleaning of sediments from the storm sewer and associated sumps, to minimize contaminant transport in the storm sewers. Alternative 15 does not involve any active remediation of surface water, but is rather designed to reflect the potential benefits to surface water from the active remediation of upgradient soil and groundwater sources.

The site map of SD033 is shown in Figure 6-1 and includes the location of the West Branch of Union Creek, the storm sewer, and Outfall II. The figure also includes a summary of the design assumptions used to size the collection and treatment systems and the portions of the storm sewer requiring slip-lining.

6.1.2 Evaluation of Group J Alternatives Against the CERCLA Criteria

The criteria of effectiveness, implementability, and cost were used to evaluate the six alternatives applicable to surface water sites. Table 6-1 shows the seven CERCLA criteria and ratings for each alternative. (For Alternative 15, source control, ratings were given assuming that the upstream groundwater and soil sites are the only sources of surface



Site Characteristics

- Storm sewer system/Facility 810 active
- Contamination in sediment, soil gas, subsurface soil, surface soil, groundwater and surface water
- Surface water contaminated with TPH, TCE and lead (ecological risk)
- Flow in Union Creek is derived from surface runoff, and at times from groundwater
- Subsurface geology beneath storm sewer system varies
- Depth to groundwater — 13 to 18 feet
- Depth to bedrock — varies
- Site also included in Group R for sediment contamination, Group P for soil contamination, and Group B for groundwater contamination

Treatment Alternatives

- Alternative #12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek
- Alternative #13: Collection Sump, Activated Carbon, Discharge to Union Creek
- Alternative #14: Slip-lining and Collaring Storm Sewers

Design Assumptions

- Maximum flow rate of 1,500 gpm at Outfall II
- Length of storm sewer system in WIOU to be slip-lined — 6,150 feet (includes storm sewer system within SD034 and SD037)
- Collection sump and treatment site located at Outfall II

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 6-1.
Conceptual Design for SD033 (Group J) Surface Water Treatment Alternatives, Travis AFB

Media: Surface Water
Group: J
Sites: SD033 (representative site), SD001

Table 6-1

CERCLA Criteria Evaluation

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #10	0	0	0	0	0	5	5 ($0)	10	0
Alternative #11	3	0	3	0	0	5	3 ($2.6M)	14	2.3
Alternative #12	5	5	3	3	5	3	-1 ($14M)	23	1.5
Alternative #13	3	3	3	3	3	3	1 ($9.1M)	19	1.6
Alternative #14	3	3	3	0	3	3	5 ($0.39M)	20	31
Alternative #15	3	3	3	3	3	5	5 ($0)	25	NA

Alternative #10: No Action
Alternative #11: Institutional Actions: Access Restrictions, Monitoring, Natural Attentuation
Alternative #12: Collection Sump, Ion Exchange, Activated Carbon, Discharge to Union Creek
Alternative #13: Collection Sump, Activated Carbon, Discharge to Union Creek
Alternative #14: Slip-lining and Collaring Storm Sewer
Alternative #15: Source Control

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effective scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

water contaminants; thus, implementation of the selected alternative for each site will mitigate contamination of the surface water.)

Overall Protection of Human Health and the Environment

The no action alternative does not afford protection to human health or the environment, thus Alternative 10 was rated 0. Alternatives 11, 13, 14, and 15 were rated 3 because some protection through institutional actions or treatment of some contaminants (organic, not metals) would result from implementation of these alternatives. Alternative 14 would prevent some contaminated groundwater from infiltrating into the storm sewer where it is lined but may not protect the West Branch of Union Creek and areas downgradient from the sewers, and thus would only partially protect human health and the environment.

Alternative 12 would treat the inorganic and organic contaminants of concern, protecting both human health and the environment, and so was rated 5.

Compliance with ARARS

Alternatives 10 and 11 were rated 0 because surface water contamination would not be treated and therefore surface water quality standards would not be met. Alternative 13 was rated 3 in meeting the limits of the National Pollutant Discharge Elimination System (NPDES) permit because only some of the surface water COCs would be treated (metals would not) under this option. Slip-lining and collaring would minimize the discharge of groundwater to the storm sewer, especially along the West Branch of Union Creek. However, downstream deposition of contaminants around the storm sewers could still result in non-compliance with ARARs; thus, this alternative was rated 3 because surface water quality standards may only be partially met. Alternative 12 would result in treatment of the COCs associated with the West Branch of Union Creek so that the surface water quality standards would be met. Alternative 15 was rated 3 because source control would not necessarily result in surface water quality improving to meet surface water ARARs.

Monitoring would be required to verify the success of source control in meeting ARARs due to the variables associated with source control, such as hydraulic gradients and contaminant transfer rates. The rate of achieving ARARs through source control may also be slow due to the extensive time periods estimated to achieved groundwater cleanup objectives.

Long-term Effectiveness and Permanence

Alternative 10 was rated 0 because no action would not provide for any contaminant control and long-term remedial action objectives (RAOs) are not likely to be achieved. Alternatives 11, 12, 13, 14, and 15 were rated 3 because the actual contaminant source would not be addressed, therefore monitoring or treatment would always be needed. Implementation of Alternative 15 would control the sources of contamination; therefore, once the source-control measures were completed, surface water quality should meet long-term RAOs; however, this alternative would not actively remediate surface water that is currently contaminated.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Alternatives 10 and 11 were rated 0 because no reduction of toxicity, mobility, or volume would occur under these alternatives of no action or institutional actions. Alternative 14 was also rated 0 because no treatment would be involved. Alternatives 12 and 13 were rated 3 because these alternatives would not treat the source of the contamination but treat the resulting degraded surface water. Alternative 15 would reduce the upstream source of the surface water contamination (reducing the volume) but not the current level of contaminated surface water and thus was rated 3.

Short-term Effectiveness

Alternatives 10 and 11 were rated 0 because implementation of these alternatives would not provide short-term environmental improvement. Alternative 14 was rated 3 because contamination would not be actively remediated although surface water quality should improve. Slip-lining and collaring would minimize the discharge of contaminated groundwater into the creek, but would not effect the downstream disposition of contaminants. Alternative 13 was also rated 3 because only organic contaminants would be treated. Alternative 15 was given a rating of 3 because some short-term benefit would be derived by pumping and treating upgradient contaminated groundwater, reducing the discharge of contaminated groundwater to the creek. However, source control will not actively remediate contamination in the creek and pumping actions will not eliminate all groundwater discharge to the creek. Alternative 12 was given a rating of 5 because implementation would immediately promote protection of human health and the environment. The activities associated with the implementation of this alternative should not pose a significant risk to human health or the environment.

Implementability

The no action, institutional actions, and source control alternatives were rated 5 for implementability because these alternatives would include no or limited additional activities, and Base operations would not be impacted. The other three alternatives were rated 3 because the treatment technology is well understood and the materials would be readily available. Permitting or administrative restrictions should be minimal. However, a full score of 5 was not given because there would be some impact on the Base operations, and effort would be required to maintain optimal system performance.

Cost

The estimated present worth costs for each alternative, except for Alternative 15, are broken out by capital, and operation and maintenance costs in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.3 provides more detail on the procedures and assumptions used to estimate costs, and Appendix B presents the cost summary worksheets including the itemized capital, and operation and maintenance costs for each alternative. For Alternatives 11, 12, and 13, the largest costs are associated with operation and maintenance (see Table 6-2). Only capital costs are seen for Alternative 14 because slip-lining and collars are considered a one-time capital expense. Maintenance costs associated with Alternative 14 (i.e., cleaning sediments from sumps) are not costed as the effort should be minimal and part of normal maintenance activities.

The no action alternative was rated 5 because the alternative has no associated costs. The source control alternative also has no associated costs because those costs are considered in the specific upstream site evaluation. Alternative 14 was also rated as 5 because the implementation costs are less than $1.5M ($0.4M). Alternative 11 was rated as 3 because the costs are between $1.5M and $5.0M. Alternatives 12 and 13 were rated -1 and 1, respectively, because costs exceed $5.0M. The cost of Alternatives 11, 12, and 13 are $2.6M, $14M and $9.1M, respectively.

6.1.3 Comparative Analysis of Group J Alternatives

The comparative analysis of the alternatives for surface water includes evaluating the total score for the CERCLA criteria and the benefit/cost ratio (Table 6-1). Alternatives 12, 13, 14, and 15 are scored between 19 and 25, with Alternative 15 scoring the highest (25). However, the success of Alternative 15 is based on the assumptions that the selected groundwater and soil site remedial alternatives would be effective in preventing migration of contaminated groundwater to Union Creek, and that the groundwater and soil

Table 6-2

Cost Summary for Group J Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#10	$0	$0	$0
#11	$0	$2,600,000	$2,600,000
#12	$2,300,000	$12,000,000	$14,000,000
#13	$920,000	$8,100,000	$9,100,000
#14	$390,000	$0	$390,000
#15*	$0	$0	$0

* Source control costs are considered as part of the groundwater alternatives.

sites are the only sources of surface water contamination. The no action and institutional action alternatives have the lowest total score, primarily because they would provide little or no remediation of the surface water contamination. The active treatment alternatives (Alternatives 12, 13, and 15) scored at least 21. Alternative 14 does not involve treatment of the contaminants but relies on preventing contamination of the surface water by slip-lining and collaring the storm sewer lines.

The highest benefit/cost ratio (31) is for slip-lining and/or collaring the storm sewer. This ratio is significantly higher than the others since slip-lining and/or collaring provide benefits nearly as great as the treatment alternatives, at much less cost. No benefit/cost ratio was calculated for Alternative 15, source control, because the costs are considered for the specific upstream groundwater and soil sites. The other cost/benefit ratios range from 1.5 (Alternative 12) to 2.3 (Alternative 11).

7.0 DETAILED ANALYSIS OF SOIL SITES

The seven alternatives identified in Section 3.0 that are applicable to the sites with soil contamination are:

- Alternative #16 — No Action
- Alternative #17 — Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
- Alternative #18 — Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19 — Soil and Bentonite Cap
- Alternative #20 — Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
- Alternative #21 — In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
- Alternative #22 — In-Situ Bioventing

The applicable alternatives and sites with soil contamination are presented in Table 7-1.

In the following sections, Sections 7.1 through 7.8, the alternatives applicable to groups with soil contamination (i.e., Groups K through R) are analyzed according to the applicable Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria. For each group, a figure is presented which displays the representative site and key site characteristics that help the reader understand the applicability of the remedial alternatives. The treatment alternatives and design assumptions are also displayed on the figure. Additional text describes the conceptual design. Figures for non-representative sites are located in Appendix B.

Table 7-1

Potential Remediation Alternatives for Soil by Group[1]

Group	Alternative #16	Alternative #17	Alternative #18	Alternative #19	Alternative #20	Alternative #21	Alternative #22
K	X	X	X	X	X	a	b
L	X	X	X	X	X	a	b
M	X	X	X	X	X	a	b
N	X	X	X	X	X	a	b
O	X	X	X	X	X	X	X
P	X	X	X	X	X	X	X
Q	X	X	X	X	X	X	X
R	X	X	X	c	X	a	b

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
Alternative #22: In-Situ Bioventing

[1] The applicable alternatives for each soil site group are indicated with an "X" in the boxes. The other boxes, which have an "a", "b", or "c" indicated, are not applicable alternatives for the reasons indicated below:

a = Not applicable since VOCs exceeding IRGs are not present in the soil gas.
b = Not applicable since bioventing is best applied at sites where TPH is the primary COC.
c = Not applicable since capping of Union Creek is not a viable alternative.

The figures show the depth and volume of soil contamination at each representative site, as discovered during remedial investigations (RIs). Contaminated soil was divided into two types: soils posing a risk to human health (and potentially also to ecological receptors) and soils posing a risk to ecological receptors only. For purposes of costing, soil exceeding interim remediation goals were included in human health risk category soil. The volume of contaminated soil posing a risk to human health was calculated using the areal and vertical extent of contamination. The maximum depth of soil contaminants was assumed to be the water table depth. The volume of contaminated soil posing a risk to ecological receptors was determined by the same method, except that 3 feet was the assumed maximum depth of contamination. The East Industrial Operable Unit RI Report (Weston, 1995) calculated ecological soil risk to receptors up to 3 feet deep. In the case of surface soil, 0.25 feet to 0.5 feet deep, the analysis assumed the actual excavation depth would be 1 foot. The capping alternative assumed all contaminated soil would be covered. For Alternatives 18 and 20, soil was classified as either acceptable for Class I or Class II landfill disposal, depending on the analyte maximum concentrations detected in the soil at the site. For purposes of this analysis, it was assumed that ex-situ high temperature thermal treatment would destroy organic contaminants. Bioventing has been identified as a viable treatment option for soils which contain total petroleum hydrocarbons (TPH) at a depth greater than 5 feet. SVE has been selected for implementation at sites with either soil gas contamination or soil which contains VOC contamination.

While Alternative 18, excavation, conservatively costed off-site disposal, and Alternative 19, capping, conservatively costed the use of clean soils, it should be noted that these alternatives could be combined by using excavated contaminated soils from certain IRP sites as a foundation material in a cap at another IRP site. For example, soils with low levels of TPH from a site could be used as foundation material in the preparation of a cap at a site such as Site LF007. Implementation of such an option would require a demonstration of environmental protectiveness and must meet the requirements of California Code of Regulations, Title 23, Chapter 15.

The conceptual designs and the estimated costs to implement the designs are for cost comparison only; actual sizing and location of the components of the remedial alternatives will be determined in the remedial design phase.

A table follows each figure, displaying scores related to the CERCLA criteria evaluation of each applicable alternative. This table employs the scoring system presented in Section 4.0. Two quantitative measures are used to evaluate each alternative. The total score is the sum of the five effectiveness scores. The benefit/cost ratio is the sum of the five effectiveness scores (first five criteria) divided by the estimated cost, in millions of dollars. The table evaluates each alternative assuming it is only addressing soil posing risks to human health. Soils in these areas may also pose a risk to ecological receptors and protectiveness of the environment is assessed in the evaluation. The sensitivity analysis, Section 8.0, addresses the cost of increasing the cleanup requirements to also address soils only posing ecological risk. (Group R evaluates alternatives that pose a risk to only ecological receptors because there are no sediment sites that pose a risk to human health.)

Text is then presented, organized by each criterion, that describes the rationale for the scoring of each alternative. Finally, a comparative analysis is provided, which summarizes the two quantitative analysis scores and provides conclusions as to how the alternatives compare to each other, based on the CERCLA criteria evaluation.

7.1 Detailed Analysis of Group K Alternatives

The soils sites of Group K include the four fire training sites: FT002, FT003, FT004, and FT005. These sites are grouped together because of the similar soil contaminants (e.g., polycyclic aromatic hydrocarbons [PAHs], polychlorinated biphenyls [PCBs], pesticides, and dioxins/furans), which may have resulted from the use of the areas for fire training exercises. In the discussion below, FT003 serves as the representative site for describing alternatives and conceptual designs. Alternatives 16, 17, 18, 19, and 20 are the applicable alternatives to this group.

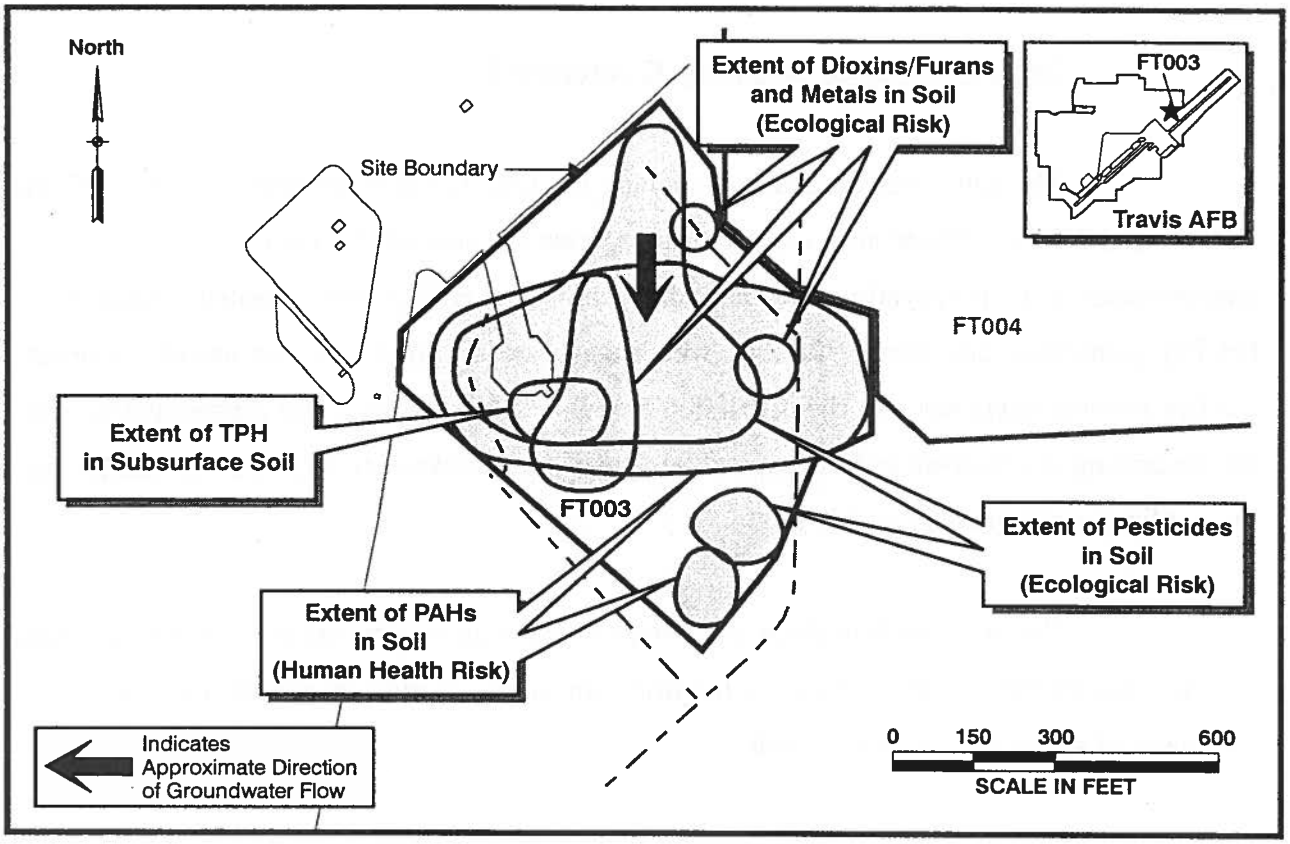
Because landfills place strict requirements upon disposal of soils which contain dioxins, Alternative 18, excavation, is modified for Group K sites to include thermal treatment of dioxin-contaminated soils.

For Sites FT002, FT003, FT004, and FT005, for cost estimated purposes, it is estimated that dioxin-contaminated soil volumes of 0, 3,200, 1,500, and 1,950 cubic yards, respectively, will require thermal destruction as an element of the Alternative 18. The final disposition of soils between landfilling and thermal treatment would depend on confirmation sampling for dioxins during excavation.

Two of these sites, FT004 and FT005, also contain groundwater contamination. Alternatives for addressing groundwater contamination at FT004 and FT005 are evaluated in Sections 5.1 (Group A) and 5.3 (Group C), respectively.

7.1.1 Description of Alternatives and Conceptual Design

Figure 7-1 summarizes the site characteristics, design assumptions, and applicable alternatives. The targeted contaminated area (including soils posing risks to both humans and ecological receptors) is currently covered by grass. Alternative 17 would restrict access by placing fences around soils that pose a risk to human health.



FT003S.CDR - VMG 8/9/96 SAC 1

Site Characteristics

- 10% paved area with 90% open field
- Paved access road
- Depth to groundwater — 5 to 15 feet
- Depth to bedrock — 30 to 40 feet
- Silt and clay to 10 feet bgs
- Silty sand with minor gravel from 10 to 40 feet bgs

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

Design Assumptions

- 230,000 ft^2 — area that contains contaminated soil (human health risk)
- 52,000 ft^2 — area that contains contaminated soil (ecological risk)
- Soils contaminated with PAH to a depth of 1 foot (human health risk)
- Soils contaminated with TPH to a depth of 5 feet (exceeds LUFT manual)
- Soils contaminated with PAH to a depth of 6 feet in central portion of site — 11,000 ft^2 (human health risk)
- Soils contaminated with dioxins/furans, pesticides, and metals to a depth of 1 foot (ecological risk)
- 13,600 cubic yards of soil within limits for Class II landfill (exceeds LUFT manual)
- 2,100 cubic yards of soil within limits for Class II landfill (ecological risk)
- 2,000 cubic yards of soil estimated to require thermal destruction, due to dioxins, as an element of Alternative 18

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-1.
Conceptual Design for FT003 (Group K) Soil Treatment Alternatives, Travis AFB

Administrative controls would be placed on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils that pose risks to human health; Alternative 20 involves treatment prior to disposal. The assumed excavation depth for the areas with human health risk and ecological risk is one foot (surface soil).

Both FT004 and FT005 have single vernal pools contained within the site. Adverse impacts to these pools will have to be considered in the remedial designs if Alternatives 18, 19, or 20 are selected. Because of the relatively small size of the pools, the scope and cost of the alternatives is unlikely to be significantly affected by the effort to mitigate the damage to these vernal pools.

7.1.2 Evaluation of Group K Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-2 shows how well each of the alternatives applicable to Group K complied with each of the seven CERCLA criteria that are applicable at this stage of the CERCLA process.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because no protection of either human health or the environment would be provided with no action. Alternative 17 was rated 3 because some limited protection would be provided. Access restrictions, such as fences or restrictions on excavation work, would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18 and 20 were rated 5 because these options should successfully achieve cleanup levels that would provide adequate protection of human health and the

Media: Soil
Group: K
Sites: FT003 (representative site), FT002, FT004, FT005

Table 7-2

CERCLA Criteria Evaluation for Group K[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	3	5 ($0.11M)	17	82
Alternative #18	5	5	3	0	3	3	3 ($2.7M)	22	5.9
Alternative #19	3	3	3	0	5	3	3 ($1.9M)	20	7.4
Alternative #20	5	5	5	5	3	5	-1 ($38M)	27	0.61

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

environment. Alternative 19, capping the soil in place, was rated 3 because soil contamination would not be eliminated. Protectiveness would also depend on the cap's integrity, which could decrease over time.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action. Under institutional actions, only ARARs related to human exposure would be met. In both cases, achieving the interim remediation goals (IRGs) and treatment of soil to reduce risk would be unlikely. Alternatives 18 and 20 were rated 5 because implementation of either option would achieve compliance with chemical-, location-, and action-specific ARARs. The excavation alternatives would meet the IRGs of eliminating soil contamination at the site. Action- and location-specific ARARs can be met for these alternatives during soil excavation and disposal. Alternative 19 was rated 3 because the cap could be designed to meet applicable standards and could be put in place to meet action- and location-specific ARARs. However, capping the soil would not achieve the chemical-specific IRGs for the site.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term remedial action objectives (RAOs) would not be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants cannot be ensured. Some long-term effectiveness is achieved by removing the contaminants from Travis AFB, where people and ecological receptors could be exposed. However, a future re-release of these contaminants from the landfill is possible.

Alternative 19 was rated 3 because the long-term integrity of the cap could not be guaranteed and future exposures would be possible without some treatment to remove contaminants from the soil. Alternative 20, the only alternative to be rated 5, would treat the organic contaminants, meet IRGs, and eliminate future exposures to human and ecological receptors.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 were all rated 0 because none of them would employ active treatment processes. It is assumed that with Alternative 18, thermal treatment for dioxin-containing soils would be very localized; thus, the rating of 0 is reasonable. Alternative 20 would treat the organic contaminants, thereby reducing the volume and toxicity of contaminated soil. It was rated 5.

Short-term Effectiveness

Alternative 16 was rated 0 because it would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although ecological receptors would continue to be exposed and cleanup goals would not be achieved.

Alternatives 18 and 20 would be effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternative 19 was rated 5 because capping the contaminated soil would effectively address contamination in the short term. It could be implemented without additional releases of contaminants.

Implementability

Alternative 16 would be easily implementable and was rated 5. Alternative 17 would also be implementable, but was rated 3 because of the potential adverse impact on potential future construction activities that deed and excavation restrictions would have. Alternative 19 was also rated 3 because a large cap could adversely limit future use of the site.

Alternative 18 was rated 3 for implementability because of the potential impacts from dioxin-containing soils. Landfills place stringent restrictions on the disposal of dioxin-containing soils. The ultimate suitability of this alternative will be determined during final sample profiling at the sites.

Alternatives 19 and 20 would be implementable and were rated 5. The technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and operation and maintenance (O&M) costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model (U.S. Air Force, 1993). Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-2 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group K Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$40,000	$73,000	$110,000
#18	$2,700,000	$0	$2,700,000
#19	$1,900,000	$54,000	$1,900,000
#20	$38,000,000	$0	$38,000,000

The alternatives were rated from -1 to 5 for this criterion, depending on the complexity of the alternative. Alternative 16 would not have any cost and Alternative 17 would cost $0.11 million. Alternatives 18, 19, and 20 would cost $2.7 million, $1.9 million, and $38 million, respectively.

7.1.3 Comparative Analysis of Group K Alternatives

Alternatives 16 and 17 have the lowest total scores (10 and 17, respectively) because they would provide little or no remediation of contaminated soil and would not protect ecological receptors from exposure. Alternatives 18 and 19 scored higher (22 and 20 points, respectively) than no action and institutional actions because they would reduce short-term exposure and would provide at least some compliance with ARARs. However, they would not eliminate contaminants through treatment. Alternative 20 had the highest total score (27 points) because it would both eliminate exposures and treat the contamination.

The benefit/cost ratios were greatest for those alternatives that would reduce exposure at little cost. The lowest benefit/cost ratio was associated with the no action alternative because the alternative would not be effective. Alternative 20 had the second lowest benefit/cost ratio because although it would provide substantial protection, it would be very expensive to implement. Alternatives 18 and 19 had total higher benefit/cost ratios (5.9 and 7.4, respectively) because they would address contamination and potential exposures with a lower associated cost. Alternative 17 had the highest benefit/cost ratio of 82 largely because it would reduce human exposure for less than a tenth of the cost of other alternatives (other than no action).

Alternatives 18, 19, and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

7.2 Detailed Analysis of Group L Alternatives

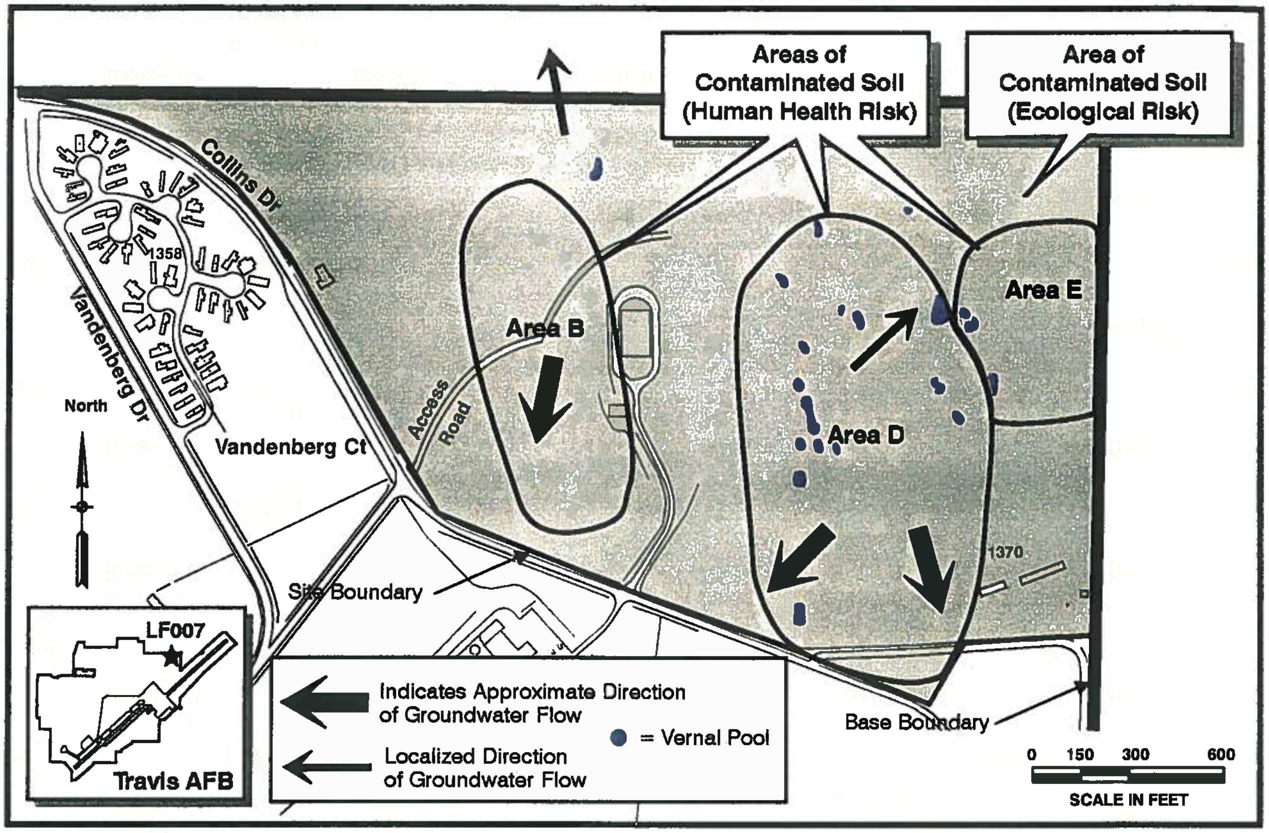
Group L comprises sites within a landfill (LF007) along the northern border of Travis AFB. Portions of LF007 (LF007B, LF007D, and LF007E) contain surface soil contamination (PAHs, PCBs, and arsenic) that pose a risk to human health. The rest of the site contains soil with organic and inorganic soil contamination that poses a risk to ecological receptors. Alternatives 16, 17, 18, 19, and 20 are the applicable alternatives to this group. No representative site was selected since the entire landfill is analyzed as one site.

LF007 also contains groundwater contamination. Alternatives for addressing groundwater contamination at LF007 are evaluated in Section 5.1 (Group A).

7.2.1 Description of Alternatives and Conceptual Design

Figure 7-2 summarizes the site characteristics, design assumptions, and applicable alternatives. The targeted contaminated area (including soils posing a risk to human health and soils posing a risk to ecological receptors) is not paved, with flat terrain in its western half and shallow disposal trenches in its eastern half. Alternative 17 would restrict access by using fences in areas which pose a risk to human health. Administrative controls would be placed on the long-term use of those areas as well as excavation and subsurface projects where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of the soils that pose risks to human health. The assumed excavation depth for the areas with either human health risk or ecological risk is one foot (surface soil). Alternative 19 would require that the site be regraded and covered with a soil and bentonite cap.

Vernal pools exist in the eastern portion of the site. Adverse impacts to these vernal pools caused by the selected remedial action will have to be mitigated, resulting in additional costs. Alternatives 18, 19, and 20 could adversely affect vernal pools during excavation, regrading, or capping. These potential impacts will be addressed in the remedial



LF007S.CDR - VMG 9/11/96 SAC 1

Site Characteristics

- Landfill — largely open field
- Depth to groundwater — 1 to 25 feet
- Depth to bedrock — 0 to 50 feet
- Variable soil between surface and bedrock, mostly composed of clays and silts
- Site also included in Group A for groundwater contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

Design Assumptions

- 1,800,000 ft^2 — area that contains contaminated soil (human health risk) (Areas B, D & E)
- PCBs, PAHs, and arsenic contaminated soil to a depth of 1 foot (human health risk)
- 1,300,000 ft^2 — area that contains contaminated soil (ecological risk)
- Metals and PCBs contaminated soil to a depth of 1 feet (ecological risk)
- 200 cubic yards of soil within limits for Class I landfill (human health risk soil)
- 2,400 cubic yards of soil within limits for Class I landfill (ecological risk soil)
- 65,000 cubic yards of soil within limits for Class II landfill (human health risk)
- 47,000 cubic yards of soil within limits for Class II landfill (ecological risk)

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-2.
Conceptual Design for LF007 (Group L) Soil Treatment Alternatives, Travis AFB

design phase. Because the vernal pools occupy a relatively small portion of the landfill, the effort to address their adverse impacts will represent a comparatively small part of the scope and cost of Alternatives 18, 19, or 20.

7.2.2 Evaluation of Group L Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-3 shows how well each of the alternatives applicable to Group L complied with each of the seven CERCLA criteria that can be evaluated at this stage in the CERCLA process.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because no protection to either human health or the environment would be provided with no action. Alternative 17 was rated 3 because some limited protection would be provided to human receptors. Access restrictions, such as fences or other restrictions on excavation work, would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18, 19, and 20 were also rated 3. Alternatives 18 and 20 would achieve cleanup levels in the short term that would adequately protect human health and the environment. However, landfills are, by nature, heterogeneous in content. These alternatives would not remediate subsurface soil contamination that may exist below the surface soil. Alternative 19, capping the soil in place, was rated 3 because soil contamination would not be eliminated. Protectiveness would depend on the cap's integrity, which could decrease over time.

In addition, Alternatives 18 through 20 would also involve grading and excavation which could be more difficult to perform than at other sites. Although the tasks

Media: Soil
Group: L
Sites: LF007

Table 7-3

CERCLA Criteria Evaluation for Group L[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.27M)	19	33
Alternative #18	3	3	3	0	3	3	-1 ($13M)	14	0.92
Alternative #19	3	3	3	0	3	3	-1 ($18M)	14	0.67
Alternative #20	3	3	3	5	3	3	-1 ($190M)	19	0.089

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal in Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal in Existing Off-site Landfill

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

could be accomplished, special precautions would need to be put in place to protect workers from containerized, high-concentrated material which could be present in the landfill surface soil.

Alternatives 18 through 20 could also adversely affect vernal pools in the eastern portion of the site.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action. Under institutional actions (Alternative 17), only ARARs related to human exposure would be met. In both cases, achieving the IRGs and treatment of soil to reduce risk would be unlikely.

Alternatives 18, 19, and 20 were rated 3. Alternatives 18 and 20 were rated 3 because implementation of either excavation alternative would achieve compliance with chemical-, location-, and action-specific ARARs for surface soil but would not address isolated contamination that may exist in subsurface soil. The excavation alternatives would meet the IRGs of eliminating surface soil contamination at the site. Action- and location-specific ARARs could be met for these alternatives during the soil excavation and disposal. Action-specific ARARs could be complied with in excavation and grading activities through the implementation of additional safety procedures tailored to excavation work in landfills. Alternative 19 was rated 3 because the cap could be designed to meet applicable standards and could be put in place to meet action- and location-specific ARARs. However, capping the soil would not achieve the chemical-specific IRGs for the site.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs would not be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternatives 18, 19, and 20 were also rated 3. Alternative 18 would remove the soil from the site where it currently poses risks, but the long-term fate of landfilled contaminants could not be ensured. A future re-release of these contaminants from the landfill would be possible. Alternative 19 would effectively prevent exposure to contaminants, but was not rated 5 because it would not eliminate the contamination below the cap. Alternative 20 is the only alternative which would actively treat organic contaminants, meeting IRGs and eliminating exposures of human and ecological receptors to soil contaminants. However, as discussed above, subsurface soil would not be addressed by this alternative. In the long term, erosion could expose the subsurface soil, creating the potential for future human and ecological exposures.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 would treat the organic contaminants, but not arsenic, thereby partially reducing the volume and toxicity of contaminated soil. It was rated 3.

Short-term Effectiveness

Alternative 16 was rated 0 because it would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although ecological receptors would continue to be exposed and cleanup goals would not be achieved.

Alternatives 18 through 20 would be effective because they would eliminate human and ecological exposure in the short term. However, the alternatives were rated 3 because of potential short-term exposure associated with soil excavation and transportation and difficulty of performing excavation and grading in a heterogeneous, contaminated landfill.

Implementability

All of the alternatives could be implemented. The technologies for all of these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location would be under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Alternatives 16 and 17 would not adversely affect Travis AFB's mission and were rated 5. Alternatives 18 through 20 would adversely affect operations of Travis AFB's Target Range, located in the southeast corner of the site. Use of the facility would have to suspended while work is performed in the eastern part of the site. These three alternatives were rated 3.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. The assumptions for Alternatives 18, 19, and 20 varied from cost assumptions at other sites. Additional costs were assumed to account for the added degree of difficulty of excavating and grading in a contaminated landfill. Table 7-3 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group L Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$110,000	$150,000	$270,000
#18	$13,000,000	$0	$13,000,000
#19	$18,000,000	$91,000	$18,000,000
#20	$190,000,000	$0	$190,000,000

Alternative 16, the no action alternative, was rated 5 because it would have no cost. Alternative 17 also was rated 5 because the only significant cost would be monitoring for 30 years and fencing.

Because of great size of the landfill and its associated contamination, any option that would require excavation or capping would be costly. Alternatives 18, 19, and 20 were all rated -1 with costs of $13 million, $18 million, and $190 million, respectively.

7.2.3 Comparative Analysis of Group L Alternatives

The highest total scores for alternatives were associated with alternatives which would provide treatment of contamination and would minimize exposure. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. Alternatives 18, 19, and 20 had higher total scores of 14, 14, and 19, respectively. These alternatives had similar total scores because they would reduce exposure and address contamination, but at a relatively large expense.

Alternative 17 had a total score of 19 because it would provide some protection at a relatively low cost.

The benefit/cost ratios are dominated by the cost of the alternatives. The lowest ratio (0) was associated with the no action alternative because the alternative would be ineffective. Alternatives 18, 19, and 20 had ratios of 0.92, 0.67, and 0.089. Alternative 17 had a ratio of 33, significantly greater than any other alternative. Alternative 17 would not be as effective as Alternatives 18, 19, and 20, but would cost approximately 1% of those alternatives.

Alternatives 18, 19, and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

7.3 Detailed Analysis of Group M Alternatives

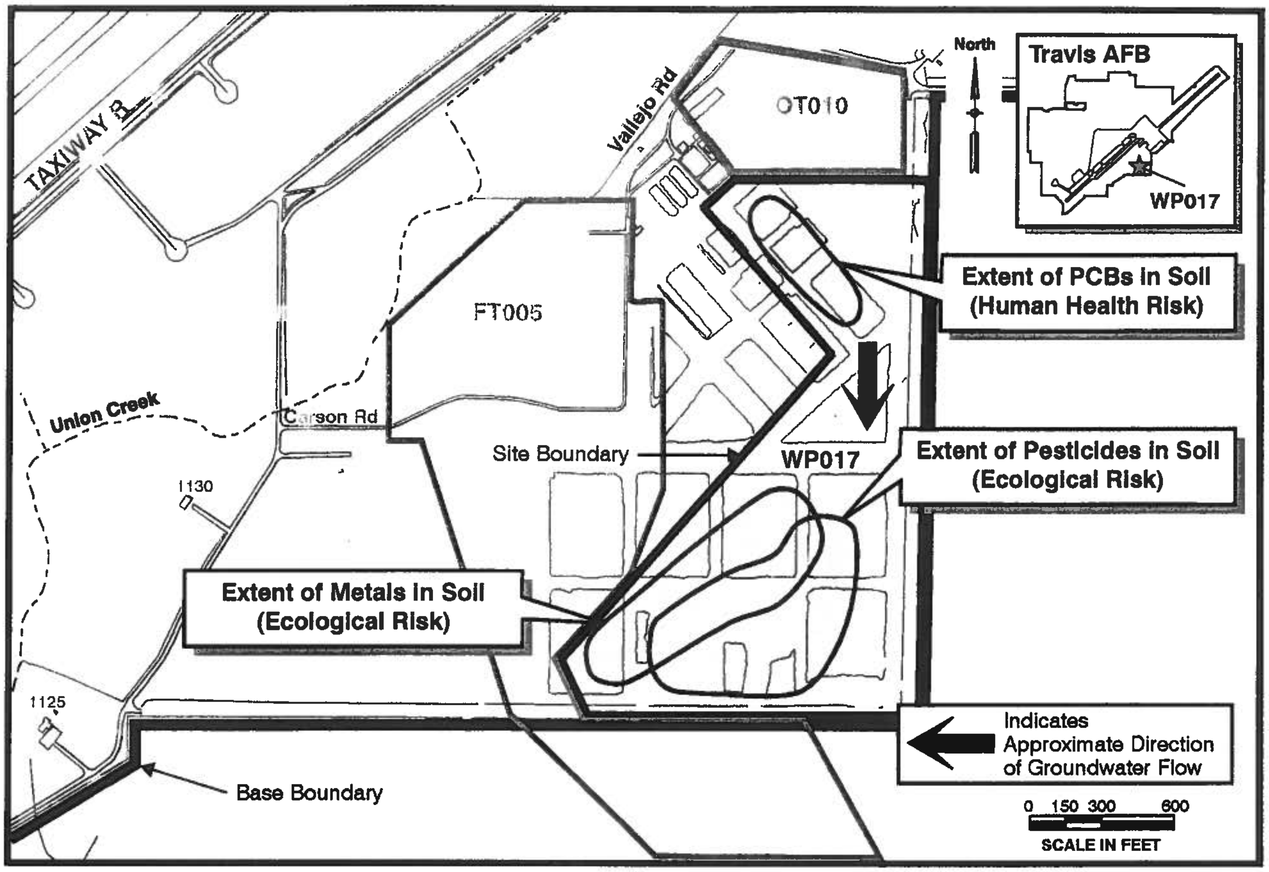
The soils sites of Group M include areas southeast of the runway. The four sites within this group are OT010, WP017, SS029, and SS030. Contaminants in these sites include pesticides, PAHs, PCBs, and high concentrations of metals. The PCBs and PAHs pose risks to human health while the pesticides and metals pose a risk to ecological receptors. In the discussion below, WP017 serves as the representative site for describing alternatives and conceptual designs. Alternatives 16, 17, 18, 19, and 20 are the applicable alternatives to this group.

7.3.1 Description of Alternatives and Conceptual Design

Figure 7-3 summarizes the site characteristics, design assumptions, and applicable alternatives. The targeted contaminated areas (including soils posing a risk to humans and soils posing a risk to ecological receptors) are mostly open fields, with none of the area paved. Alternative 17 would restrict access by placing fences around soils that pose a risk to human health. Administrative controls would be placed on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils that pose risks to human health. These soils have organic contaminants, but do not have inorganic contaminants. The assumed excavation depth for the areas with either human health risk or ecological risk is one foot (surface soil). Alternative 19 would place a soil and bentonite cap over the contaminated soil.

7.3.2 Evaluation of Group M Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-4 shows how well each of the alternatives applicable to Group M complied with each of the seven CERCLA criteria that are applicable at this stage of the CERCLA process.



WP017S.CDR - VMG 7/25/96 SAC 1

Site Characteristics

- Site is located in an inactive area of Travis AFB
- Depth to groundwater — 5 to 20 feet
- Depth to bedrock — 30 to 50 feet
- Permeable materials (sand and silt) occur through depths of 20 to 40 feet bgs
- Some low permeability soils (clay and silt) occur between 10 and 30 feet bgs

Treatment Alternatives

- Alternative #18: Backhoe, Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

Design Assumptions

- 210,000 ft^2 — area that contains contaminated soil (human health risk)
- PAH contaminated soil to an average depth of 1 foot (human health risk)
- 410,000 ft^2 — area that contains contaminated soil (ecological risk)
- Pesticides and metals contaminated soil to a depth of 1 foot (ecological risk)
- 1,100 cubic yards of soil within limits for Class I landfill (human health risk)
- 6,800 cubic yards of soil within limits for Class II landfill (human health risk)
- 15,000 cubic yards of soil within limits for Class II landfill (ecological risk)

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-3.
Conceptual Design for WP017 (Group M) Soil Treatment Alternatives, Travis AFB

Media: Soil
Group: M
Sites: WP017 (representative site), OT010, SS029, SS030

Table 7-4

CERCLA Criteria Evaluation for Group M[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.13M)	19	69
Alternative #18	5	5	3	0	3	5	1 ($7.4M)	22	2.2
Alternative #19	3	3	3	0	5	5	3 ($2.2M)	22	6.4
Alternative #20	5	5	5	5	3	5	-1 ($22M)	27	1.0

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because no protection to either human health or the environment would be provided by no action. Alternative 17 was rated 3 because some limited protection would be provided. Access restrictions, such as fences or other restrictions on excavation work, would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18 and 20 were rated 5 because these options should successfully achieve cleanup levels that would provide adequate protection of human health and the environment. Alternative 19, capping the soil in place, was rated 3 because soil contamination would not be eliminated. Protectiveness would depend on the cap's integrity, which may decrease over time.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action. Under institutional actions, only ARARs related to human exposure would be met. In both cases, achieving the IRGs and treatment of soil to reduce risk would be unlikely.

Alternatives 18 through 20 all were rated 3. Alternatives 18 and 20 were rated 5 because either alternative would achieve compliance with chemical-, location-, and action-specific ARARs. The excavation alternatives would meet the IRGs of eliminating soil contamination at the site. Action- and location-specific ARARs could be met for these alternatives during the soil excavation and disposal. Alternative 19 was rated 3 because the cap could be designed to meet applicable standards and could be put in place to meet action- and location-specific ARARs. However, capping the soil would not achieve the chemical-specific IRGs for the site.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs would not be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where people and ecological receptors could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 19 was rated 3 because the long-term integrity of the cap could not be guaranteed and future exposures would be possible without further measures. Alternative 20, the only alternative to be rated 5, would treat the organic contaminants, meeting IRGs and eliminating future exposures of human and ecological receptors to organic contaminants.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 would treat the organic contaminants (the contaminants posing risks to human health), thereby reducing the volume and toxicity of contaminated soil. It was rated 5.

Short-term Effectiveness

Alternative 16 was rated 0 because it would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although ecological receptors would continue to be exposed and cleanup goals would not be achieved.

Alternatives 18 and 20 would be effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternative 19 was rated 5 because capping the contaminated soil would effectively address contamination in the short term. It could be implemented without additional releases of contamination.

Implementability

All alternatives were rated 5 for this criterion. Alternative 16 would be implementable because it would require no action. The other alternatives would be implementable because the action they would take would not interfere with Travis AFB's mission. The site is not active. The technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated on the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-4 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group M Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$25,000	$100,000	$130,000
#18	$7,400,000	$0	$7,400,000
#19	$2,100,000	$97,000	$2,200,000
#20	$22,000,000	$0	$22,000,000

The alternatives that would not involve excavation or major construction would cost much less and were rated much higher than those that would involve such work. Alternative 16, the no action alternative, was rated 5 because it would have no cost. Alternative 17 was also rated 5 with a total cost of $0.13 million. Alternative 18 was rated 1 with a cost of $7.4 million. Alternative 19 was rated 3 with a cost of $2.2 million. Alternative 20 was rated -1 with a cost of $22 million. The high costs of these alternatives were driven by the large volumes of contaminated soil that would need to be addressed.

7.3.3 Comparative Analysis of Group M Alternatives

The highest total scores for alternatives were associated with alternatives that provide treatment of contamination and minimize exposure. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. Alternatives 17, 18, and 19 had higher total scores of 19, 22, and 22, respectively. All these alternatives would protect against exposure and Alternatives 18 and 19 would also, at least partially, comply with ARARs. However, none would reduce contamination through treatment. Alternative 20 had the highest total score (31 points) because it would both eliminate exposures and treat the contamination.

The benefit/cost ratios are dominated by the cost of the alternatives. The lowest benefit/cost ratio (0) was associated with the no action alternative because the alternative would not be effective. Alternatives 18, 19, and 20 had benefit/cost ratios of 2.2, 6.4, and 6.6. Alternative 17 had a benefit/cost ratio of 69, over 10 times greater than any other alternative. Alternative 17 would not be as effective as Alternatives 18, 19, and 20, but would cost about a twentieth as much as those alternatives.

Alternatives 18, 19, and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment. It was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

7.4 Detailed Analysis of Group N Alternatives

The soils sites of Group N include SS035, SS015, and SS016. Contaminants in these sites include PCBs, PAHs, and high metals concentrations. In the discussion below, SS035 serves as the representative site for describing alternatives and conceptual designs. Alternatives 16, 17, 18, 19, and 20 are the applicable alternatives to this group.

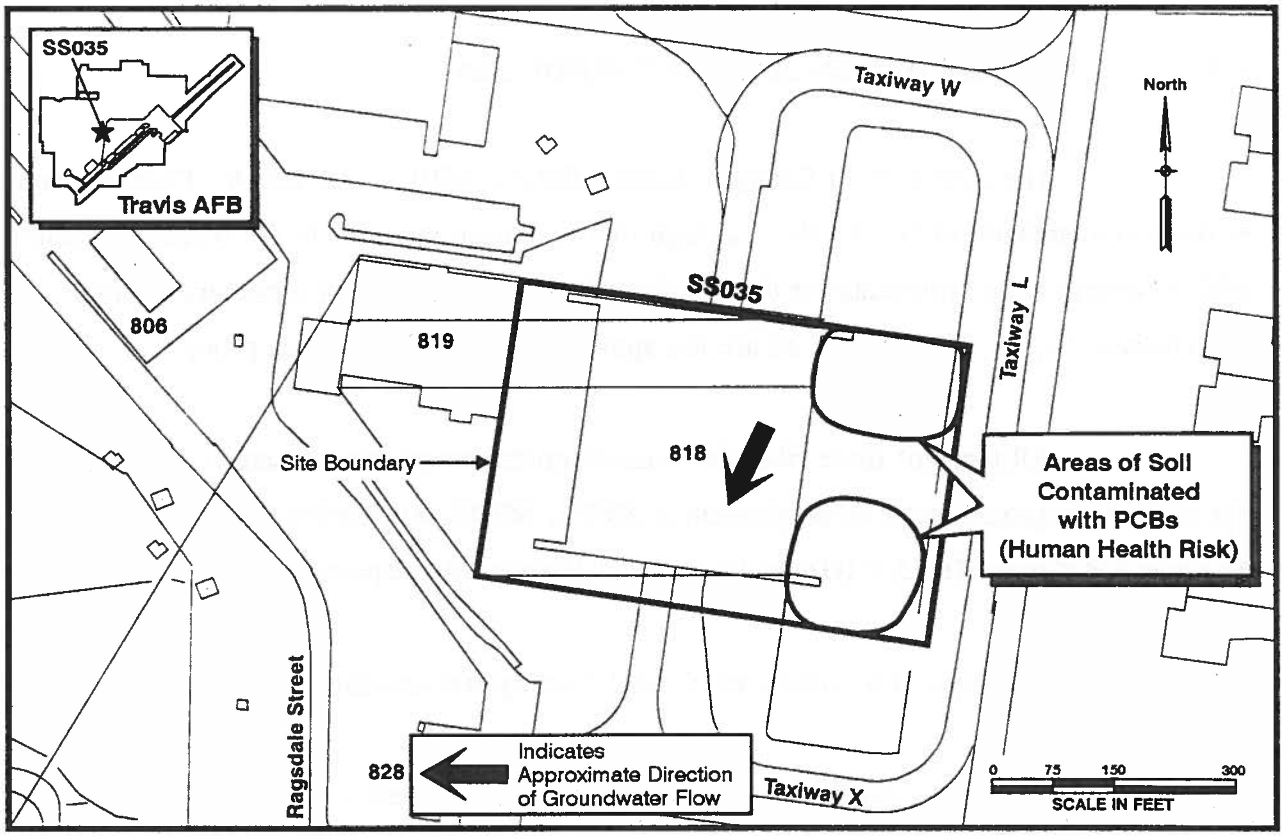
All three of these sites also contain groundwater contamination. Alternatives for addressing groundwater contamination at SS035, SS015, and SS016 are evaluated in Sections 5.8 (Group H), 5.2 (Group B), and 5.4 (Group D), respectively.

7.4.1 Description of Alternatives and Conceptual Design

Figure 7-4 summarizes the site characteristics, design assumptions, and applicable alternatives. The targeted contaminated area is flat and unpaved, but surrounded by taxiways associated with the hangars and the tarmac. This site has soil that poses a risk to human health (and possibly ecological receptors), but none that poses a risk only to ecological receptors. Alternative 17 would restrict access using warning signs in unpaved areas which pose a risk to human health. Because of the proximity to the tarmac, fences would be unacceptable. Administrative controls would be placed on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils posing risks to human health. The assumed excavation depth for the areas is one foot (surface soil).

7.4.2 Evaluation of Group N Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-5 shows



SS035S.CDR - VMG 7/25/96 SAC 1

Site Characteristics

- Site is covered with grass
- Facility 818/819 includes a wash area, oil/water separator and sump, hydraulic lift storage area, and hazardous material accumulation area
- TCE in soil gas detected @ 1,100 ppbv
- Depth to groundwater — 15 feet
- Depth to bedrock — 14 feet
- Low permeability soils (clay and silt) to about 15 feet bgs
- Site also included in Group H for groundwater contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

Design Assumptions

- 50,000 ft² — area which contains contaminated soil (human health risk)
- PCB-contaminated soil to a depth of 1 foot (human health risk)
- Contaminated soil posing ecological risk lies within area where contaminated soil poses human health risk
- 1,800 cubic yards of soil within limits for Class II landfill (human health risk)

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-4.
Conceptual Design for SS035 (Group N) Soil Treatment Alternatives, Travis AFB

Media: Soil
Group: N
Sites: SS035 (representative site), SS015, SS016

Table 7-5

CERCLA Criteria Evaluation for Group N

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[1]	Total[2] Score	Benefit/Cost[3] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.057M)	19	160
Alternative #18	5	5	3	0	3	3	5 ($0.38M)	24	42
Alternative #19	3	3	3	0	5	3	5 ($0.58M)	22	24
Alternative #20	5	5	5	3	3	3	1 ($5.1M)	25	4.1

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

1 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
2 The total score is the sum of the 7 CERCLA Criteria Score.
3 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

how well each of the alternatives applicable to Group N complied with each of the seven CERCLA criteria that are applicable at this stage of the CERCLA process.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because no protection to human health would be provided by no action. Alternative 17 was rated 3 because some limited protection would be provided. Access restrictions, such as warning signs or other restrictions on excavation work, would reduce potential human exposure to contaminants at the site and prevent future exposure by workers. If fencing were a possibility, institutional actions would be more effective at providing protection of human health. However, access to the site is limited because of its proximity to the tarmac.

PCBs, the soils COC at the representative site, are highly immobile due to their physical properties that cause them to adsorb to soil. The contaminants are unlikely to migrate. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18 and 20 were rated 5 because these options should successfully achieve cleanup levels that would provide adequate protection of human health.

Alternative 19 was rated 3. It would prevent exposure to contaminants, but would not remove the contaminants from the site.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action, while under institutional actions, only ARARs related to human exposure would be met. In both cases, achieving the IRGs and treatment of soil to reduce risk would be unlikely. Alternatives 18 and 20 were rated 5 because either alternative would achieve compliance with chemical-, location-, and action-specific ARARs. Alternative 19 was rated 3 because compliance with chemical-specific ARARs would not be achieved.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs are unlikely to be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access restrictions and natural degradation. Exposure in the long term would be limited and contaminants are unlikely to migrate off site.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where people and ecological receptors could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 19 was rated 3. It would prevent exposure over the long term, but it would not treat or remove the contaminants.

Alternative 20 was the only alternative that was rated 5. It is the only alternative which would treat the organic contaminants, meet IRGs, and eliminate future exposures of human and ecological receptors to organic contaminants.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 would treat the organic contaminants, thereby reducing the volume and toxicity of contaminated soil. However, because it would not treat inorganic contaminants, it was rated 3.

Short-term Effectiveness

Alternative 16 was rated 0 because no action would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although ecological receptors would continue to be exposed and cleanup goals will not be achieved.

Alternatives 18 and 20 are effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternative 19 was rated 5 because capping the contaminated soil would effectively address contamination in the short term. It could be implemented without additional releases of contamination.

Implementability

The primary obstacle to implementability would be the proximity of the site to the tarmac and taxiways. Alternative 16 would be implementable and was rated 5 because it would require no action. Similarly, Alternative 17 would be implementable because institutional actions would not adversely affect Travis AFB's mission and was rated 5.

Alternatives 18, 19, and 20 were rated 3 because they would adversely affect Travis AFB's mission in the short term by temporarily keeping aircraft from using nearby taxiways as excavation work or capping took place. The technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-5 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group N Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$0	$57,000	$57,000
#18	$380,000	$0	$380,000
#19	$530,000	$54,000	$580,000
#20	$5,100,000	$0	$5,100,000

Because of the small volume of contaminated soil (relative to other sites), the costs of the alternatives would not vary as much as they would for other sites. Alternative 16, the no action alternative, was rated 5 because it would have no cost. Alternatives 17, 18, and 19 were also rated 5 with costs of $0.057 million, $0.38 million, and $0.58 million, respectively. Alternative 20 was rated 1 with a cost of $5,100,000.

7.4.3 Comparative Analysis of Group N Alternatives

The highest total scores for alternatives were associated with alternatives which would eliminate the potential for human exposure at the sites by excavating the soil. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. With a total score of 19, Alternative 17 had a higher score than the no action alternative because it would limit human exposure. Alternatives 18 and 19 had the next highest total scores (24 and 22, respectively) because they would remove the potential for exposure to the contaminated soil at the site. Alternative 20 had the highest total score (25) because it would treat and destroy the organic contaminants.

Because the effectiveness of the alternatives (except the no action alternative) would vary much less than their costs, the most important factor in the benefit/cost ratios was the cost of each alternative. The lowest ratio (0) was associated with the no action alternative because the alternative would not be effective. Alternative 20 would be the most effective, but also would cost at least ten times more than any other alternative. It has a benefit/cost ratio of 4.1. Alternatives 18 and 19 have lower effectiveness scores, but would cost much less than Alternative 20. Their benefit/cost ratios were 42 and 24, respectively. The highest benefit/cost ratio, 160, was associated with Alternative 17 because it would provide some protection at a minimal cost.

Alternatives 18, 19, and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 does not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

7.5 Detailed Analysis of Group O Alternatives

The soils site for Group O is SD036. Contaminants at this site include volatile and extractable total petroleum hydrocarbons (TPH) in the soil, as well as TPH-gasoline, TCE, DCE, and vinyl chloride in the soil gas. The contaminants, mostly TPH-gasoline, are in subsurface soil between the asphalt cover and the water table. Alternatives 16, 17, 18, 19, 20, 21, and 22 are applicable to this group.

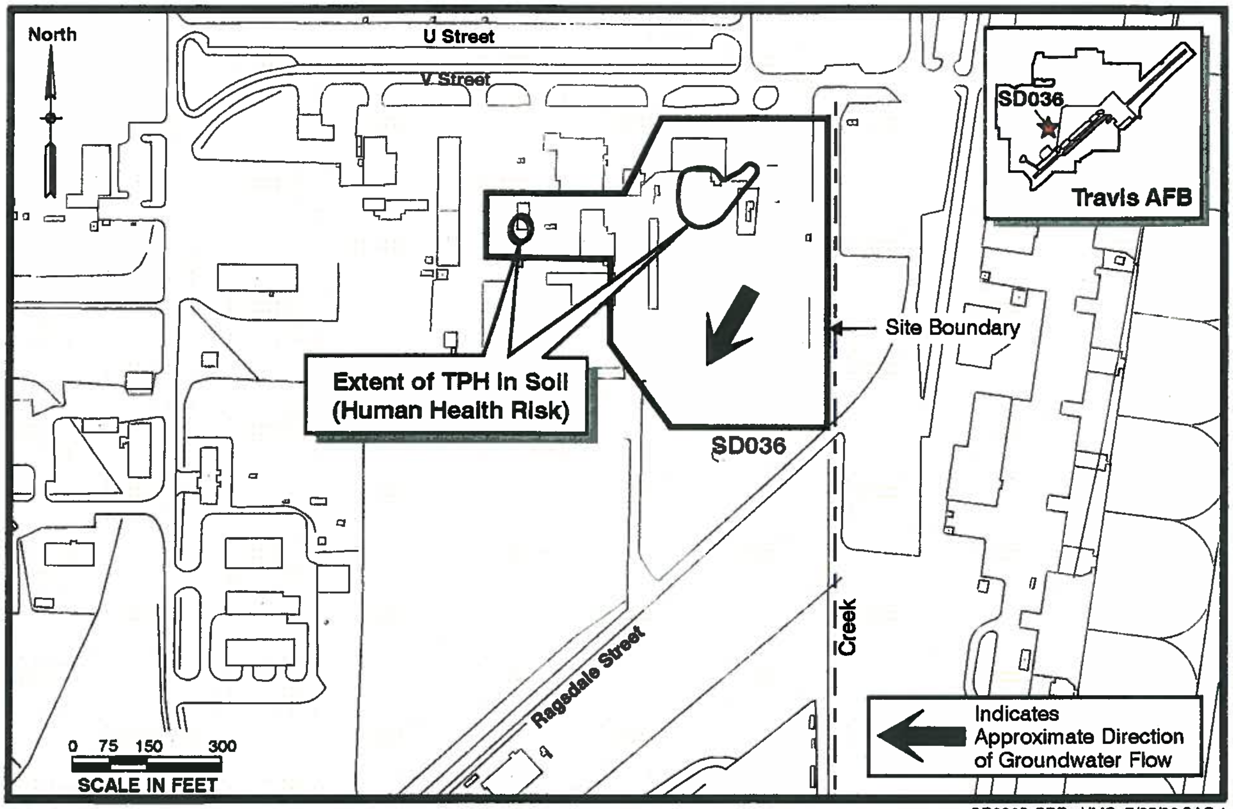
SD036 also contains groundwater contamination. Alternatives for addressing groundwater contamination at SD036 are evaluated in Section 5.2 (Group B).

7.5.1 Description of Alternatives and Conceptual Design

Figure 7-5 summarizes the site characteristics, design assumptions, and applicable alternatives. Alternative 17 would restrict access by using administrative controls on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils posing risks to both human health and ecological receptors. Alternative 19 would remove the existing asphalt and replace it with an engineered cap. Alternative 21 would use soil vapor extraction to volatilize and remove soil contaminants and soil gas followed by catalytic oxidation of the off gas. Alternative 22 would use in-situ bioventing to convert degradable TPH to carbon dioxide and water.

7.5.2 Evaluation of Group O Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-6 shows how well each of the alternatives applicable to Group O complied with each of the seven CERCLA criteria that are applicable at this point in the CERCLA process.



SD036S.CDR - VMG 7/25/96 SAC 1

Site Characteristics

- The site is paved and is surrounded by buildings
- The site is active
- Site is adjacent to SD037 — groundwater plumes overlap
- Depth to groundwater — 10 feet
- Depth to bedrock — >30 feet
- Two to four feet of asphalt and road base material
- Thick, discontinuous sand units
- Site also included in Group B for groundwater contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-SiteLandfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-Site Landfill
- Alternative #21: Soil Vapor Extraction, Offgas Catalytic Oxidation
- Alternative #22: In-situ Bioventing

Design Assumptions

- 10,800 ft^2 — area which contains contaminated soil (exceeds LUFT manual)
- Contaminated subsurface soil between 5 and 11 feet (exceeds LUFT manual)
- Subsurface soils contaminated with TPH-extractable and TPH-volatile (exceeds LUFT manual)
- 2,300 cubic yards of soil within limits for Class II landfill (human health risk)
- Soil gas contaminants include TPH-gasoline, TCE, DCE and vinyl chloride
- Soil gas is associated with TPH-contaminated soil and contaminated groundwater

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-5. Conceptual Design for SD036 (Group O) Soil Treatment Alternatives, Travis AFB

Media: Soil
Group: O
Sites: SD036

Table 7-6

CERCLA Criteria Evaluation for Group O[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.064M)	19	140
Alternative #18	3	3	3	0	0	3	5 ($0.50M)	17	18
Alternative #19	3	3	3	0	3	3	5 ($0.23M)	20	52
Alternative #20	3	3	5	5	0	3	1 ($6.4M)	20	2.5
Alternative #21	3	3	3	3	5	3	5 ($0.26M)	25	65
Alternative #22	3	3	3	3	5	3	5 ($0.18M))	25	94

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
Alternative #22: In-Situ Bioventing

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because it would not provide protection to either human health or the environment. Alternative 17 was rated 3 because it would provide some limited protection. Deed and excavation restrictions would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18 and 20 were rated 3 because these options should successfully achieve cleanup levels that would provide adequate protection of human health and the environment. However, because much of the contamination is in soil gas, the contamination could be lost in the excavation and transportation processes. The volatilization of contaminants during the excavation process could expose workers to the TPH-gasoline and other VOCs.

Alternative 19 was rated 3 because it would prevent exposure to people, although it would not remediate the soil. Alternative 21 was rated 3; it would remove volatile contaminants without releasing them. However, because the TPH-extractable is not volatile, SVE is not entirely effective. Alternative 22 was rated 3 because it is effective in treating TPH but not halogenated hydrocarbons.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action, while under institutional actions, only ARARs related to human exposure would be met. In both cases, achieving the IRGs and treating soil to reduce risk would be unlikely. Alternatives 18 and 20 were rated 3 because either alternative would achieve compliance with chemical- and location-specific ARARs. However, as discussed above, action-specific ARARs could be difficult with which to comply. Alternative 19 was rated 3 because it would prevent exposure, but not achieve chemical-specific IRGs. Alternative 21 was rated 3 because it would only achieve ARARs associated with soil gas removal and destruction as well as with air emissions. Chemical-specific ARARs for TPH-extractable would not be met. Alternative 22 was rated 3 because only chemical-specific ARARs associated with TPH-contaminated soil would be met.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs are unlikely to be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where people could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 19 was rated 3 because it would prevent exposure, but would not address cleaning up the contamination in the soil.

Alternative 20 was the only alternative rated 5. It is the only alternative which would treat the organic contaminants, meet IRGs, and prevent future exposures of human and ecological receptors to organic contaminants.

Alternative 21 was rated 3 because, although SVE is effective in removing volatile substances, non-volatile contaminants would remain in soil.

Alternative 22 was rated 3 because bioventing is effective in remediating TPH-contaminated soil, but soil gas and volatile, non-biodegradable contaminants would remain.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 was rated 5 because it would treat the organic contaminants, thereby reducing the volume and toxicity of contaminated soil. Alternative 21 was rated 3 because it would meet the objectives of this criterion for volatile contaminants but not for TPH-extractable. Alternative 22 was rated 3 because bioventing would have a limited impact on soil gas contaminants.

Short-term Effectiveness

Alternative 16 was rated 0 because no action would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although this alternative would not take any action to clean up the contaminated soil. Alternative 19 was rated 3 for the same reason.

Alternatives 18 and 20 would be effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternatives 21 and 22 were rated 5 because they would immediately begin remediating the site without unduly releasing contaminants to the atmosphere or exposing workers.

Implementability

The primary obstacle to implementability would be the potential of interference with Travis AFB operations. The site is used as a storage yard for above ground equipment.

Alternative 16 would be implementable and was rated 5 because it requires no action. Alternative 17 would be implementable because it would not affect current use of the site.

Alternatives 18 and 20 were rated 0 because they would require removing existing pavement and moving mission-related equipment stored in the area while extensive volumes of soil would be removed. Similarly, Alternatives 19, 21, and 22 would interfere with current site operations. However, because the subsurface scopes of work for these two alternatives would not be as great, they were rated 3 for this criterion. The technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-6 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group O Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$0	$64,000	$64,000
#18	$500,000	$0	$500,000
#19	$170,000	$59,000	$230,000
#20	$6,400,000	$0	$6,400,000
#21	$190,000	$70,000	$260,000
#22	$95,000	$85,000	$180,000

Because of the relatively small size of the site, all alternatives were rated 5.

7.5.3 Comparative Analysis of Group O Alternatives

The highest total scores for alternatives were associated with alternatives that would provide the most protection and compliance with ARARs. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. With total scores of 19, 17, 20, and 20, Alternatives 17, 18, 19, and 20 had higher scores than the no action alternative because they would limit human exposure. Alternatives 21 and 22 both had the highest total score of 25 because they would remove much of the potential for exposure to the contaminated soil at the site and would treat contamination.

The higher benefit/cost ratios are associated with alternatives that would provide at least some protection at relatively little cost. Alternative 16 had a ratio of 0 because it would not be effective. Alternatives 18 and 20 had ratios of 18 and 2.5, respectively.

Alternatives 18, 19, 20, 21, and 22 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 19 had the third highest benefit/cost ratio (52) because it would protect against exposure for much lower the cost than Alternatives 18 and 20. Both alternatives would provide at least some protection and compliance with ARARs at relatively large costs.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

Alternatives 17, 21, and 22 had much higher ratios than other alternatives because they would provide protection for very little cost. Alternative 17, with a benefit/cost ratio of 140, would be moderately effective at protecting against human exposure at very low cost. Both Alternatives 21 and 22 would provide substantial treatment of contaminants at costs much less than Alternative 20. Alternative 21, which had a benefit/cost ratio of 65, would treat much of the contamination for one tenth of the cost of Alternative 20. Alternative 22, with a benefit/cost ratio of 94, would treat the TPH-contaminated soil for less than a tenth of the cost of Alternative 20.

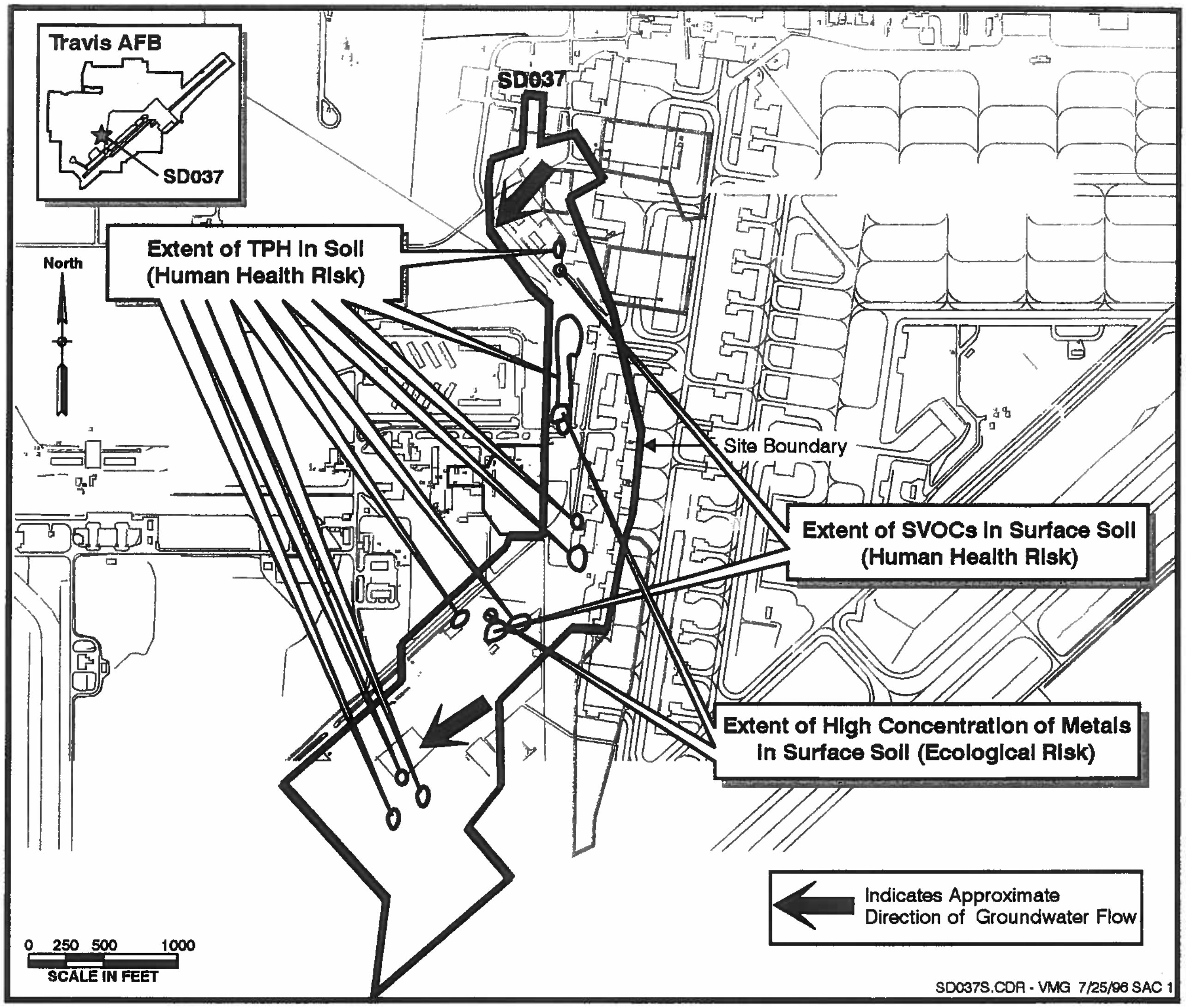
7.6 Detailed Analysis of Group P Alternatives

The sites in Group P are SD037 and SD033. Contaminants at this site include PAHs and metals in surface soil, TPH-gasoline and TPH-diesel in subsurface soil, and TPH-gasoline, benzene, and TCE in soil gas. Alternatives 16, 17, 18, 19, 20, 21, and 22 are applicable to this group.

SD037, the representative site, also contains groundwater contamination. Alternatives for addressing groundwater contamination at SD037 are evaluated in Section 5.9 (Group I).

7.6.1 Description of Alternatives and Conceptual Design

Figure 7-6 summarizes the site characteristics, design assumptions, and applicable alternatives. Approximately half of the targeted contaminated area (including soils posing a risk to humans and soils posing a risk to ecological receptors) is paved. Alternative 17 would restrict access by using fences in unpaved areas which pose a risk to human health. Administrative controls and access restrictions would be placed on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils posing risks to human health. The assumed depth of excavation for the PAH contaminated surface soil is 1 foot and the assumed excavation depth for TPH contaminated soil is 10 feet, the approximate depth to groundwater. Alternative 19 would place a soil and bentonite cap above soil contamination. Alternative 21 would install soil vapor extraction to volatilize and remove soil contaminants and soil gas followed by catalytic oxidation of the off gas. Alternative 22 would use in-situ bioventing to convert TPH to carbon dioxide and water.



Site Characteristics

- The sanitary sewer system includes approximately 67,700 feet of piping, as well as associated oil water separators, sumps, and wash racks
- Depth to groundwater — 10 feet
- Depth to bedrock — 30 feet
- Subsurface geology beneath the sanitary sewer system varies
- In general, low permeability alluvium underlies the area with discontinuous permeable layers
- Weathered sandstone and shale interbed to form bedrock layer beneath the alluvium
- Site also included in Group I for groundwater contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
- Alternative #21: Soil Vapor Extraction, Offgas Catalytic Oxidation
- Alternative #22: In-situ Bioventing

Design Assumptions

- 200,000 ft^2 — area which contains contaminated soil (human health risk)
- 20,000 ft^2 — area which contains contaminated soil (ecological risk)
- SVOC-contaminated surface soil to a depth of about 1 foot (human health risk)
- TPH-extractable and TPH-volatile-contaminated subsurface soil from about 5 feet to water table (exceeds LUFT manual)
- Metals-contaminated surface soil to a depth of 1 foot (ecological risk)
- 20,000 cubic yards of soil within limits for Class II landfill (exceeds LUFT manual)
- 740 cubic yards of soil within limits for Class II landfill (ecological risk)
- Soil gas contaminants include TPH-gasoline, benzene and TCE
- Soil gas contamination is associated with TPH-contaminated soil and contaminated groundwater

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-6. Conceptual Design for SD037 (Group P) Soil Treatment Alternatives, Travis AFB

7.6.2 Evaluation of Group P Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-7 shows how well each of the alternatives applicable to Group P complied with each of the seven CERCLA criteria that are applicable at this point in the CERCLA process.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because it would not provide protection to either human health or the environment. Alternative 17 was rated 3 because it would provide some limited protection. Access restrictions, such as fences or other restrictions on work, would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural degradation.

Alternatives 18 and 20 were rated 3 because these options should successfully achieve cleanup levels that would provide adequate protection of human health and the environment. However, because much of the contamination is in the form of soil gas, the contamination could be lost in the excavation and transportation processes. Alternative 19 was rated 3 because it would provide protection from surface soil PAH contamination, but would not effectively address soil gas contamination. Alternative 21 was also rated 3 because, although it would be effective with volatile compounds, it would not remediate surface soil PAH and metals (non-volatile) contamination. Alternative 22 was rated 3 because it would effectively remediate TPH-contaminated soil, but it would not be effective with near-surface contamination and non-biodegradable compounds.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action. Under institutional actions (Alternative 17) and capping (Alternative 19), only ARARs related

Media: Soil
Group: P
Sites: SD037

Table 7-7

CERCLA Criteria Evaluation for Group P[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.14M)	19	64
Alternative #18	3	3	3	0	3	3	3 ($4.0M)	18	3.0
Alternative #19	3	3	3	0	3	3	3 ($1.6M)	18	7.5
Alternative #20	3	3	5	5	3	3	-1 ($55M)	21	0.35
Alternative #21	3	3	3	3	5	3	5 ($0.63M)	25	27
Alternative #22	3	3	3	3	5	3	5 ($0.58M)	25	29

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
Alternative #22: In-Situ Bioventing

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

to human exposure would be met. In all three cases, achieving the IRGs and treatment of soil to reduce risk would be unlikely. Alternatives 18 and 20 were rated 3 because either alternative would achieve compliance with chemical- and location-specific ARARs. However, as discussed above, compliance with action-specific ARARs, including exposure during the remedial action, might not be achieved with the excavation alternatives. Alternative 19 was rated 3 because it would achieve all ARARs except chemical-specific ARARs for fuel contaminants. Alternative 21 was rated 3 because it would only achieve ARARs associated with soil gas removal and destruction, as well as with air emissions. Chemical-specific ARARs for TPH-extractable would not be met. Alternative 22 was rated 3 because it would only meet ARARs associated with TPH-contaminated soil.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs would not be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where people could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 19 was rated 3 because it would prevent exposure, but would not address cleanup of the organic contaminants.

Alternative 20 was the only alternative rated 5. It is the only alternative which would treat the organic contaminants, meet IRGs, and eliminate future exposures of human and ecological receptors to organic contaminants.

Alternative 21 was rated 3 because, although SVE would be effective in removing volatile substances, non-volatile contaminants would remain in the soil.

Alternative 22 was rated 3 because it would not be effective in removing highly volatile and non-biodegradable compounds.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 was rated 5 because it would treat the organic contaminants, thereby reducing the volume and toxicity of contaminated soil. Alternative 21 was rated 3 because it would treat the volatile contaminants, but not the TPH-diesel or PAHs. Alternative 22 was rated 3 because it would only treat and reduce the volume of TPH-contaminated soil, not the PAH contaminated surface soil.

Short-term Effectiveness

Alternative 16 was rated 0 because no action would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although this alternative would not take any action to clean up the contaminated soils. Alternative 19 was rated 3 for the same reason.

Alternatives 18 and 20 would be effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternatives 21 and 22 were rated 5 because they would immediately begin remediating the site without unduly releasing contaminants to the atmosphere or exposing workers.

Implementability

The primary obstacle to implementability would be the potential impact on base operations. Alternative 16 would be implementable and was rated 5 because it would require no action. Alternative 17 was rated 3 and would be implementable because limiting excavation at the site could limit future development at the base.

Alternatives 18, 19, 20, 21, and 22 were rated 3 because they would require disrupting base activities at soil sites near Buildings 981, 819, and 838. The technologies for these alternatives are well understood, and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. In the case of Alternatives 21 and 22, SVE and bioventing technology is readily understood and commercially available. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-6 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group P Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$9,100	$140,000	$140,000
#18	$4,000,000	$0	$4,000,000
#19	$1,500,000	$100,000	$1,600,000
#20	$55,000,000	$0	$55,000,000
#21	$530,000	$99,000	$630,000
#22	$450,000	$130,000	$580,000

The alternatives that had the highest cost scores would require little or no major construction or excavation work. The no action alternative, Alternative 16, would not have any cost and was rated 5. Alternatives 17, 21, and 22 were also rated 5. They both would have O&M costs, but neither would have large capital costs. Alternatives 18, 19, and 20 scored lower (3, 3, and -1, respectively) because they would require construction or excavation over a large site.

7.6.3 Comparative Analysis of Group P Alternatives

The highest total scores were associated with alternatives that would provide treatment of contaminants. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. With total scores of 19, 18, and 18, respectively, Alternatives 17, 18, and 19 have higher scores than the no action alternative because they would limit human exposure. Alternatives 20, 21, and 22 had the highest total scores (21, 25, and 25, respectively) because they would treat contaminants while other alternatives would not.

The benefit/cost ratios were associated with alternatives that would provide at least some protection at relatively little cost. Alternative 16 had a ratio of 0 because it is not effective. Alternatives 18, 19, and 20 had ratios of 3.0, 7.5, and 2.1, respectively. All three alternatives would provide at least some protection and compliance with ARARs. Alternative 20 had the lowest ratio because its incremental effectiveness would be more than offset by its incremental cost.

Alternatives 18, 19, 20, 21, and 22 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 does not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

Alternatives 17, 21, and 22 had much higher ratios than other alternatives because they would provide protection for very little cost. Alternative 17, with a benefit to cost ratio of 64, would be moderately effective of protecting against human exposure at very low cost. Both Alternatives 21 and 22 provide substantial treatment at comparatively little cost. Alternative 21, with a benefit to cost ratio of 27, would treat much of the contamination for approximately one percent of the cost of Alternative 20. Alternative 22, with a benefit/cost ratio of 29, would treat the TPH-contaminated soil at a greatly reduced cost relative to Alternative 20.

7.7 Detailed Analysis of Group Q Alternatives

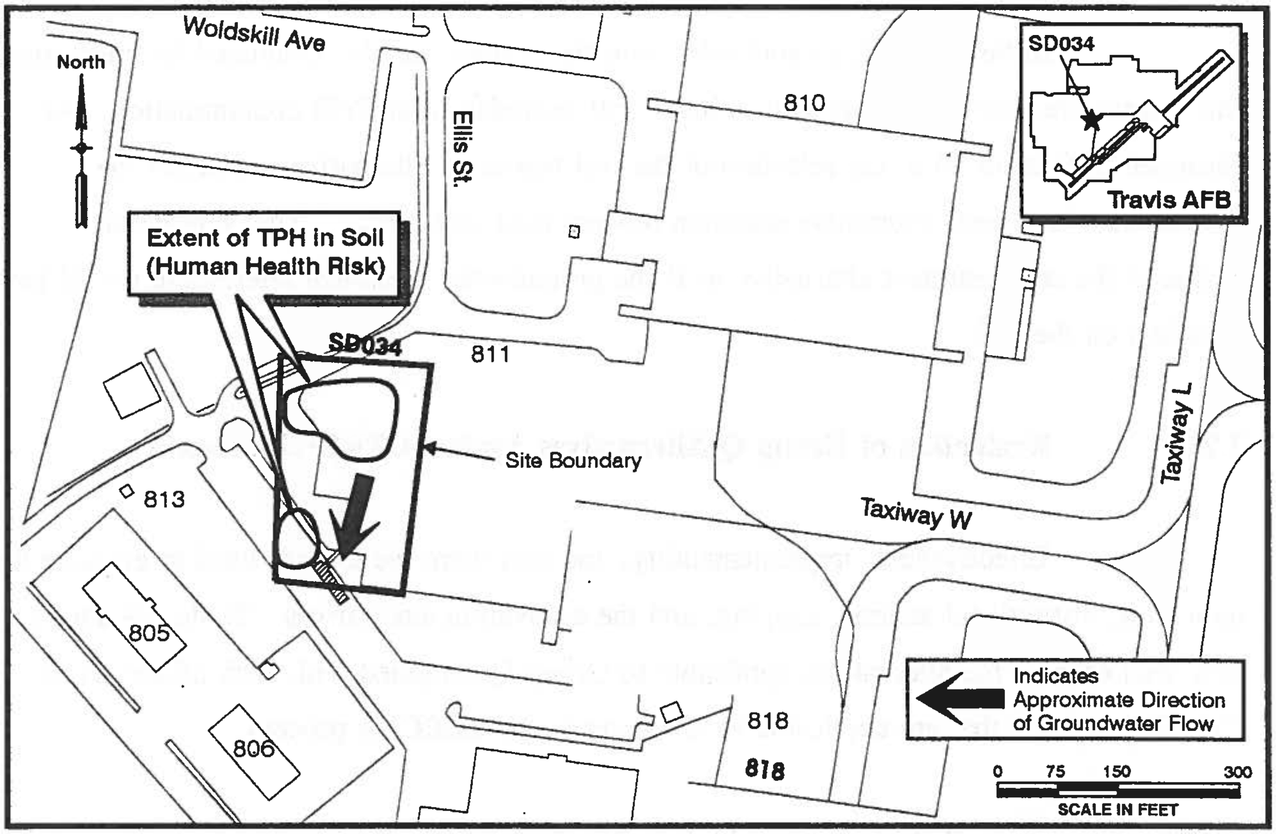
The soils sites for Group Q are SD034 (representative) and ST032. Contaminants at these sites include fuel hydrocarbons, principally TPH-gasoline in subsurface soil and soil gas, including TPH-gasoline and TCE. TPH-diesel was also detected at the site. In the discussion below, SD034 serves as the representative site for describing alternatives and conceptual designs. Alternatives 16, 17, 18, 19, 20, 21, and 22 are applicable to this group.

Both SD034 and ST032 contain groundwater contamination, as well as soil contamination. Alternatives for addressing groundwater contamination at these sites are evaluated in Section 5.7 (Group G).

7.7.1 Description of Alternatives and Conceptual Design

Figure 7-7 summarizes the site characteristics, design assumptions, and applicable alternatives. Nearly all of the targeted contaminated area is paved. Contaminated soil appears to extend up to and possibly beneath the foundation of Building 818. Alternative 17 would restrict access by using fences in unpaved areas which pose a risk to human health. Administrative controls would be placed on the long-term use of those areas as well as excavation and subsurface work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of soils posing risks to human health. The assumed excavation depth for the areas with human health risk is to the groundwater table, about 10 feet below ground surface.

Alternative 19 would remove existing pavement and replace it with a cap. Alternative 21 would involve installing soil vapor extraction and soil vapor treatment equipment to volatilize and remove soil contaminants and soil gas followed by catalytic oxidation of the off gas. Alternative 22 would include installation of an in-situ bioventing system, including injection wells, to promote natural biodegradation of TPH.



Site Characteristics

- Includes an indoor washrack, an oil/water separator, and a concrete-lined overflow pond
- Approximately 75% of the area is covered with roadbase and asphalt
- Depth to groundwater — 10 feet
- Depth to bedrock — 16 feet
- Site also included in Group G for groundwater contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #19: Soil and Bentonite Cap
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
- Alternative #21: Soil Vapor Extraction, Offgas Catalytic Oxidation
- Alternative #22: In-situ Bioventing

Design Assumptions

- 17,600 ft^2 — area which contains contaminated soil (human health risk)
- Contaminated subsurface soil between 5 and 10 feet (human health risk)
- Subsurface soils contaminated with TPH (exceeds LUFT manual)
- 3,300 cubic yards of soil within limits for Class II landfill (human health risk)
- Soil gas contaminants include TPH-gasoline and TCE

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-7.
Conceptual Design for SD034 (Group Q) Soil Treatment Alternatives, Travis AFB

In Section 5.7, groundwater remedial actions are also evaluated for these sites. One alternative, bioslurping, promotes biological degradation of TPH contamination. As discussed in Section 10.0, the selection of the soil treatment alternative can affect the groundwater treatment alternative selection process (and vice versa). This subsection evaluates the soil treatment alternative as if the groundwater treatment alternative would have no effect on the soil.

7.7.2 Evaluation of Group Q Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, capping, and the excavation alternatives. Table 7-8 shows how well each of the alternatives applicable to Group Q complied with each of the seven CERCLA criteria that are applicable at this point in the CERCLA process.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because it would not provide protection to either human health or the environment. Alternative 17 was rated 3 because it would provide some limited protection. Deed and access restrictions on excavation work would reduce potential human exposure to contaminants at the site. Monitoring would assess the extent of contaminant reduction resulting from natural attenuation.

Alternatives 18 and 20 were rated 3 because these options should successfully achieve cleanup levels that would provide adequate protection of human health and the environment. However, because much of the contamination is soil gas (principally TPH-gasoline), the contaminants may be lost (and groundwater exposed) during the excavation process. Alternative 19 was rated 3 because it would restrict exposure, but would not clean up the contamination.

Media: Soil
Group: Q
Sites: SD034 (representative site), ST032

Table 7-8

CERCLA Criteria Evaluation for Group Q[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0)	10	0
Alternative #17	3	0	3	0	3	5	5 ($0.073M)	19	120
Alternative #18	3	3	3	0	3	3	5 ($0.71M)	20	17
Alternative #19	3	3	3	0	3	5	5 ($0.31M)	22	39
Alternative #20	3	3	5	5	3	3	1 ($9.1M)	23	2.1
Alternative #21	3	3	3	3	5	3	5 ($0.23M)	25	74
Alternative #22	3	3	3	3	5	3	5 ($0.19M)	25	89

Alternative #16: No Action
Alternative #17: Institutional Actions: Access Restrictions, Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #19: Soil and Bentonite Cap
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill
Alternative #21: In-Situ Soil Vapor Extraction (SVE), Off Gas Catalytic Oxidation
Alternative #22: In-Situ Bioventing

1 Evaluation for soil posing risk to either human or ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Alternatives 21 and 22 were each rated 3 for overall protection of human health and the environment. SVE is limited primarily to remediation of volatile contaminants, and bioventing is limited primarily to readily biodegradable compounds, such as TPH.

Compliance with ARARs

Alternative 16 was rated 0 because ARARs would not be met under no action. Under institutional actions (Alternative 17) and capping (Alternative 19), only ARARs related to human exposure would be met. In all three cases, achieving the IRGs and treatment of soil to reduce risk would be unlikely and the alternatives were rated 0. Alternatives 18 and 20 were rated 3 because either alternative would achieve compliance with chemical- and location-specific ARARs. Alternatives 21 and 22 are limited in the range of COCs for which cleanup levels could be achieved. Both alternatives were rated 3 for compliance with ARARs.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs are unlikely to be achieved under no action. Alternative 17 was rated 3 because some protection and cleanup would be provided by access limitations and natural degradation.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where people could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 19 was rated 3 because it would prevent exposure, but would not address cleanup of the organic contaminants.

Alternative 20 was the only alternative rated 5. It is the only alternative which would treat the organic contaminants, meeting IRGs, and eliminating future exposures of human and ecological receptors to organic contaminants.

Alternatives 21 and 22 were each rated 3 for long-term effectiveness. SVE could only address volatile soil contaminants, and bioventing could only address biodegradable soil contaminants.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, 18, and 19 all were rated 0 because none of them would employ active treatment processes. Alternative 20 was rated 5 because it would treat the organic contaminants, thereby reducing the volume and toxicity of contaminated soil. Alternatives 21 and 22 were both rated 3 because they are both active treatment options but would be limited in overall effectiveness.

Short-term Effectiveness

Alternative 16 was rated 0 because no action would not mitigate the threat to human health and the environment or achieve IRGs in the short term. Alternative 17 was rated 3 because the threat to human health would be reduced by access restrictions, although this alternative would not take any action to clean up contaminated soils. Alternative 19 was rated 3 for the same reason.

Alternatives 18 and 20 are effective because they would eliminate human and ecological exposure in the short term. However, both alternatives were rated 3 because of the potential short-term exposure associated with soil excavation and transportation.

Alternatives 21 and 22 were both rated 5 because they would immediately begin remediating the site without unduly releasing contaminants to the atmosphere or exposing workers.

Implementability

The primary obstacle to implementability would be the proximity of the site to Building 818. Alternative 16 would be implementable and was rated 5 because it would require no action. Alternative 17 would be implementable because future excavation work in the area would be unlikely and no equipment would be stored above the contaminated soil. Alternative 19 was rated 5 because the work to complete a cap in this area would cause minimal interference with Travis AFB operations.

Alternatives 18, 20, 21, and 22 were rated 3 because they would require removing existing pavement and excavating in soils adjacent to the building's foundation. Care would have to be taken to ensure the foundation is not damaged. The technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. The implementation of Alternatives 21 and 22 would result in some impacts on the Base; however, these technologies are also well understood and commercially available. No prohibitive permitting or administrative barriers to implementation are expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting must be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-8 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group Q Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$2,700	$70,000	$73,000
#18	$710,000	$0	$710,000
#19	$260,000	$54,000	$310,000
#20	$9,100,000	$0	$9,100,000
#21	$170,000	$69,000	$230,000
#22	$99,000	$87,000	$190,000

The alternatives that would require excavation and disposal of the contaminated soil cost more than the other alternatives. The no action alternative, Alternative 16, would not have any cost and was rated 5. Alternatives 17, 18, 19, 21, and 22 were also rated 5 and would have costs of $0.073 million, $0.71 million, $0.31 million, $0.23 million, and $0.19 million, respectively. Alternative 20 was rated 1 and would cost $9.1 million. This alternative would require extensive excavation.

7.7.3 Comparative Analysis of Group Q Alternatives

The highest total scores for alternatives were associated with alternatives which would reduce the potential for human exposure at the sites by treating the soil. Alternative 16, the no action alternative, had the lowest total score (total of 10) because it would neither treat nor prevent exposure to contamination. With total scores of 19 and 20, Alternatives 17 and 18 had higher scores than the no action alternative because they would limit human exposure. Alternative 19 had the second highest score, a total of 22. It would protect against exposure at a lower cost than Alternative 18. Alternatives 20, 21, and 22 all had total scores of 25. These high scores reflect the fact that these alternatives would provide treatment of contaminants, while others would not.

The highest benefit/cost ratios are associated with alternatives that would provide protection at very low relative costs. Alternative 16 had a ratio of 0 because it would not be effective. Alternatives 18 and 20 had ratios of 17 and 2.1, respectively. Although they would be nearly as effective as other alternatives, they would cost much more. Alternatives 19 and 21 had higher ratios, 39 and 74, respectively. They would achieve protection of human health and some compliance with ARARs at a relatively moderate cost. Finally, Alternatives 17 and 22 had the highest benefit/cost ratios, 120 and 89, respectively, because they would provide some protection at less than the cost of other alternatives (other than no action). Alternative 22 would provide the most cost-effective means of treating the contaminants.

Alternatives 18 and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 17 would be partially protective of human health and the environment and was rated 0 for compliance with ARARs because it would not likely comply with most chemical-specific ARARs. However, given its low cost relative to other alternatives, it should continue to be considered.

7.8 Detailed Analysis of Group R Alternatives

The soils sites for Group R are SD033 and SD001. Contaminants in these sites include including PAHs, PCBs, and high concentrations of metals. In the discussion below, SD001 serves as the representative site for describing alternatives and conceptual designs. Alternatives 16, 17, 18, and 20 are the applicable alternatives to this group.

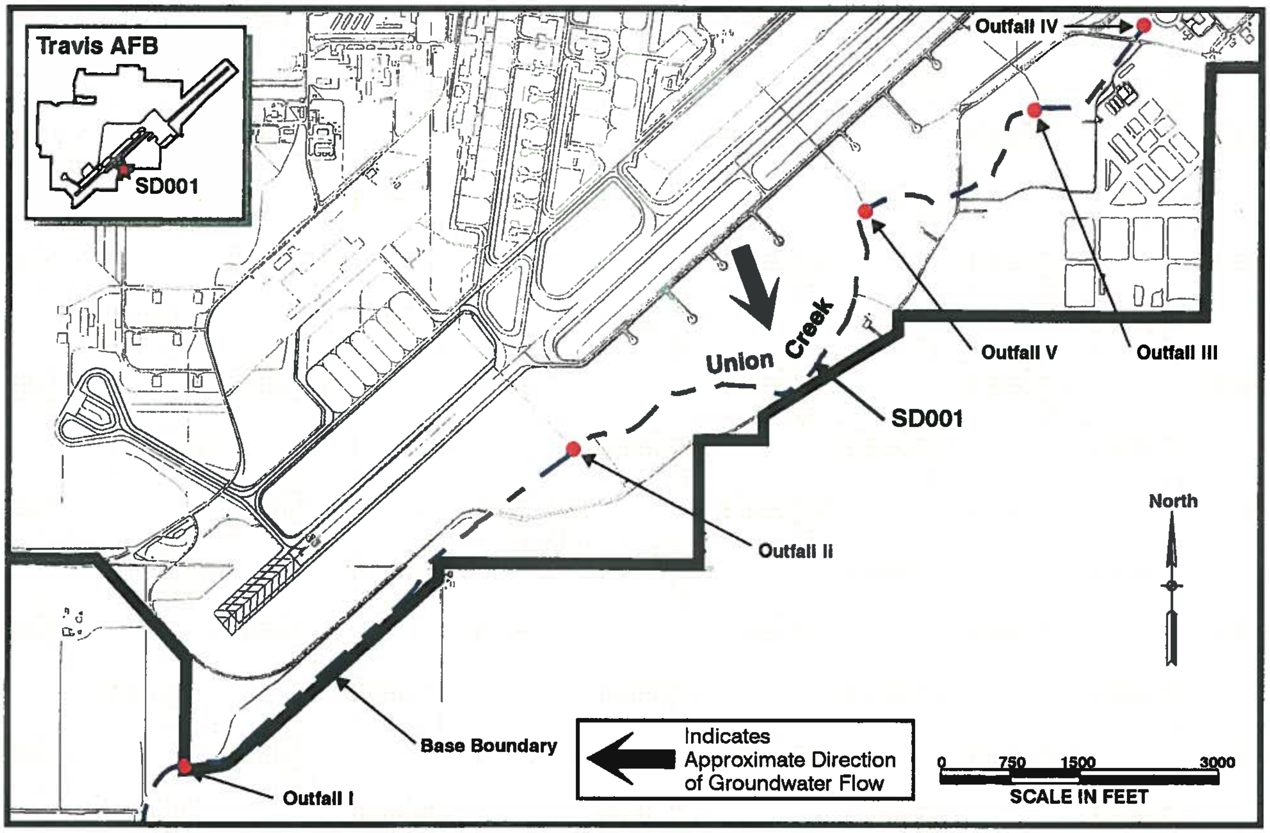
Both SD033 and SD001 contain surface water contamination. Alternatives for addressing surface water contamination at these sites are evaluated in Section 6.1 (Group J).

7.8.1 Description of Alternatives and Conceptual Design

Figure 7-8 summarizes the site characteristics, design assumptions, and applicable alternatives. The targeted contaminated area includes the sediment within Union Creek (a length of approximately 13,900 feet) which poses a risk to ecological receptors. The length of Union Creek requiring sediment treatment was estimated based on sediment samples collected mainly during 1987 and 1988. Additional sampling may be needed to determine which reaches of the creek actually contain sediment that poses a risk to ecological receptors. Alternative 17 would include administrative controls to be placed on the long-term use of Union Creek as well as on any excavation work where workers would encounter contamination. Alternatives 18 and 20 would excavate and dispose of sediment posing risks to ecological receptors. The assumed excavation depth is 6 inches.

7.8.2 Evaluation of Group R Alternatives Against CERCLA Criteria

Effectiveness, implementability, and cost were the criteria used to evaluate the no action, institutional actions, and the excavation alternatives. Table 7-9 shows how well each of the alternatives applicable to Group R complied with each of the seven CERCLA criteria that are applicable at this point in the CERCLA process.



Site Characteristics

- Site includes open drainages/creek in the southern portion of EIOU
- Aluminum in sediment — 46,700 mg/kg maximum (1988)
- Copper in sediment — 237 mg/kg maximum (1988)
- Chromium in sediment — 496 mg/kg maximum (1988)
- PAH (Benzo(a)pyrene) in sediment — 25 mg/kg (1988)
- Storm sewer systems discharge into Union Creek at Outfalls II, III and IV
- Union Creek exits Travis AFB at the southwest tip and flows south to Hill Slough, which discharges into Suisun Marsh, and ultimately to Suisun Bay
- Treatment plant at Outfall III treats surface water runoff from Storm Sewer III for VOCs
- Metals concentrations in treated water from Outfall III treatment plant sometimes exceed effluent limitations set by RWQCB
- Site also included in Group J for surface water contamination

Treatment Alternatives

- Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
- Alternative #20: Backhoe, Ex-situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

Design Assumptions

- Length of Union Creek with sediment contaminant concentrations above screening criteria — 13,900 feet
- Depth of sediment — 0.5 feet
- All excavated sediment within limits for Class II landfill

NOTE: The figure conceptually displays components for comparative purposes only. Actual layout may vary significantly from that shown and will be determined during the remedial design phase.

Figure 7-8.
Conceptual Design for SD001 (Group R) Soil/Sediment Treatment Alternatives, Travis AFB

Media: Soil
Group: R
Sites: SD001 (representative site), SD033

Table 7-9

CERCLA Criteria Evaluation for Group R[1]

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume through Treatment	Short-term Effectiveness	Implementability	Cost[2]	Total[3] Score	Benefit/Cost[4] Ratio
Alternative #16	0	0	0	0	0	5	5 ($0M)	10	0
Alternative #17	0	0	0	0	0	5	5 ($0.10M)	10	0
Alternative #18	5	5	3	0	0	3	5 ($0.30M)	21	43
Alternative #20	5	5	3	3	0	3	3 ($3.6M)	22	4.4

Alternative #16: No Action
Alternative #17: Institutional Actions: Monitoring, Natural Degradation
Alternative #18: Backhoe, Disposal at Existing Off-site Landfill
Alternative #20: Backhoe, Ex-Situ High Temperature Thermal Treatment, Disposal at Existing Off-site Landfill

1 Evaluation for soil posing risk to ecological receptors.
2 The figure in the upper part of the cost box is the score; the figure in the lower part of the box is the estimated present worth cost, in millions (M) of dollars.
3 The total score is the sum of the 7 CERCLA Criteria Score.
4 The benefit/cost ratio is the sum of the 5 effectiveness scores (for all criteria except implementability and cost) divided by the cost, in millions of dollars.

Overall Protection of Human Health and the Environment

Alternative 16 was rated 0 because it would not provide protection to the environment. Alternative 17 was rated 0 because it would provide some limited protection, but would not prevent animals from accessing the creek bed. Alternatives 18 and 20 were rated 5 because these options should successfully achieve cleanup levels that would provide adequate protection of the environment, as long as upstream sources were also controlled. (A rating of 5 assumes that the habitat would be reestablished after the alternative was implemented.)

Compliance with ARARs

Alternatives 16 and 17 were rated 0 because ARARs would not be met under either alternative. Alternatives 18 and 20 were rated 5 because either alternative would achieve compliance with chemical-, location-, and action-specific ARARs by removing the contaminated sediment.

Long-term Effectiveness and Permanence

Alternative 16 was rated 0 because the long-term RAOs would not be achieved under no action. Alternative 17 was also rated 0 because no protection would be provided by access limitations, and natural degradation would be very slow.

Alternative 18 was rated 3 because the long-term fate of landfilled contaminants could not be ensured. Some long-term effectiveness would be achieved by removing the contaminants from Travis AFB, where ecological receptors could be exposed. However, a future re-release of these contaminants from the landfill would be possible.

Alternative 20 was also rated 3. It is the only alternative which would treat the organic contaminants but would not treat the metal COCs. Therefore, IRGs would be partially met and the possibility of future exposures of ecological receptors to organic contaminants would be eliminated.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternatives 16, 17, and 18 all were rated 0 because none of them would employ active treatment processes. Alternative 20 was rated 3 because it would treat the organic contaminants but would not treat metal COCs, thereby partially reducing the volume and toxicity of contaminated soil.

Short-term Effectiveness

Alternative 16 was rated 0 because no action would not mitigate the threat to the environment or achieve IRGs in the short term. Alternative 17 also was rated 0 because ecological receptors would continue to be exposed and cleanup goals would not be achieved.

Alternatives 18 and 20 were rated 0 because of the potential short-term exposure associated with disturbing the stream bed, disrupting creek flows, and removing habitat.

Implementability

The primary obstacle to implementability would be the disruption to the creek itself and the disturbance to the existing habitat. Alternatives 16 and 17 would be implementable and were rated 5 because they would require no physical action. Alternatives 18 and 20 were rated 3 because of the destruction of habitat, but the technologies for these alternatives are well understood and the facilities for soil treatment and disposal are available in the region surrounding Travis AFB. No prohibitive permitting or administrative barriers to implementation would be expected for the treatment alternatives because the location is under the control of Travis AFB and only the substantive requirements of permitting would have to be followed.

Cost

The estimated present worth costs for each alternative, broken out by capital and O&M costs, are indicated in the table below. These costs were calculated using the RACER/ENVEST™ cost estimating model. Section 4.4 provides more detail on the procedures and assumptions used to estimate costs. Appendix B presents the cost summary worksheets, which itemize the various capital and O&M costs for each alternative. Table 7-9 displays each alternative's total present worth cost rounded to two significant figures, from the table below, as well as indicates into which cost scoring category (refer to Table 4-8) each cost falls.

Cost Summary for Group R Alternatives

Alternative	Capital Costs	Operation and Maintenance Present Worth	Total
#16	$0	$0	$0
#17	$0	$100,000	$100,000
#18	$300,000	$0	$300,000
#20	$3,600,000	$0	$3,600,000

The alternatives that would require excavation and disposal of the contaminated soil would cost more than the other alternatives. The no action alternative, Alternative 16, would not have any cost and was rated 5. Alternative 17 was rated 5 and would cost $0.10 million, all in O&M costs. Alternative 18 was rated 5 and would cost $0.30 million, all in capital costs. Alternative 20 had the highest cost, $3.6 million.

7.8.3 Comparative Analysis of Group R Alternatives

The highest total scores for alternatives were associated with alternatives which would eliminate the potential for ecological exposure at the sites by excavating the soil. Alternatives 16 and 17, the no action alternative and the institutional actions alternative, both had the lowest total score (total of 10) because neither would treat nor prevent exposure to contamination. Alternatives 18 and 20 had the highest total scores (21 and 24, respectively) because they would remove the potential for exposure to the contaminated soil at the site. Alternative 20 had the highest total score because it would treat and destroy the organic contaminants.

The benefit/cost ratios indicate that increasing effectiveness between alternatives would be matched with increasing costs. Alternative 16, the no action alternative, had a ratio of 0 because it would not be effective. Alternative 17 also had a benefit/cost ratio of 0 because institutional actions would not provide protection to ecological receptors or comply with ARARs. Alternatives 18 and 20 had ratios of 43 and 4.4, respectively. Alternative 20 scored lower because additional cost would not be offset by additional effectiveness.

Alternatives 18 and 20 would at least partially meet the threshold criteria, Overall Protection of Human Health and the Environment and Compliance with ARARs. Therefore, those alternatives should be considered for addressing soil contamination. Alternative 16 would not meet either criteria and should not be considered.

Alternative 17, while scoring 0 for all effectiveness criteria, should continue to be considered since the nature and extent of ecological risks at this site have not been finalized.

On 31 May 1996, the final document, *Comprehensive Basewide Ecological Risk Assessment - Tier 2: Screening Assessment*, (CH2M Hill, 1996) was published to provide a basewide analysis of ecological risks at Travis AFB. This document contains preliminary ecological remedial goals (PERGs) (see Table 9-2 in Tier 2 report) for contaminants in sediment. These PERGs will factor into the Proposed Plan and ROD negotiations to establish cleanup levels for sediments at Sites SD033 and SD001.