Section 11. Identification and Screening of Technologies and Process Options

This section identifies GRAs and evaluates available technologies and process options to address the RAOs for Parcel E-2 discussed in Section 9. The section is organized as follows:

- Subsection 11.1 presents the selected GRAs for each media type at the Parcel E-2, which includes the Landfill Area, Panhandle Area, East Adjacent Area, and Shoreline Area (Figure 11-1).
- Subsection 11.2 identifies the criteria used to evaluate specific technologies and process options for each GRA.
- Subsections 11.3 through 11.6 present the detailed evaluations of each GRA with respect to media at Parcel E-2.
- Subsection 11.7 provides a summary of the evaluations.

Some of the GRAs being evaluated in this FS for remediation of wastes have the potential to impact the freshwater and tidal wetlands in the Panhandle and Shoreline Areas, south and west of the landfill. Depending on the nature of the remedial alternative selected, wetlands mitigation may be required. Subsection 11.8 summarizes the available wetland mitigation alternatives discussed in Appendix O.

The GRAs, associated remedial technologies, and process options have been screened to determine which ones most appropriately meet the RAOs. GRAs considered for Parcel E-2 are institutional actions (including monitoring and institutional controls), containment, and removal. These GRAs have been evaluated individually and in combination with others. Within each GRA, remedial technologies, such as containment through capping, are identified to address the media, characteristics, and objectives specific to Parcel E-2. Within each remedial technology, process options are identified. For example, the capping remedial technology includes various process options such as a monolithic soil cover, a multilayer soil cover, or a multilayer soil and geotextile cover.

This FS report focuses the process option analysis, consistent with the presumptive remedy approach for CERCLA municipal landfills, to a limited set of GRAs and remedial technologies. In addition, the heterogeneous contaminant distribution in the adjacent areas (the Panhandle Area, East Adjacent Area, and Shoreline Area) limits the types of potential response actions that are potentially applicable, and requires that these response actions be applied throughout Parcel E-2.

The following EPA guidance documents were used in developing the focused approach for this FS:

- Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites (EPA, 1991a)
- Presumptive Remedy for CERCLA Municipal Landfill Sites (EPA, 1993a) (Appendix H)
- Presumptive Remedy: Policy and Procedures (EPA, 1993b) (Appendix H)
- Feasibility Study Analysis for CERCLA Municipal Landfill Sites (EPA, 1994) (Appendix H)
- Application of the CERCLA Municipal Presumptive Remedy to Military Landfills (EPA, 1996) (Appendix H)

Also, information from the NCP, 40 CFR Section 300.430 (a)(1)(iii)(B), was considered. The NCP states that containment technologies are likely to be appropriate for sites with relatively low-level threats or where treatment is impractical.

Containment has been identified in these guidance documents as the most likely response action at municipal landfill sites because these landfills are primarily composed of municipal waste and a lesser proportion of hazardous waste, and they often pose a low-level threat rather than a principal threat (EPA, 1991a). The volume and heterogeneity of waste typically found within CERCLA municipal landfills often make treatment impractical (EPA, 1991a). In support of this determination, the EPA examined the technical literature and technology screening and remedy selection process at 30 CERCLA municipal landfills, and found that containment was selected at all 30 sites (EPA, 1994). Remedial technologies associated with collection, treatment, and discharge were routinely screened out, primarily because of their difficult implementation and high cost. The remedial technologies that were routinely screened out included excavation/disposal, bioremediation, chemical destruction, thermal treatment, chemical/physical extraction, thermal desorption, and immobilization (EPA, 1994).

As presented in Subsection 8.8.1, the Parcel E-2 Landfill meets all of the criteria specified in EPA guidance for application of the containment presumptive remedy. However, the Navy has agreed to evaluate excavation of the landfill as part of this report to provide information to support the community's review of potential remedial alternatives for Parcel E-2. Therefore, the remedial technologies and process options identified and screened in this section are limited to those related to the containment and removal GRAs.

Evaluation of the containment GRA also includes addressing groundwater in Parcel E-2 and leachate emanating from the Parcel E-2 Landfill. This evaluation is provided for completeness, despite the uncertainty of the human and ecological risk from exposure to groundwater, and as a formal evaluation of the current GES in the southeast portion of Parcel E-2 (that was installed as part of an interim action).

11.1. APPLICABLE GENERAL RESPONSE ACTIONS

This subsection describes the GRAs to be evaluated for achieving the Parcel E-2 RAOs (Section 9). The RAOs were established to address potential exposure pathways that could affect human health and the

environment from affected media at Parcel E-2. The following GRAs have been selected for Parcel E-2 media:

GRA	General Description	Applicable Media
No Action	No-action GRA is required by the NCP; used as a baseline for comparison	Solid waste, soil, sediment, landfill gas, groundwater, and surface water
Institutional Actions	Includes institutional controls, engineering controls, and site monitoring	Solid waste, soil, sediment, landfill gas, groundwater, and surface water
Containment Actions (with or without collection, treatment, and/or disposal)	Includes technologies that isolate media to reduce or eliminate exposure to, and off-site migration of, surface and subsurface contaminants	Solid waste, soil, sediment, landfill gas, and groundwater
Removal Actions	Includes removal of contaminated media for treatment and/or disposal off site; exposure risk and migration potential are diminished by eliminating or reducing the contaminant source	Solid waste, soil, and sediment

As shown in the table above, all affected media are evaluated for both the institutional action and containment action GRAs, with the exception of surface water. As discussed in Subsection 6.2.5, surface water runoff (including runoff from freshwater wetlands located in the Panhandle Area) can be contaminated through surface erosion and could result in unacceptable exposures to aquatic receptors in the Bay. However, this potential exposure can be effectively controlled by management (through implementation of BMPs) and monitoring of surface water runoff should be evaluated as part of any remedial alternative that leaves contaminated soil in place. Therefore, only institutional actions are evaluated for potentially affected surface water at Parcel E-2.

The following subsections describe the GRAs appropriate for addressing contaminated media at Parcel E-2 in more detail.

11.1.1. No Action

Consideration of the No Action GRA is required by the NCP, and is used as a baseline against which other remedial actions are compared.

11.1.2. Institutional Actions

Actions that can be taken to limit exposure to hazardous chemicals in media at Parcel E-2 include both institutional and engineering controls. In addition, site monitoring can be used to track the effectiveness of the remedy alternative or to verify that hazardous chemicals in media at the site do not migrate and impact human or ecological receptors.

Institutional controls, as defined by the U.S. Department of Defense (DoD) (DoD, 2001), are non-engineering measures limiting potential exposures to a site or media of concern, or ensuring that engineering measures designed to remediate a site, or limit access to a site, remain in place. Similarly, the EPA defines institutional controls as "non-engineering measures designed to prevent or limit exposure to hazardous substances left in place at a site, or assure effectiveness of a selected remedy."

Engineering controls are implemented technologies that serve to reduce exposure to contaminants in media. Examples of engineering controls include fencing and other physical barriers, which can be effective in limiting access to contaminated media.

Under CERCLA, site monitoring is a required component for any site remedy. Short-term monitoring is conducted to ensure that potential risks to human health and the environment are controlled while a site remedy is being implemented. Long-term monitoring can be used to track site contaminants after an active remedial technology has been used or to ensure that hazardous chemicals are not migrating off site at concentrations that might affect humans or the environment.

11.1.3. Containment Actions (With or Without Collection, Treatment, and/or Disposal)

Containment actions include technologies that isolate contaminated media from human and environmental receptors. For contaminated solid waste, soil, and sediment, containment technologies are meant to minimize disturbance to the surfaces of those media, and reduce or eliminate off-site migration of surface and subsurface contaminants. These actions are effective at preventing direct contact with these media as well as their migration by surface water, air (wind erosion), subsurface air (landfill gas), or groundwater.

Containment technologies for unlined landfill waste and soil typically include surface controls, such as runoff controls, erosion controls, and capping. Process options include the various types of caps, shoreline protection options, and drainage enhancements.

Containment of landfill gas is typically achieved by collection and treatment of landfill gas through a gas control system, which can minimize or prevent off-site subsurface migration and accumulation of the gas above explosive concentrations. Process options include passive gas venting and active gas collection.

Containment actions for groundwater refer to actions that isolate the contaminant source or impacted groundwater from downgradient areas to prevent further contaminant migration. Technologies typically used for groundwater containment include physical barriers, such as sheet pile or slurry walls and hydraulic barriers, such as extraction wells. Depending on the concentration of contaminants present, groundwater collected with hydraulic barriers can be disposed of off site, discharged to the surface, discharged to a publicly-owned treatment facility for additional treatment, or reinjected into the ground after treatment. Numerous technologies are used for water treatment, most of which are contaminant- and site-specific.

11.1.4. Removal Actions

Removal actions refer to removing contaminated media from a site to significantly reduce or eliminate the risk of exposure to humans and ecological receptors. Removal actions for contaminated solid waste, soil, and sediment would require excavation and disposal off site at a facility approved to receive the waste.

11.2. EVALUATION CRITERIA FOR TECHNOLOGIES AND PROCESS OPTIONS

The technologies and associated process options selected for this evaluation have been screened using three criteria:

1. Effectiveness: Effectiveness is a judgment regarding the potential for the technology and process options to address the area and volume of contaminated media adequately and reliably. It also identifies any impacts to human health and the environment caused by the implementation of the technology.
2. Implementability: Implementability is an evaluation of the technical appropriateness and the administrative implementability of the technology for the impacted media.
3. Cost: Cost is an approximation of the dollar value of the project; it is neither a bid cost nor an engineer's estimate and, in some cases, is a relative cost (high, medium, or low) rather than a quantified value.

Two issues in evaluating the effectiveness and implementability of all of the technologies and process options are future land use and local climate. According to the redevelopment plan, most of the planned reuse for Parcel E-2 is open space. Other planned reuses of areas within Parcel E-2 include industrial and research and development (SFRA, 1997). As discussed in Subsection 1.8, land uses other than open space are incompatible with the landfill area, and restrictive covenants will address this incompatibility. Although the specific open space use has not been determined, it is assumed that the general public will have access to most of the Landfill Area and adjacent areas.

The following subsections describe remedial technologies and process options under each GRA that are appropriate for addressing solid waste, soil, sediment, landfill gas, groundwater, and surface water at Parcel E-2. The GRAs evaluated are: no action (Subsection 11.3), institutional actions (Subsection 11.4), containment (with or without collection, treatment, and/or disposal) (Subsection 11.5), and removal (Subsection 11.6). Each process option within the GRA is discussed for each media if applicable. The evaluation of the remedial technologies and process options is presented in Figure 11-2.

11.3. NO ACTION

As discussed above, the NCP requires evaluation of the no action response for all media to provide a baseline for comparison to other response actions. Under this GRA, no additional action would be taken to address:

- Contaminated solid waste and soil in the Landfill Area and isolated solid waste, soil and sediment in the adjacent areas (as described in Section 2, a portion of the Landfill Area has been capped with an engineered multilayer cap, and the remainder has been covered with an approximately 2-foot-thick layer of soil)
- Landfill gas
- Groundwater
- Surface water

Under this GRA, engineered systems currently in place (landfill cap/cover, gas control system, and groundwater extraction system) would remain in place, but would not be maintained. In addition, no landfill gas, groundwater, or surface water monitoring would be performed under the no action GRA.

No Action General Screening

- Effectiveness: Low
- Implementability: High
- Cost: No cost
- Retained for Further Analysis: Yes (to provide a baseline for comparison to other response actions for each of the impacted media at Parcel E-2)

11.4. INSTITUTIONAL ACTIONS

The following subsections address the remedial technologies and process options under the institutional action GRA applicable to the impacted media at Parcel E-2. The three remedial technologies are: 1) institutional controls (Subsection 11.4.1); 2) engineering controls (Subsection 11.4.2); and 3) site monitoring (Subsection 11.4.3). The evaluation of the remedial technologies and process options under the institutional action GRA is presented in Figure 11-2.

11.4.1. Institutional Controls

Institutional controls are legal and administrative mechanisms used to implement land use and access restrictions that are used to limit the exposure of future landowner(s) and/or user(s) of the property to hazardous substances and to maintain the integrity of the remedial action until remediation is complete and remediation goals have been achieved. Monitoring and inspections are conducted to assure that the land-use restrictions are being followed.

A summary of institutional control process options and their applicability to Parcel E-2 is provided below:

Legal Mechanisms

- Restrictive covenants: The Navy has determined that it will rely upon proprietary controls in the form of environmental restrictive covenants as provided in the "Memorandum of Agreement (MOA) Between the United States Department of the Navy and the California Department of Toxic Substances Control" and attached covenant models (2000) (hereinafter referred to as "Navy/DTSC MOA"). More specifically, land use restrictions will be incorporated into and

implemented through two separate legal instruments as provided in the Navy/DTSC MOA: 1) restrictive covenants included in one or more Quitclaim Deeds from the Navy to the property recipient; and 2) restrictive covenants included in one or more "Covenant to Restrict Use of Property" entered into by the Navy and DTSC as provided in the Navy/DTSC MOA and consistent with the substantive provisions of 22 CCR Section 67391.1. The "Covenant to Restrict Use of Property" will incorporate the land use restrictions into environmental restrictive covenants that run with the land and that are enforceable by DTSC against future transferees. The Quitclaim Deed(s) will include the identical land use restrictions in environmental restrictive covenants that run with the land and that will be enforceable by the Navy against future transferees. Land use restrictions will be applied to the property and included in findings of suitability to transfer, findings of suitability for early transfer, "Covenant to Restrict Use of Property" between the Navy and DTSC, and any Quitclaim Deeds conveying real property containing HPS Parcel E-2. Restrictive covenants will be recorded to limit land uses within the adjacent areas to open space, to prohibit the use of A-aquifer groundwater, to protect groundwater monitoring equipment, require compliance with a soil and groundwater management plan, and to preserve access to the sites and associated monitoring equipment for the Navy and the FFA signatories. Additional institutional controls will include establishment of an easement (to perform remediation activities on non-Navy property).

- Negative easements: At remediation sites, easements are often used to maintain the integrity of containment units, such as landfill caps, that extend onto private property. Such easements include affirmative easements that are used to secure access to the property, and negative easements that are used to control property use that is incompatible with the containment units. For remedial alternatives that leave waste in place, the portion of the Parcel E-2 Landfill that extends onto property owned by UCSF will require both affirmative and negative easements to maintain the containment systems.
- Deed notifications: Certain environmental factors may exist which do not prompt land use restrictions but instead require deed notifications. These environmental factors may include both CERCLA factors (such as identifying the presence of hazardous substances as defined by CERCLA) and non-CERCLA factors (such as identifying the potential presence of asbestos-containing materials). Notices will be specified in the deed to inform the transferee of relevant environmental conditions of the property.

Administrative Mechanisms

- Local land use plans and ordinances: The redevelopment plan for HPS serves as the primary administrative mechanism for the cleanup of Parcel E-2, by providing the basis for identifying the planned reuses; this information is then used to develop the appropriate remedial alternatives to protect human health and the environment. Therefore, reuse of the HPS property in accordance with the planned reuse helps ensure the protectiveness of the final remedy. Other local ordinances that may be appropriate for Parcel E-2 include a prohibition on installation of groundwater wells for domestic use.
- Soil and groundwater management procedures and policies: The proper management of contaminated soil, sediment, solid waste, and groundwater during construction activities is necessary to control exposure to site workers, and will be administered through a soil and groundwater management plan. This soil and groundwater management plan is anticipated to be

developed by the transferee and to be implemented during post-transfer site development activities.

- Construction permitting: The establishment of permitting requirements for future construction activities is anticipated to be a primary means of implementing the soil and groundwater management plan. Requirements would include notification and procedural steps for a variety of construction activities, including excavation and subsurface drilling.
- Public notices and educational materials: Advising the public of the presence of contaminated media at Parcel E-2 and communicating the policies and procedures used to minimize exposures would assist in ensuring the protectiveness of the remedy. Specific actions may include the posting of public notices prior to construction activities and the publication of educational material regarding how exposures to hazardous substances are controlled.

Institutional controls, including the legal and administrative mechanisms discussed above, are intended to manage risk associated with exposure to contaminated solid waste, soil, sediment, or groundwater by limiting the potential for ingestion, inhalation, and dermal contact. These institutional controls are anticipated to be required to enforce a variety of land use restrictions for Parcel E-2, which are summarized below:

- Restrict the use of the parcel to open space
- Require maintenance of control systems
- Maintain the integrity of covers (or access restrictions where covers are not present)
- Ensure compliance with 27 CCR postclosure land use requirements for structures within 1,000 feet of a landfill
- Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as subsurface construction)
- Restrict the use of groundwater within the Parcel E-2 boundaries
- Prohibit the installation of wells that have the potential to affect the migration of contaminated groundwater within Parcel E-2.

An evaluation of institutional controls based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Under existing conditions, institutional controls alone would not be effective at controlling human and ecological risk at the site. However institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.

Implementability

Institutional controls would be readily implementable. The Navy, as the current owner of the property, would establish covenants with the DTSC and easements with the UCSF, and would include restrictions in the property deed to enforce land use restrictions, as necessary, to control exposure and to ensure the

integrity of any final remedy at Parcel E-2. Various policies and procedures would be established to implement the land use restrictions, and would require ongoing administration and enforcement to ensure their effectiveness.

Cost

The cost of implementing institutional controls would be low, but would be incurred over a relatively long time period. This time period is assumed, for estimating purposes, as 30 years in order to be consistent with the minimum period for postclosure maintenance, as specified in 27 CCR. Institutional controls will be maintained until it is demonstrated the landfill no longer poses a threat to the environment and human health, and when regulatory agency approval has been obtained. Costs would include regular administration and enforcement tasks associated with implementing the soil and groundwater management plan.

Institutional Controls General Screening

- Effectiveness: High (if used to maintain the integrity of a final remedy)
- Implementability: High
- Cost: Low
- Retained for Further Analysis: Yes

11.4.2. Engineering Controls

Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options for engineering controls include warning and no trespassing signs, engineered barriers to vehicular traffic, and perimeter fencing to reduce the potential for direct human contact with contaminated media. Engineering controls may also include BMPs; however, these may be implemented as part of a short- or long-term monitoring program, and thus are discussed under the site monitoring (Subsection 11.4.3). Engineering containment systems, such as landfill caps and gas control systems, are discussed under the containment GRA and, for the purposes of this report, are not considered under the institutional action GRA. An evaluation of engineering controls based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Under existing conditions, engineering controls could assist in meeting the specified RAOs; however, long-term access restrictions would conflict with the planned open space reuse for Parcel E-2. The short-term use of fencing, warning signs, and other access restrictions would be effective during implementation of a remedial alternative (e.g., to restrict access during construction activities). In addition, small-scale use of fencing and warning signs (e.g., to restrict access to treatment equipment) would be effective in minimizing exposure to contaminated media. Therefore, engineering controls are not considered effective as a part of a permanent remedy at Parcel E-2, but could be used during implementation of an active remediation technology.

Implementability

Engineering controls would be readily implementable on a short-term basis, and would face no technical or administrative issues associated with implementation. However, implementability would be low in the long term, as most engineering controls would restrict site access, thereby conflicting with the planned reuse of Parcel E-2 as open space.

Cost

The cost of implementing engineering controls to prevent access would be low, but would be incurred over a relatively long time period (approximately 30 years). Capital costs would include (but not be limited to) installation, inspection, and maintenance of security fencing (which already exists at Parcel E-2) and installation of warning signs.

Engineering Controls General Screening

- Effectiveness: Low (if used as part of a permanent remedy); High (if used during implementation of an active remediation technology)
- Implementability: Low (if used as part of a permanent remedy); High (if used during implementation of an active remediation technology)
- Cost: Low
- Retained for Further Analysis: No (not considered as part of a permanent remedy but can be used in conjunction with active remediation technologies)

11.4.3. Site Monitoring

Short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2. Monitoring would be used to track landfill gas migration, if waste were left in place. It would also be used to inspect and maintain the current interim (and any future permanent) gas collection system. Under the current landfill gas monitoring and control program, monitoring results are effectively tracking potential landfill gas migration. Monitoring data are evaluated to determine if any response actions are required (such as switching the current gas extraction system from passive to active collection mode).

Long-term groundwater monitoring would provide information regarding contaminant migration within and beyond the Parcel E-2 boundary. For this process option, site-specific data would be evaluated to determine if groundwater contamination migrating from the source area would be attenuated before groundwater reaches the compliance monitoring wells. A method for comparing groundwater data to aquatic criteria, in a manner that accounts for chemical attenuation and the near-shore mixing process, has not been agreed to by the Navy and the regulatory agencies. Long-term stormwater and groundwater discharge monitoring (from wells along the bay shoreline) would be used to demonstrate compliance with RAOs designed to prevent unacceptable exposures to aquatic receptors in the Bay.

Stormwater and landfill cap inspection is another type of monitoring that would be used to verify the effectiveness of BMPs and the integrity of the containment systems in both the short-term (during remedy implementation) and long-term (following remedy implementation). Regular inspections would identify any potential problems and necessary corrective actions, which would be implemented during regular maintenance activities. Additional short-term monitoring would include outdoor air monitoring during construction activities to monitor dust emissions and provide a mechanism to prompt additional control measures if needed.

The monitoring programs discussed above have been established at Parcel E-2, and their ongoing implementation provides the basis of the following evaluation. An evaluation of site monitoring based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

Future landfill gas monitoring programs would be highly effective at monitoring potential gas migration and triggering appropriate response actions assuming that landfill solid waste is left in place.

Long-term groundwater monitoring would be necessary and effective for assessing compliance with chemical-specific ARARs at the Parcel E-2 boundary. Additional monitoring wells may be needed to ensure the effective tracking of groundwater contamination within and beyond the Parcel E-2 boundary. A preliminary monitoring plan is presented in Subsection 12.1.2; this plan will be refined in the remedial design. If groundwater quality at the point of compliance (the Parcel E-2 boundary) does not meet the existing RAOs, supplementation with another remediation technology (such as containment) would be required along with groundwater monitoring.

The existing stormwater discharge management program has been shown to effectively monitor stormwater discharges and demonstrate that BMPs are effective in preventing discharge of surface runoff at concentrations exceeding applicable water quality criteria. The existing stormwater discharge management plan is updated on an annual basis, and would serve as an effective long-term means of monitoring and controlling surface water runoff. In addition, regular inspection and maintenance of the cap would ensure its integrity and effectiveness at containing the waste material.

Implementability

The existing monitoring programs for landfill gas, groundwater, and stormwater could readily be enhanced and converted into effective and long-term monitoring systems. Ongoing inspection and maintenance programs for stormwater BMPs and the interim landfill cap and gas control systems could be used to develop permanent operation and maintenance programs.

Cost

The cost of implementing monitoring programs for all applicable media would be low, but would be incurred over a relatively long time period (approximately 30 years). Capital costs would include expansion (as needed) and maintenance of the gas and groundwater monitoring network, as well as

stormwater BMPs and cap inspections/maintenance actions. The operational costs would include field sampling, laboratory analysis, data validation and evaluation, and reporting.

Site Monitoring General Screening

- Effectiveness: High (monitoring networks may require expansion to ensure that data can be used to verify compliance with RAOs)
- Implementability: High
- Cost: Low
- Retained for Further Analysis: Yes

11.5. CONTAINMENT (WITH OR WITHOUT REMOVAL, TREATMENT, AND/OR DISPOSAL)

The process options considered under the containment GRA are divided into three categories based on the media being addressed. The types of media addressed by containment are: 1) solid waste, soil, and sediment; 2) landfill gas; and 3) groundwater. Within each of these media, the process options summarized in the following table were considered:

Applicable Media	Remedial Technology	Process Options Evaluated Under Containment GRA
Solid waste,soil, and sediment	Caps/covers	▪ Low-permeability soil cap ▪ Geosynthetic cap ▪ Multilayer geosynthetic cap ▪ Evapotranspiration cap
	Shoreline protection [a]	▪ Armoring ▪ Beach stabilization structures ▪ Beach nourishment
Landfill gas [b]	Collection	▪ Passive venting ▪ Active collection
	Treatment [c]	▪ Adsorption ▪ Destruction (e.g., combustion)
Groundwater [d]	Physical barrier	▪ Sheet pile wall ▪ Slurry wall ▪ Grout curtain ▪ Vertical geomembrane
	Hydraulic barrier	▪ Extraction from wells and off-site discharge ▪ Phytoremediation

Notes:

a Shoreline protection is required to protect the containment structures from erosion via tidal or wave action; therefore, shoreline protection options are evaluated in conjunction with containment options

b Landfill gas collection may be required for any containment option that leaves waste in place; therefore, gas collection options are evaluated in conjunction with the containment GRA

c Treatment may be required for any landfill gas collected at Parcel E-2; therefore, treatment options are evaluated in conjunction with landfill gas collection options

d Groundwater containment options are being evaluated for completeness, despite the uncertainty of the human and ecological risk from exposure to groundwater, and as a formal evaluation of the current GES in the southeast portion of Parcel E-2

The following subsections address the remedial technologies and process options under the containment GRA applicable to the impacted media at Parcel E-2. The evaluation is divided into five subsections: 1) solid waste, soil, and sediment containment (Subsection 11.5.1); 2) shoreline protection (Subsection 11.5.2); 3) landfill gas collection (Subsection 11.5.3); 4) landfill gas treatment (Subsection 11.5.4); and 5) groundwater containment (Subsection 11.5.5). The evaluation of the remedial technologies and process options under the containment GRA is presented in Figure 11-2.

11.5.1. Solid Waste, Soil, and Sediment Containment

For solid waste, soil, and sediment in Parcel E-2, capping is the primary proposed containment technology. Capping is the primary containment technology for municipal solid waste according to the EPA guidance (EPA; 1991a, 1993a, 1994, and 1996); thus, it is the primary technology considered for the Landfill Area. Capping is also considered the primary containment technology for the East Adjacent, Panhandle, and Shoreline Areas because there are multiple, non-contiguous locations of potentially

contaminated waste and soil throughout these adjacent areas. For this reason, as discussed in Subsection 8.4.4, capping will be considered for uniform implementation throughout the adjacent areas.

The following capping and erosion protection process options are evaluated in this subsection:

- Low-Permeability Soil Cap
- Geosynthetic Cap
- Multilayer Geosynthetic Cap
- Evapotranspiration Cap

Table 11-1 summarizes the capping process option evaluations described in the following subsections.

11.5.1.1. Low-Permeability Soil Cap

Figure 11-3 shows a cross section of the low-permeability soil cap (27 CCR cover, prescriptive standard). The low-permeability soil cap system includes a low-permeability soil layer (such as clay) at least 12 inches thick, with a maximum permeability of 1×10^{-6} centimeter per second (cm/sec) or equal to the hydraulic conductivity of the base liner system, if any.

Use of a low-permeability soil cap discussed above would involve additional design and/or use considerations, as follows:

- The low-permeability soil layer would be placed on a minimum 2-foot-thick soil foundation layer, and an additional 1-foot-thick vegetative soil layer would cover the low-permeability soil layer.
- The purpose of the vegetative soil layer would be to protect the low-permeability layer and sustain plant growth in order to limit future erosion.
- This type of cap would be susceptible to damage by desiccation cracking, or by burrowing creatures or deep-rooted plants.
- Also, the low-permeability soil cap is generally less effective for minimizing infiltration than a cap containing a geomembrane.

An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This process option would meet the established RAOs. A low-permeability soil cap would be effective because it would: 1) allow for landfill gas control; 2) prevent direct contact of human and ecological receptors with waste; and 3) reduce stormwater infiltration.

Cap effectiveness is measured by the predicted quantity of precipitation infiltration allowed through the cap. High volumes of infiltration are not desirable because of the potential leachate generation and negative groundwater impacts. The Hydrologic Evaluation of Landfill Performance, Version 3 (HELP-3) computer model has been used to evaluate precipitation infiltration through various cap types. Based on

HELP-3 modeling, a low-permeability soil cap would allow an annual average infiltration of 5.7 inches per acre into the subsurface (Appendix P and Table 11-1).

Another measure of effectiveness for a cap is its ability to withstand the design seismic event. To determine that the conceptual cap designs presented for comparison in the FS are technically feasible, the Navy performed a liquefaction study (Appendix C) and a preliminary slope stability analysis (Appendix Q) using available site data and the maximum seismic event predicted to occur at the site. This evaluation indicates that no stability problems should arise under static or seismic conditions for a properly designed slope. If containment is selected as the final remedy, a detailed slope stability analysis will be performed on the final slope design to complement the previously performed analyses. The proper design and maintenance of a cap would minimize erosion, liquefaction, and slope stability concerns.

The potential impacts on human health and the environment from implementation of this process option would be short term. These include windblown dust during cap construction and sediment in stormwater runoff; however, soil used for the cap would not be contaminated, and off-site sediment migration could be adequately managed through proper construction techniques. No chemical constituents from the landfill are likely to be released during construction because minimal, if any, disturbance of the solid waste would occur.

This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. The cap must be properly maintained to ensure the effectiveness of the low-permeability soil layer and to prevent damage from burrowing animals and deep-rooted plants. With proper maintenance, the low-permeability soil cap would be durable and capable of sustaining foot traffic, which is anticipated for the planned open space reuse.

Implementability

Material within each area would be graded for proper drainage prior to capping. Throughout the Shoreline Area, erosion protection measures are required to protect the cap. The shoreline protection technologies are discussed in Subsection 11.5.2. Implementation of the capping and erosion protection technologies may require restrictions on future land use because contaminated solid waste, soil, and sediment would be left in place. Capping and installing erosion protection would require excavation and placement of fill on existing wetlands in the Panhandle and Shoreline Areas. Existing wetlands that may be permanently affected by cap and shoreline protection construction would be mitigated by the construction of wetlands in the Panhandle Area.

Another parameter affecting the implementability and cost of each cap type is the availability of materials. Each type of capping process would require imported soil. The foundation layer soil must be structurally stable, but the requirements for this layer are not as stringent as those for a low-permeability soil layer. The vegetative layer soil must be capable of supporting vegetative growth, but a wide variety

of soils are suitable. The low-permeability soil layer generally must consist of a clay material possessing specific properties to provide low permeability after placement.

A low-permeability soil cap could be constructed at Parcel E-2, but a high level of quality control would be required during placement of the low-permeability soil layer. Insufficient compaction or improper moisture conditioning may prevent the permeability requirements from being met. Skilled labor, and proper supplies, and equipment are required to allow proper implementation of this process option. There is no known, local source of the low-permeability soil needed to construct a low-permeability soil cap, and the regional availability of a suitable low-permeability soil material(s) cannot be accurately determined until the timing for construction is known. Off-site quarry testing investigations are generally required to ascertain if suitable low-permeability soil is available. Typically, the foundation layer soil and vegetative layer soil are the most readily available and the low-permeability layer soil is more difficult to obtain.

Cost

The cost of a low-permeability soil cap would be moderately high as compared to other cap designs, because of the need to purchase and import suitable low-permeability soils. Maintenance costs for a low-permeability soil cap are comparable to those associated with other cap alternatives.

Solid Waste, Soil and Sediment Containment - Low-Permeability Soil Cap General Screening

- Effectiveness: High
- Implementability: Moderate-High (with proper quality assurance/quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate-High (costly to purchase and import suitable low-permeability soils)
- Retained for Further Analysis: No

11.5.1.2. Geosynthetic Cap

Figure 11-4 shows a cross section through the geosynthetic cap (27 CCR cover, engineered alternative). The geosynthetic cap is considered in this FS primarily to address possible difficulties and costs in obtaining suitable low-permeability soil. The geosynthetic cap system would include an HDPE geomembrane 60-mil in thickness in place of the low-permeability soil layer (1 mil is equivalent to 0.001 inch). The typical permeability of an HDPE geomembrane is 1×10^{-13} cm/sec. A properly constructed 60-mil HDPE liner provides better performance against infiltration than a 12-inch-thick soil layer with a permeability of 1×10^{-6} cm/sec. Similar to the low-permeability soil layer in a low-permeability soil cap, the geomembrane would be placed on a soil foundation layer. A geocomposite drainage layer would be placed on top of the geomembrane, where necessary, to provide a drainage path for water infiltrating through the vegetative layer. A vegetative soil layer consisting of 18 inches of soil to support plant growth would cover the geomembrane/geocomposite drainage layer.

The geosynthetic components of the cap would provide good protection against burrowing animals, roots, and desiccation cracking as compared to a low-permeability soil layer. In addition, the geomembrane would allow much less infiltration than a low-permeability soil layer. An evaluation of this process option based on effectiveness, implementability, and cost is briefly summarized in the following text.

Effectiveness

This process option would meet the established RAOs. A geosynthetic cap would: 1) enhance landfill gas control; 2) prevent direct contact of human and ecological receptors with waste; and 3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Subsection 11.5.1.1. Based on HELP-3 modeling, a geosynthetic cap would allow an annual average of 0.03 inch per acre of infiltration into the subsurface (Appendix P and Table 11-1). This infiltration rate is based on having a completely intact HDPE liner, free from defects, cracks, tears, or pinholes. If the geomembrane is punctured, the infiltration rate would increase.

Similar to the low-permeability soil cap, potential impacts on human health and the environment from implementation of this process option would be short-term and could be managed through proper construction techniques. This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. Proper design and maintenance would minimize erosion, liquefaction, and slope stability concerns. The cap is durable and could handle foot traffic. In addition, this cap would resist damage from deep-rooted plants, desiccation cracking, and burrowing animals more effectively than a low-permeability soil cap.

Implementability

As discussed in Subsection 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the geosynthetic cap, the material requirements for the foundation and vegetative layer would be similar as for the low-permeability soil cap. The low-permeability layer would consist of a geosynthetic material possessing specific properties to provide low permeability after placement.

A geosynthetic cap would be implementable and would provide performance advantages over a low-permeability soil cap. The advantages are mainly due to the use of geosynthetic materials as the predominant impermeable layer, as opposed to a low-permeability soil. Soil needed for the foundation and vegetative layers is readily available from local sources, and the geosynthetic materials required could be easily obtained. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this process option. In addition, the geosynthetic materials are manufactured under shop conditions with high-quality control and, assuming that the installation is performed by properly-trained personnel and with adequate construction quality control, the resulting quality and performance of the cap is expected to be consistent and predictable, thereby ensuring an effective barrier to infiltration. No administrative issues are associated with the implementation of this process option.

Cost

The cost of a geosynthetic cap would be moderate, as it generally costs the same or less to install than a low-permeability soil cap (which depends on the availability of suitable low-permeability soil). A geosynthetic cap would also cost less to install than a multilayer geosynthetic cap. Maintenance costs for a geosynthetic cap are similar to those associated with other cap alternatives.

Solid Waste, Soil and Sediment Containment - Geosynthetic Cap General Screening

- Effectiveness: High
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate
- Retained for Further Analysis: Yes

11.5.1.3. Multilayer Geosynthetic Cap

Figure 11-5 shows a cross section of a multilayer geosynthetic cap. A multilayer geosynthetic cap has already been installed over a portion of the Landfill Area in response to the August 2000 fire. This type of landfill cap is considered to meet or exceed the established RAOs for solid waste, soil, and sediment.

The multilayer geosynthetic cap includes a composite low-permeability layer consisting of an HDPE geomembrane at least 60 mils thick over a geosynthetic clay liner (GCL). The composite low-permeability layer is placed on a soil foundation layer, and the geomembrane is overlain by a geocomposite drainage layer, where necessary, to provide a drainage path for water infiltrating through the vegetative layer. The geomembrane/geocomposite drainage layer is covered by an 18-inch-thick vegetative soil layer capable of supporting plant growth.

Effectiveness

This process option would meet the established RAOs. A multilayer geosynthetic cap would: 1) enhance landfill gas control; 2) prevent direct contact of human and ecological receptors with waste; and 3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Subsection 11.5.1.1. Based on HELP-3 modeling, a multilayer geosynthetic cap would allow an annual average infiltration of 0.03 inches per acre into the subsurface (Appendix P and Table 11-1). The presence of a GCL would provide additional protection against leakage through pinholes or small tears in the geomembrane. The GCL is composed of bentonite sandwiched between two geotextile layers, and has a permeability of $5x10^{-9}$ cm/sec or less. The unique attributes of the bentonite include:

- High swell and water adsorption potential
- Low permeability (lowest of all naturally occurring soil)
- Chemical stability (inert mineral)

One advantage of a GCL in the composite layer system is the swell capability of the bentonite when it becomes hydrated. Bentonite, when hydrated, will swell into the defect in the overlying geomembrane to impede infiltration. The interaction between the two components of the composite cap creates a self-sealing system that is extremely impermeable to infiltration. In addition, the self-sealing properties of the composite cap will limit landfill gas emissions in a variety of site conditions. Because of the higher volume and proportion of putrescible waste in the landfill relative to the adjacent areas, the extra protection afforded by the composite cap is important to the control of landfill gas emissions.

Similar to the other capping options, the potential impacts on human health and the environment from this process option would be short term and could be adequately managed through proper construction techniques. This type of cap is proven and reliable in the climatic conditions present at Parcel E-2. Proper design and maintenance would minimize erosion and slope stability concerns. The cap is durable and could handle moderate traffic. In addition, this cap would resist damage from deep-rooted plants and burrowing animals more effectively than a low-permeability soil cap.

Implementability

As discussed in Subsection 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the multilayer geosynthetic cap, the material requirements for the foundation and vegetative layer would be similar as for the low-permeability soil cap. The low-permeability layer would consist of two different geosynthetic materials possessing specific properties to provide low permeability after placement.

Similar to the geosynthetic cap, the multilayer geosynthetic cap would be implementable and would provide performance advantages over a low-permeability soil cap. The types of soils and materials needed to construct a multilayer geosynthetic cap are readily available locally, and skilled labor, supplies, and equipment are sufficient to allow proper implementation of this process option. Assuming that the installation is performed by properly-trained personnel and with adequate construction quality control, the resulting quality and performance of the cap is expected to be consistent and predictable, thereby ensuring an effective barrier to infiltration. No administrative issues would impact the implementability of a multilayer geosynthetic cap.

Cost

A multilayer geosynthetic cap would cost moderately more than a geosynthetic cap, and is comparable in price to a low-permeability soil cap. Maintenance costs for a multilayer geosynthetic cap are similar to the other capping options.

Solid Waste, Soil and Sediment Containment - Multilayer Geosynthetic Cap General Screening

- Effectiveness: High (most effective of the containment barriers screened for this evaluation)
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)

- Cost: Moderate-High
- Retained for Further Analysis: Yes

11.5.1.4. Evapotranspiration Cap

Figure 11-6 shows a cross section of an evapotranspiration cap. An evapotranspiration cap is typically a 4- to 6-foot-thick soil layer over a soil foundation layer. The evapotranspiration cap acts to store moisture within the cap thickness, while minimizing infiltration, until the moisture is removed through vegetative uptake or evaporation. The soil layer consists of specially selected soils planted with fast-growing trees, shrubs, and grasses. The soil pores hold moisture like a sponge until plant roots can access the water. Plants take up this water for growth and release it into the atmosphere through transpiration. The system would be designed to be thick enough and with enough vegetation to minimize infiltration of the expected precipitation at the landfill.

An evapotranspiration cap is more appropriate for arid and semi-arid climates typical of southern California, and requires a rigorous infiltration analysis and post-construction moisture monitoring. This cap is more susceptible to burrowing animals and may be less effective at minimizing infiltration than cap systems that include a geomembrane layer. This type of cap also requires large volumes of soil material to meet its thickness requirement. In addition, this cap requires the establishment of a robust vegetative growth, which can require several growing seasons to develop. The vegetative growth may also not be compatible with certain types of end uses, and can be susceptible to damage by animals, humans, and climatic changes.

Effectiveness

This technology may meet the established RAOs. An evapotranspiration cap would: 1) allow for landfill gas control; 2) prevent direct contact of human and ecological receptors with waste and soil exceeding evaluation criteria; and 3) reduce stormwater infiltration. In addition, proper design and maintenance would minimize erosion and slope stability concerns. The infiltration modeling used to evaluate the effectiveness of each cap type was discussed in Subsection 11.5.1.1. However, the HELP-3 model is not appropriate for evaluating the performance of an evapotranspiration cap, and a more extensive modeling would be required if an evapotranspiration cap is considered a viable process option. As discussed below, the evapotranspiration cap is not expected to be effective at this site due to the climatic conditions. Therefore, the more extensive modeling required for an evapotranspiration cap was not performed.

For non-irrigated end uses in arid and semi-arid areas, the performance of an evapotranspiration cap can be comparable to other cap alternatives; however, the more temperate climate in northern California diminishes the effectiveness of this type of cap. This is because the rate of evaporatranspiration may not adequately eliminate the water percolating through the cap during the wet season. Landfill gas collection, particularly active collection, may also be less effective with this type of cap.

Implementability

As discussed in Subsection 11.5.1.1, the availability of materials is a major parameter that affects the implementability of each cap type. For the evapotranspiration cap, the material requirements for the foundation and vegetative layer would be similar as for the other cap types. The low-permeability layer from the other cap types would be replaced by a relatively thicker soil cover consisting of a sandy material with sufficient content of fine-grained soil to retain moisture.

In all likelihood, it would not be possible to construct an evapotranspiration cap in the northern part of Parcel E-2 without encroaching on neighboring property to the north. The required soil thickness of 4 or more feet would result in a final cap elevation several feet higher than the surrounding area and, because of the close proximity of waste to the UCSF compound, the resulting transition slope would likely encroach on the UCSF compound. The thickness of this cap would induce heavier loads on the subgrade and might cause additional settlement. In addition, this type of cap would require a significantly higher volume of truck or rail traffic through the local community to deliver the quantity of import soil necessary to construct the cap.

Similar to the other capping options, the potential impacts on human health and the environment from implementation of this process option would be short term and could be adequately managed through proper construction techniques. No administrative issues are associated with the implementation of this process option.

Cost

The cost of constructing an evapotranspiration cap would be moderate to high considering the volume and specialized properties of the required import soil. Because soil for an evapotranspiration cap generally must be a sandy material, but must also contain a sufficient amount of fine-grained soil to retain moisture, mixing of two or more different soil sources may be needed to achieve the required properties, and such a mixing effort would result in higher costs. Maintenance costs for an evapotranspiration cap are similar to those associated with other capping options.

Solid Waste, Soil and Sediment Containment - Evapotranspiration Cap General Screening

- Effectiveness: Moderate (diminished effectiveness in temperate climates; ideal in arid or semi-arid climates)
- Implementability: Low (would require importation of a significant amount of cover soil and may encroach on neighboring property)
- Cost: Moderate to High
- Retained for Further Analysis: No

11.5.2. Shoreline Protection

Shoreline protection works are used to retain or rebuild natural systems (cliffs, dunes, wetlands, and beaches) or to protect man-made structures (buildings, infrastructure, engineered berms, etc.) landward of

the shoreline. In the case of Parcel E-2, shoreline protection is necessary to protect the Landfill Area and adjacent areas from erosion and to allow wetlands to be rebuilt in the Panhandle and Shoreline Areas.

The following erosion protection process options are evaluated in this subsection:

- Armoring
- Beach stabilization structures
- Beach nourishment

Similar to the evaluation of solid waste and soil containment options, the ability of the shoreline containment system to withstand the design seismic event was evaluated. This evaluation was discussed in Subsection 11.5.1.

11.5.2.1. Armoring

Armoring includes seawalls, bulkheads, and protective revetments. The primary purpose of a seawall is to prevent inland flooding from major storm events accompanied by large, powerful waves. The key functional element in the design of a seawall is the crest elevation to minimize the overtopping from storm surge and wave runup. A seawall is typically a massive concrete structure with its weight providing its stability. Bulkheads are vertical retaining walls to hold or prevent soil from sliding seaward. Their main purpose is to reduce land erosion and loss to the sea, not to mitigate coastal flooding and wave damage. Bulkheads are either cantilevered or anchored sheet piles or gravity structures, such as rock-filled timber cribs and gabions. Revetments are a cover or facing of erosion resistant material placed directly on a slope, embankment, or dike to protect the area from waves and strong currents.

Effectiveness

Armoring would meet the established RAOs. Armoring would: 1) protect the containment systems in the Landfill Area and adjacent areas from erosion, 2) provide an appropriate termination point for the cap, and 3) allow the establishment of wetlands in the Panhandle Area. Proper design and maintenance would minimize future erosion and slope stability concerns.

Potential impacts on human health and the environment from implementation of this option would be short-term and could be managed through proper construction techniques. Armoring is proven and reliable in applications similar to Parcel E-2.

Implementability

The technical implementability of armoring is high. Armoring would be subject to, and must comply with various location-specific ARARs regarding work within a coastal zone. The types of materials needed to construct the armoring would be readily available. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this option.

Cost

The cost of armoring would be high compared to other shoreline protection options. Maintenance costs for armoring would be similar to or less than other shoreline protection options.

<u>Shoreline Protection – Armoring General Screening</u>

- Effectiveness: High
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: High
- Retained for Further Analysis: Yes

11.5.2.2. Beach Stabilization Structures

Beach stabilization structures, such as headland and nearshore breakwaters, groins, sills and reefs, and wetlands, moderate the coastal sediment transport processes to reduce the local erosion rate. Beach stabilization structures are used where chronic erosion is a problem due to diminished sediment supply. Their purpose is to slow the loss of placed sand. In some locations, the improper design or construction of beach stabilization structures has produced adverse environmental impacts by starving the supply of sand to downdrift beaches. To be effective, a minimum beach width is necessary to achieve stable conditions. The volume of sediment present protects the uplands from damage under normal or average storm conditions.

Effectiveness

Beach stabilization structures may meet the established RAOs. Beach stabilization structures can be effective where there is a minimum width of beach with which to work. However, beach stabilization structures typically are not intended to prevent erosion associated with greater than average storm conditions. Beach stabilization structures may: 1) protect the containment systems in the Landfill Area and adjacent areas from erosion, 2) provide an appropriate termination point for the cap, and 3) allow the establishment of wetlands in the Panhandle Area. Proper design and maintenance may minimize, but not eliminate, future erosion and slope stability concerns.

Implementability

The technical implementability of beach stabilization structures is high. Beach stabilization structures would be subject to, and must comply with various location-specific ARARs regarding work within a coastal zone. The types of materials needed to construct the beach stabilization structures would be readily available. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this option.

Cost

The cost of beach stabilization structures would be moderate compared to other shoreline protection options. Maintenance costs for beach stabilization structures could be higher than other shoreline protection options due to the need for maintenance following larger than average storms.

Shoreline Protection – Beach Stabilization Structures General Screening

- Effectiveness: Low to Moderate
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate to High
- Retained for Further Analysis: No

11.5.2.3. Beach Nourishment

The primary function of beach nourishment is to provide improved protection to upland structures and infrastructures from the effects of storms. Beach nourishment typically involves constructing a wider beach and/or more substantial dune to reduce storm damage relative to the level of damage that would have resulted without the beach nourishment. Beach nourishment can include berms, dunes, feeder beach, nearshore berm, dune stabilization, or structural stabilization. Aspects of beach nourishment that can affect the integrity of the dune/berm include periodic renourishment, advance nourishment, and emergency maintenance.

The level of storm protection provided by beach nourishment is not an absolute measure due to the uncertainties in the frequency of high intensity storms. There is always some risk that a storm will cause property damage even with the beach nourishment in place.

Effectiveness

Beach nourishment would not meet the established RAOs. Beach nourishment can be effective where there is a sufficient width of beach to allow construction beyond the anticipated erosion zone. However, beach nourishment is not intended to prevent erosion. Beach nourishment would not: 1) protect the containment systems in the Landfill Area and adjacent areas from erosion, 2) provide an appropriate termination point for the cap, and 3) allow the establishment of wetlands in the Panhandle Area.

Implementability

The technical implementability of beach nourishment is high. Beach nourishment would be subject to, and must comply with various location-specific ARARs regarding work within a coastal zone. The types of materials needed to construct the beach nourishment would be readily available. Skilled labor, supplies, and equipment are sufficient to allow proper implementation of this option.

Cost

The cost of beach nourishment would be moderate compared to other shoreline protection options. Maintenance costs for beach nourishment could be higher than other shoreline protection options due to the need for maintenance associated with continued erosion.

Shoreline Protection – Beach Nourishment General Screening

- Effectiveness: Low
- Implementability: High (with proper quality control, skilled labor, and appropriate supplies and equipment)
- Cost: Moderate
- Retained for Further Analysis: No

11.5.3. Landfill Gas Collection

Two process options, passive landfill gas venting and active landfill gas collection, are considered for the landfill gas collection technology. Both process options include the installation of vertical wells into the landfill that extend through the cap. The landfill gas collection process option evaluations are described in Subsections 11.5.3.1 and 11.5.3.2. Both may also need to be paired with a technology to treat the collected gas. Because treatment may be required for landfill gas collected from Parcel E-2, treatment technologies are evaluated in conjunction with the collection technologies (Subsection 11.5.4).

11.5.3.1. Passive Venting

Passive venting technology uses the physical properties of methane to control the migration of landfill gas. Landfill gas is typically composed of approximately 50 percent methane, and the specific gravity of methane is 0.55, or about half that of air at sea level; therefore, landfill gas tends to rise in the presence of air. Also, as landfill gas is generated during waste decomposition, pressure will build within the solid waste mass. Landfill gas will migrate from areas of higher pressure to areas of lower pressure. Landfill gas travels along permeable zones of lower pressure, and these permeable zones are the primary pathways of subsurface landfill gas migration. A passive landfill gas venting system attempts to provide a preferential pathway for gas to migrate to the surface to prevent pressure buildup and horizontal subsurface gas migration. The system would vent landfill gas from the landfill, thereby controlling off-site migration.

A passive system at Parcel E-2 would include a series of venting wells extending from below the historic low water-table elevation through the cap and discharging to the atmosphere above the surface of the cap. Figure 11-7 shows the conceptual landfill gas vent that would be installed at Parcel E-2. In areas where a new cap is installed, a thin venting layer, such as a geotextile, may be installed. This layer would be connected to vent risers under the cap to prevent landfill gas from building up beneath the cap. The vents would extend high enough above the cap to ensure that the landfill gas being vented would not

accumulate at ground level. Each vent may have passive wind-driven turbines on top of the vent to enhance venting and disperse landfill gas at the vent outlet.

Passive gas venting does not require an outside power source to control landfill gas. Barrier walls, gas collection trenches, and gas vents are possible passive gas collection technologies. Passive collection is meant to provide a preferential pathway for gas to escape to the surface, rather than allowing it to migrate laterally underground. Treatment units, such as activated carbon, can be used in combination with passive gas collection.

Effectiveness

This technology is considered moderately effective. Venting is a proven technology for landfills that have a bottom and sidewall liner system, or landfills that have sufficient buffer space between the edge of waste and the compliance points to allow for restriction of subsurface gas flow. If NMOC treatment is required at the discharge points, the required treatment systems could restrict landfill gas venting, rendering this technology less effective. At Parcel E-2, the lack of buffer space at the northern and western boundaries, and the difficulties associated with installing an effective landfill gas barrier due to the presence of large debris may limit the effectiveness of a passive venting system in those areas.

Landfill gas that dissipates through the passive vents would vent directly to the atmosphere, in the absence of a control device. Preliminary air modeling conducted during the landfill gas TCRA indicated that landfill gas vented 15 feet above the ground would not present an unacceptable risk to human health; however, this preliminary modeling was based on soil gas data from the northern area of the landfill and may not be representative of the amount and quality of landfill gas to be vented across the entire landfill if a permanent cap is installed. Additional data would be collected to support the final design of a gas control system and determine if treatment is required. Gas treatment process options are evaluated in Subsection 11.5.4.

Implementability

The technical implementability of the passive gas collection system is high. The labor and materials needed to design and construct a passive gas system are readily available. Any landfill gas collection system installed at Parcel E-2 must comply with the substantive BAAQMD regulations.

Cost

The construction cost for the passive venting technology would be low. Because the system takes advantage of the properties of landfill gas and natural wind currents to vent gases, the operation costs would also be low. This assessment of cost does not consider potential treatment costs, which are discussed further in Subsection 11.5.4.

<u>Landfill Gas Collection - Passive Venting General Screening</u>

- Effectiveness: Moderate

- Implementability: High
- Cost: Low
- Retained for Further Analysis: Yes

11.5.3.2. Active Collection

Active collection uses vacuum blowers to alter pressure gradients and direct the flow of landfill gas to desired locations, where it is collected through a series of extraction wells or trenches, and piped to a centralized location for atmospheric discharge or treatment. The vacuum applied during active collection prevents pressure buildup from landfill gas generation and also creates an inward pressure gradient away from the Parcel E-2 boundaries to prevent outward landfill gas migration. Landfill gas collected in this manner could either be; discharged directly, treated, or utilized for a beneficial use such as energy or product generation, depending on the gas composition, flow rates, and whether treatment is needed to achieve the RAOs.

Active collection requires an outside power source to control landfill gas. Adsorption, or other treatment technologies, can be used in combination with active gas collection.

Effectiveness

Active landfill gas collection with treatment generally provides the most effective gas migration control. An active system would be less affected by treatment of emissions, gas generation rates, barometric pressure fluctuations, and heterogeneous subsurface conditions than a passive system. This type of system could be designed to collect landfill gas from the entire landfill, thereby reducing or eliminating the potential for off-site landfill gas migration in all directions. By removing much of the landfill gas as it is generated and reducing pressure in the landfill, active collection could also remove volatile contaminants in the unsaturated zone. Except for the central collection point, this system would be installed primarily underground; this is a favorable scenario because an underground system is less likely to be vandalized. With proper maintenance, system performance would remain very effective; maintenance requirements could be adjusted over time to address varying landfill gas conditions.

Implementability

The technical implementability of the active gas collection system is high. An active gas collection system would be subject to, and must comply with, the substantive BAAQMD regulations. This technology could be used both with the existing cap and a new cap, and is effective for both soil and geosynthetic caps. However, it is more effective with geosynthetic caps in shallow landfills, like the Parcel E-2 Landfill, because geosynthetic materials offer a better barrier against vacuum short-circuiting to the surface. The labor and materials needed to design and construct an active gas collection system are readily available. No administrative issues would affect the implementability of active gas collection.

Cost

The overall cost of active gas collection would be moderate. The capital costs for system installation would be higher than for a passive system because more electrical and mechanical systems are involved. Detailed design and construction of a system that can adequately control landfill gas for the entire landfill would require more engineering than other types of systems. Site-specific conditions should be considered in the design to accommodate Parcel E-2's unique characteristics, such as its proximity to surface water and residential and commercial structures. Because active collection systems are typically more flexible than passive systems, evaluation of landfill gas generation rates and subsurface conditions could be less detailed. The O&M costs are moderate. This assessment of cost does not consider potential treatment costs, which are discussed further in Subsection 11.5.4.

Landfill Gas Collection - Active Collection General Screening

- Effectiveness: High
- Implementability: High
- Cost: Moderate
- Retained for Further Analysis: Yes

11.5.4. Landfill Gas Treatment

Two process options, adsorption and destruction, are considered for the landfill gas treatment technology. Adsorption consists of passing the collected landfill gas stream through media, such as granular activated carbon (GAC), to remove NMOCs prior to discharge. Destruction uses either a combustion device or a non-combustion conversion process to destroy both methane and NMOCs.

For the current interim control system, gas treatment consists of adsorption to remove NMOCs. Methane concentrations are sufficiently low as to not require destruction. However, the existing treatment process may require modification, depending on the collection technology selected to control the landfill gas in the future (if necessary), the anticipated NMOC and methane concentrations, and the total flow of collected landfill gas.

In order to further evaluate the treatment processes, modeling was performed to predict future landfill gas generation rates as described in Appendix P. The results indicate that anywhere from 5 to 30 cubic feet per minute of gas may be generated within the landfill. Although this is not a substantial amount as compared to modern active landfills, a landfill gas generation rate of 10 cubic feet per minute would create enough landfill gas to fill all of the void spaces (assuming 25 percent) within the landfill in less than a year. The modeling indicates a slow rate of landfill gas generation at this time. Prior to finalizing the design of a gas control system, a landfill gas generation study is needed to better estimate the gas generation rates from the landfill, and to determine the content of the landfill gas. This study may reveal that direct discharge of landfill gas would not meet RAOs, and that treatment of the landfill gas, prior to discharge, is required.

The following subsections discuss the following treatment process options: adsorption (Subsection 11.5.4.1), destruction through combustion (Subsection 11.5.4.2), and destruction through non-combustion processes (Subsection 11.5.4.3).

11.5.4.1. Adsorption

Adsorption would remove NMOCs from the landfill gas stream. Methane remaining in the gas stream would not be effectively removed through adsorption, and would either be discharged directly to the atmosphere or would require destruction. The two adsorbent media considered for landfill gas treatment are GAC and a potassium permanganate-impregnated medium (such as Hydrosil®). The two could be used independently or in combination depending on the NMOCs in the landfill gas. GAC would remove SVOCs and most VOCs. Potassium permanganate would remove lighter VOCs such as vinyl chloride.

Adsorption could be used with either a passive venting or active landfill gas collection system. However, treatment units could restrict the airflow of passive venting systems, rendering them less effective. To use adsorption with a passive venting system, small treatment units would be installed at each passive vent that is determined to require treatment. In an area that allows public access, each system would require security to prevent vandalism and potential exposure to NMOCs or explosion hazards. Adsorption on an active collection system could be achieved with one treatment system located at the central landfill gas collection point. This type of system, if designed properly, would not limit the effectiveness of the collection system.

Effectiveness

Adsorption would effectively remove and prevent the inhalation of carcinogenic NMOCs. Treatment would be designed so that NMOCs no greater than 5 ppm above background levels would be discharged. Adsorption would not remove methane, which is a nontoxic gas. Methane could possibly be discharged directly to the atmosphere, depending on the concentrations in the landfill gas. The venting system would need to be designed to ensure adequate dispersion of the methane gas; a potential health and safety concern exists from freely venting methane.

Implementability

Adsorption could be readily implemented as part of an active collection system. Implementing adsorption into a passive collection system would be more difficult because of safety concerns that arise when public access is allowed. The labor and materials needed to design, construct, and operate an adsorption treatment system are readily available. Adsorption is currently used as part of the interim gas control system. Implementing an adsorption treatment system is subject to BAAQMD regulations depending on the emissions from the treatment system.

Cost

Design and construction necessary to use adsorption with either a passive or an active landfill gas collection system should require minimal effort and cost, especially if commercially available,

pre-manufactured treatment units and automated controls are used. Based on current (interim) landfill gas mitigation efforts at Parcel E-2, projected O&M costs would be relatively low because the system is not complex and media usage would be low. However, significant costs for operating an adsorption treatment system could be realized with an active collection system after the remainder of the landfill is capped. The flow and concentration of the landfill gas to be treated could increase by more than an order of magnitude above that currently observed in the northern area of the landfill. As such, costs for treatment by adsorption could be limiting for this technology. Additionally, methane, which is not effectively removed by adsorption, could require destruction.

Landfill Gas Treatment - Adsorption General Screening

- Effectiveness: High
- Implementability: High
- Cost: Low (based on low NMOC concentrations from current control system); High (if NMOC concentrations increased significantly following capping of the entire landfill)
- Retained for Further Analysis: Yes

11.5.4.2. Destruction by Combustion

Combustion devices are standard technologies for landfill gas destruction that have been successfully implemented nationwide and worldwide. These devices include open and enclosed flares, internal combustion engines, and boilers. Because of their improved system controls relative to open flares, enclosed flares are routinely used to destroy landfill gas at landfills throughout the Bay Area. These devices are used at the following facilities:

- Redwood Landfill (Marin County)
- American Canyon Landfill (Napa County)
- Keller Canyon Landfill (Contra Costa County)
- Berkeley, Davis Street, Altamont, Pleasanton, Tri Cities, and Newby Island Landfills (Alameda County)
- Kirby Canyon Landfill (Santa Clara County)

Internal combustion engines and boilers, which use landfill gas to generate power, are used at landfills with a sufficient volume of methane (and resulting power generation) to offset the higher capital costs relative to flares. Based on preliminary gas generation estimates (Appendix P), the volume of gas generated by the Parcel E-2 Landfill is not anticipated to be sufficient to support the cost-effective implementation of internal combustion engines or boilers. Therefore, an enclosed flare is considered the only viable process option for destruction by combustion.

Figure 11-8 shows a typical enclosed flare. A typical flare may pose aesthetic concerns to future site occupants because the stack of a typical flare extends 15 to 20 above the ground surface. Figure 11-9 shows an enclosed burner, which may be considered as an alternative to a typical flare because of its low

profile design. A flare destroys landfill gas, including NMOCs and methane, through combustion. The primary chemical by-products from flares are carbon dioxide and nitrogen oxide compounds. These by-products are managed by controlling flare combustion temperatures. Further, management of these by-products is achieved through flare designs that maximize air dispersion to reduce potential impacts. A flare can only be used in conjunction with an active collection system, and is most cost-effective when landfill gas concentrations are sufficient to facilitate combustion.

Effectiveness

If the volume and concentration of landfill gas collected is sufficient to support combustion (after the landfill is fully capped), a flare would effectively destroy landfill gas when a proper operating temperature is maintained. It could be designed to treat all of the landfill gas extracted by an active collection system. The destruction efficiencies of properly designed and operated ground flares are typically 99 percent or better for NMOCs and methane. EPA recognizes this treatment technology as the best demonstrated available technology for landfill gas (EPA, 1999b), and the technology has been approved by the BAAQMD, as shown by the implementation of flares at many Bay Area municipal landfills.

Implementability

There are no technical barriers to implementing a flare. This technology has been successfully implemented at many landfills. As with any treatment unit, a flare would require security to restrict public access for safety reasons. The labor and materials needed to install, operate, and maintain a flare are readily available. Administratively, several regulatory agencies have expressed concern about the potential creation of dioxins as a by-product of flare combustion, and this concern would need to be evaluated if a flare is to be implemented. The conditions required to allow for the possible creation of dioxin are controlled in an enclosed flare so as to not promote the creation of dioxins. For example, dioxins require organics, temperatures in the 400 to 800 degree Fahrenheit range, and a minimal combustion duration. Enclosed flares utilize automated controls to maintain temperatures in the 1,400 to 1,800 degree Fahrenheit range over an extended residence time. These operating conditions reduce the possibility of dioxin formation by: 1) promoting the destruction of organics; 2) operating at temperatures above those that would allow dioxin formation followed by rapid quenching to temperatures below 400 degrees Fahrenheit; and 3) extending the combustion residence time to further deter the formation of dioxins. Operating a flare would be subject to the substantive BAAQMD regulations.

Cost

Capital costs for flares would be low to moderate, and would depend on the complexity of the control system required. Flare operation is relatively cost-effective when methane concentrations in the landfill gas stream are sufficient to facilitate combustion; however, operation costs would increase if the methane concentrations become too low to maintain proper operating temperature. Supplemental fuel may be required to maintain the proper operating temperature, and costs could be moderately high, depending on

the size of the flare and the amount of supplemental fuel required. Alternatively, the flare could be operated intermittently and shut off when methane concentrations are sufficiently low as to not support combustion, provided that NMOC concentrations are sufficiently low as to not pose a risk to human health.

Landfill Gas Treatment - Destruction by Combustion (Enclosed Flare) General Screening

- Effectiveness: High
- Implementability: Moderate to High (public and regulatory agency concerns about flare combustion process by products)
- Cost: Low to Moderate (depending on type of flare used and landfill gas properties; costs could increase if supplemental fuel is required to support combustion)
- Retained for Further Analysis: Yes

11.5.4.3. Destruction by Non-Combustion Processes

Non-combustion conversion processes are alternative technologies for the management, treatment, and utilization of landfill gas. Alternative technologies are those new or innovative technologies that have not been commonly used at a commercial scale to manage landfill gas. An evaluation of each alternative technology is not presented in this evaluation because it is unknown, based on the uncertainties related to the gas volume and composition, which technologies would be implementable at the site. Instead, the technologies are evaluated collectively. The results of a landfill gas generation study will help support the final selection of a landfill gas treatment alternative (if necessary), and may reveal that an innovative, emerging technology may be well suited for landfill gas treatment at Parcel E-2.

Most modern landfills employ a landfill gas management system that includes enclosed flares, which destroy a significant proportion of the methane and NMOCs within landfill gas. Research and development in the field of landfill gas management have led to the design of non-combustion technologies that typically offer higher gas treatment efficiencies, and/or allow for gas conversion to energy. These innovative technologies could be used to manage landfill gas at Parcel E-2, if the appropriate gas characteristics exist.

The following paragraphs discuss several emerging non-combustion treatment/destruction technologies that potentially could be implemented at Parcel E-2; these technologies fall under two general categories: energy recovery and gas-to-product conversion.

Energy recovery technologies use landfill gas to produce energy directly using a fuel cell. The phosphoric acid fuel cell is the most commercially available non-combustion energy recovery technology, although other viable fuel cell technologies exist (e.g., molten carbonate, solid oxide, solid polymer). Several chemical reactions occur within this system to create water, electricity, and heat.

Gas-to-product conversion technologies focus on converting landfill gas into commercial products, such as compressed natural gas, methanol, purified carbon dioxide and methane, or liquefied natural gas.

The chemical processes required to produce each of these vary, but each includes landfill gas collection, pre-treatment, and chemical reactions and/ or purification techniques.

Effectiveness

Under proper operating conditions, energy recovery or gas-to-product systems can be highly effective in destroying methane and NMOCs in landfill gas. However, the effectiveness of energy recovery and gas-to-product systems incorporated into a Parcel E-2 gas management system is likely to be low, due to the gas generation rates at the landfill, which are expected to be insufficient to support an energy recovery or gas-to-product system. If gas conditions at Parcel E-2 allow for implementation of such a system, the effectiveness of the system is presumed to be moderate to high.

Implementability

Energy recovery and gas-to-product systems have been implemented at other sites, but the specialized equipment and skilled operators needed are not as widely available compared to more common technologies such as adsorption and flares. The implementability of an energy recovery or gas-to-product systems at Parcel E-2 is likely to be low due to gas generation rates at the landfill, which are expected to be insufficient to support an energy recovery system or gas-to-product system. Better definition of the site-specific conditions at Parcel E-2 (through a gas generation study) would be required to evaluate implementability. In addition, implementation of an alternative technology would require review and approval by the BAAQMD to ensure that it would meet the substantive BAAQMD regulations.

Cost

Because equipment for energy recovery or gas-to-product systems is specialized and not widely available as compared to more common technologies, the capital cost of implementing such a system is assumed to be moderate to high. However if gas conditions at Parcel E-2 allow for implementation of such a system, the moderate to high capital costs could be offset by the value of the energy or product generated by the respective processes.

Landfill Gas Treatment - Destruction by Non-Combustion Processes General Screening

- Effectiveness: Likely low (assumed moderate to high, if implementable at Parcel E-2)
- Implementability: Likely low (site-specific conditions need to be better defined)
- Cost: High (could be offset by the value of the energy or product generated)
- Retained for Further Analysis: Yes (for consideration following collection of additional data regarding gas volume and composition)

11.5.5. Groundwater Containment / Leachate Collection (With or Without Treatment and Discharge)

Groundwater containment and leachate collection/treatment are considered components of the presumptive remedy for CERCLA municipal landfills (EPA, 1993a). Because the solid waste in the

Parcel E-2 Landfill is submerged in the A-aquifer, groundwater containment (adjacent to the landfill) and leachate collection/treatment are functionally the same actions and are evaluated together in this subsection. A final cap over the landfill source area would reduce infiltration and associated leachate generation, and could be sufficient in preventing continued contaminant migration in groundwater. As discussed in Subsection 8.5.2.3, groundwater conditions along the Parcel E-2 shoreline may pose a risk to aquatic receptors in the Bay. Although this potential risk must be verified through quantitative evaluations, it is prudent to evaluate groundwater containment and leachate collection/treatment options in the event that they are needed in the future. This evaluation was focused by utilizing the engineering evaluation/cost analysis (EE/CA) previously prepared for the existing GES (PRC, 1996e). Consistent with the EE/CA, both physical barriers and hydraulic containment were evaluated as possible remedial technologies for containing leachate and contaminated groundwater in the event that containment is required.

Physical barriers are used to contain or divert contaminated groundwater using a subsurface obstruction. Physical barriers are often used in landfill remediation situations when a waste mass is difficult to treat or remove, and where soluble and mobile constituents pose an imminent threat to a downgradient source of drinking water or ecological receptors. The process options for this remedial technology are: 1) slurry wall; 2) grout curtains; 3) vertical geomembrane; and 4) sheet pile wall. The evaluation of the physical barrier process options was focused into Subsection 11.5.5.1 because the previous EE/CA evaluated these options individually and concluded that a sheet pile wall was the most viable process option (PRC, 1996e).

Hydraulic barriers aim to stop contaminated groundwater from flowing beyond a specified boundary. This is achieved by installing a series of groundwater extraction wells or by plant uptake (phytoremediation). In the case of conventional extraction, the intercepted water typically is stored, tested, and treated (if necessary) before it is reinjected at another location, or discharged to a reservoir, surface water body, or sewer system, or transported off site for treatment and/or disposal. Phytoremediation is a process by which plants uptake water (including dissolved chemicals in water). Much of the water is then released to the atmosphere through transpiration. The two process options for hydraulic barriers are evaluated in Subsections 11.5.5.2 and 11.5.5.3.

11.5.5.1. Physical Barrier

This option would involve installing a physical barrier, such as a slurry wall, grout curtain, vertical geomembrane, or sheet pile wall to cut off and/or redirect groundwater flow. A physical barrier would generally extend from the ground surface down to an aquitard to prevent groundwater flow under the barrier.

Effectiveness

Physical containment technologies, specifically a slurry wall or sheet pile wall, which has been used previously at HPS, would likely be moderately to highly effective in preventing off-site migration of

groundwater contamination from the landfill. The long-term effectiveness of a sheet pile wall would be limited by corrosion; however, the corrosion potential could be mitigated by use of a cathodic protection system (one was installed as part of the existing GES) or by use of alternative materials (such as polyvinyl chloride). Use of these technologies may require augmentation with extraction wells or phytoremediation techniques to prevent excessive groundwater mounding behind the barrier.

Implementability

Installation of a physical barrier would require trenching 10 to 15 feet below the groundwater table in order to key the barrier into the Bay Mud aquitard. The site conditions generally preclude the installation of a grout curtain or vertical geomembrane because these process options must be installed within a stable, open trench. Shoring and dewatering to facilitate open trench construction is not feasible in near-shore areas (where a physical barrier would likely be required) because of the proximity to the Bay. As a result, physical barriers that can be installed in saturated conditions (such as slurry walls or sheet pile walls) are the only viable process options at Parcel E-2. Installation of slurry walls or sheet pile walls would be affected by site conditions identified during previous interim actions, including the presence of large debris (which would make excavation difficult) and the presence of irregular subsurface voids (which could result in slurry loss during construction). However, the site conditions would not preclude construction of a slurry wall or sheet pile wall, and could be mitigated by removing the large debris or realigning the wall. Such techniques were previously utilized at Parcel E-2 during the construction of the GES and the interim gas control system.

Cost

The cost of installing a sheet pile or slurry wall at Parcel E-2 would vary from moderate to high depending on the length of shoreline requiring containment (not known at this time). If the existing sheet pile was to be extended along the shoreline where the landfill solid waste is located within 50 to 100 feet, the costs would be moderate. However, the costs would be high if containment were required along the entire shoreline (2,500 to 3,000 feet long). Costs would also be higher if obstructions that required realignment or re-design of the sheet pile wall were encountered.

Groundwater Containment – Physical Barrier General Screening

- Effectiveness: Moderate to High
- Implementability: Moderate to High (except for grout curtain and vertical geomembrane)
- Cost: Moderate to High
- Retained for Further Analysis: Yes (sheet pile wall or slurry wall to be considered if groundwater containment and leachate collection/treatment is required)

11.5.5.2. Hydraulic Containment by Well Extraction

Hydraulic containment could be accomplished through groundwater extraction using strategically placed pumping wells along the Parcel E-2 shoreline. Extracted groundwater could be discharged to the sanitary

sewer system (without treatment based on the operation of the current GES), treated and reinjected, or treated and discharged to the Bay. Based on the evaluation conducted in the EE/CA (PRC, 1996e), discharge to the sanitary sewer system is considered the most viable process option because it presents the fewest technical and administrative issues.

Effectiveness

Hydraulic containment through pumping has been previously used at HPS, and likely would be effective in preventing off-site migration of groundwater contamination from Parcel E-2. Groundwater modeling would be required to optimize extraction well placement and pumping rates, and to minimize the volume of water pumped from the Parcel E-2 aquifers.

Implementability

The implementability of hydraulic containment through pumping has already been demonstrated at Parcel E-2. The current GES was successfully installed along a section of the Parcel E-2 shoreline, and was successfully operated from 1998 to 2005 (when the implementation of the PCB Hot Spot removal action required its decommissioning). Operation of the GES required regular monitoring of the extracted groundwater and coordination with the City and County of San Francisco to facilitate discharge to the sanitary sewer system.

Cost

Installation and operation of a hydraulic containment system using pumping would be moderate to high, depending on the length of time the extraction system would require operation. Construction costs for the system would include costs of the wells and pumping systems, which would be moderate. If required, the construction and operation of any associated treatment technology would result in higher costs. The costs for ongoing operation and maintenance would be moderate if the system could be operated for a relatively short period of time (approximately 5 to 10 years) and the long-term containment could be achieved through an alternate method (such as, phytoremediation). However, if containment through pumping is required for a longer period of time (e.g., more than 20 years), the overall costs would be high.

Groundwater Containment – Hydraulic Containment by Well Extraction General Screening

- Effectiveness: Moderate to High
- Implementability: High
- Cost: Moderate to High
- Retained for Further Analysis: Yes (to be considered if groundwater containment and leachate collection/treatment is required)

11.5.5.3. Hydraulic Containment through Phytoremediation

Hydraulic containment could be accomplished through the application of phytoremediation techniques, in particular phytohydraulics, strategically implemented along the Parcel E-2 shoreline. Phytohydraulics is

the use of plants to control rainfall infiltration and/or groundwater levels and movement. In this type of application, plants are used to remove water through evapotranspiration. Deep rooting, fast growing trees and shrubs may be most effective in providing hydraulic control of groundwater flow. Trees generally have a greater rooting depth than grasses and take up large amounts of water. The high evapotranspiration rate of trees will help dewater surface soils during the rainy season, and their roots will seek groundwater for use when rainfall is limited. In addition to hydraulic control, phytoremediation could potentially help reduce chemical concentrations in subsurface soils and groundwater. Many plants, including hybrid poplar and eucalyptus, have been shown to tolerate and take up chlorinated solvents and other volatile organic chemicals. Further, trees and other plants can enhance biodegradation in soil and groundwater by creating an environment favorable for bacterial and fungal activity in the root zone (rhizosphere).

Effectiveness

Hydraulic containment through phytohydraulics has not been previously used at HPS but could be moderately to highly effective in preventing off-site migration of groundwater contamination from Parcel E-2. Further groundwater and evapotranspiration modeling would be required to optimize the application of phytohydraulics, in particular taking into consideration the remedial technology selected for the other impacted media as well as selection of the plant species to employ. In addition, the need to collect and dispose of the plant material would require further evaluation.

Implementability

Phytohydraulics has been successfully implemented at other sites in the U.S., but may be limited in its use at Parcel E-2 depending on the remedial technology selected for the other impacted media. If containment of solid waste, soil, and sediment is selected for the adjacent areas (where phytohydraulics would potentially be implemented), then the design objective of creating a continuous low-permeability layer would be incompatible with phytohydraulics. However, if an area could be identified where a continuous low-permeability layer was not required to prevent exposure to human or ecological receptors, then the cap design could be altered to allow phytohydraulics to be implemented. For example, the PCB Hot Spot is being remediated to depths greater than 10 feet bgs and, following completion of the remediation, direct human or ecological exposure to these areas would not pose an unacceptable risk. If groundwater from behind a sheet pile wall could be diverted (by either gravity drain or mechanical pumping) to these locations, then phytohydraulics may be a feasible alternative to extraction from wells and off-site discharge. These two process options could also be applied in combination with the extraction from wells being used during the initial 5 to 10 years of operation while the roots of the phytohydraulic network grew to the groundwater table. No administrative issues would affect the implementability of phytohydraulics.

Cost

Installation and operation of a phytohydraulic containment system would be low to moderate. Construction costs for the system would include costs of the plants (trees and shrubs), installation of the plants, cultivation (i.e. watering and fertilizing), and the replacement of trees that do not survive. Long term costs, once the plant roots have reached the groundwater table costs would be very low.

Groundwater Containment – Hydraulic Containment through Phytoremediation General Screening

- Effectiveness: Moderate to High
- Implementability: Low to Moderate
- Cost: Low to Moderate
- Retained for Further Analysis: Yes (to be considered if groundwater containment and leachate collection/treatment is required)

11.6. REMOVAL BY EXCAVATION AND OFF-SITE DISPOSAL

The removal GRA includes the excavation and off-site disposal of all solid waste and impacted soil in the Landfill Area, and contaminated soil/sediment in the adjacent areas that may pose a risk to human or ecological receptors. This material includes construction debris, industrial and municipal-type waste, contaminated soil, existing multilayer geosynthetic cap, and existing soil cover. The excavated areas would require backfilling with clean imported fill to provide proper drainage of surface water runoff. The depth of excavation required in the adjacent areas would be initially estimated based on the results of the risk assessment and the specified RAOs, and confirmation sampling would be used to evaluate post-excavation conditions. All excavated material, estimated at over 1 million cubic yards, would be disposed of at a licensed off-site facility authorized to accept wastes from a CERCLA site (per 40 CFR Part 300.440, also referred to as the "CERCLA Off-Site Rule"). Because large excavation volumes are anticipated under the removal GRA, transportation of the excavated material by rail may be a cost-effective alternative to truck transport, and would also minimize vehicle traffic through the local community.

For the removal GRA, the only viable process option is off-site disposal. Other process options, including on-site treatment/disposal or consolidation, either do not meet the RAOs or would require resolution of numerous technical and administrative issues that would render these options ineffective, difficult to implement, and cost-prohibitive. The evaluation of the remedial technologies and process options under the removal GRA is presented in Figure 11-2.

Effectiveness

Excavation and off-site disposal is a proven and reliable process option capable of addressing the solid waste, soil, and sediment at Parcel E-2. Excavation and off-site disposal would meet the RAOs by: 1) eliminating human health and ecological risk from exposure to contaminated solid waste, soil, and sediment; 2) eliminating leachate generation and subsequent impacts to groundwater and surface water;

and 3) eliminating generation of on-site landfill gas from waste decomposition. The potential human health and environmental effects that may be caused by implementation of this technology would be short-term, and could be effectively managed by appropriate health and safety, dust control, and stormwater management procedures. These include windblown dust during excavation, sediment in stormwater runoff, and inhalation of volatile contaminants, such as VOCs. Dust would be controlled through regular spraying with water, and off-site sediment and volatile contaminant migration would be controlled through proper construction techniques and BMPs and verified by site monitoring.

Implementability

Excavation is possible, but may be very difficult to implement because of the depth of waste at the landfill, the proximity to surface water (the Bay), and the proximity to adjacent non-Navy property. Difficulties associated with the removal of solid waste and soil from the landfill include:

- Slope stability during excavation
- Surface water control to prevent inundation resulting from tides or stormwater
- Groundwater inflow control for excavation below the water table
- Moisture content control and ease of dewatering of waste and soil prior to transportation and off-site disposal
- Dewatering of the subsurface during excavation and prior to backfilling
- Handling, disposal, and/or on-site treatment of contaminated water removed from open excavations or from excavated material (as it is dewatered prior to transportation)
- Radiological screening, characterization, and confirmation sampling of all soils and debris transported from the site (for disposal/treatment) and to the site (for backfill/restoration)
- Segregation and handling of a variety of waste types, including crushing or shredding large construction debris and segregating small radioluminescent devices from the surrounding soil and large debris
- Location of multiple, large-volume sources of backfill material that are free of contamination and do not contain metals concentrations in excess of existing ambient levels
- Importing, placement, and compaction of the large volume of imported fill required for backfill to provide positive drainage
- Quantification of contaminated soils currently underlying the waste to be removed due to limited characterization data within landfill
- Control of potential releases of contaminants from waste and/or soil during removal and transport through the surrounding neighborhood
- Removal of, or damage caused to, existing wetlands, mudflats, and shoreline habitat

Overcoming the technical difficulties identified above is possible, but will require a large expenditure of human and material resources. This process option would use proven techniques for which both skilled labor and appropriate equipment are readily available; however, the large volume of material

contemplated for excavation will require a large number of labor hours and pieces of equipment that could exceed the available resources from the local area.

Excavations deeper than 3 feet bgs may require dewatering prior to and during excavation. This water must be managed by pumping and storage. Disposal or on-site treatment of any contaminated groundwater encountered is typically very expensive, so this option would require careful dewatering and excavation management to minimize costs. Sheet pile walls or shoring would be required around the excavation to provide stable slopes for the deep excavations and to provide groundwater control for excavation below the water table. Well-point dewatering systems could be installed if sheet pile walls are not feasible at certain locations. Additional impediments to excavation could include large pieces of construction debris intermingled with the soil, and the need to restore wetland areas damaged or destroyed during excavation.

The implementation of this GRA would significantly affect the local community. There may also be effects on the neighboring communities located along the materials disposal and importation transportation route. These effects could include potential exposure to accidental releases of impacted materials and nuisance effects, such as increased vehicle noise (from trucks and rail cars), vehicle congestion (from trucks), and odor issues (from exposed putrefiable waste). Foul odor complaints are likely to be the most prevalent of all nuisance complaints. This disturbance would be minimized with the use of a railroad-based transportation system for hauling the waste to disposal facilities, but this GRA undoubtedly would take longer to implement and be more disruptive to the surrounding community during implementation than the technologies and process options considered under the containment GRA.

The administrative implementability of this GRA is uncertain. Excavation would result in removal of a considerable area (more than 3 acres) covered by wetlands and surface drainage routes. The excavation and restoration plan would incorporate avoidance and mitigation measures to minimize and compensate for such losses, to adequately restore mudflat and wetland acreage.

Cost

The technical issues that make implementation of the removal GRA difficult and require a large expenditure of human and material resources directly correspond to the high projected costs. The primary factors that result in the high costs of excavation and disposal are:

- Large volume of solid waste, soil, and sediment to be excavated and disposed of off site
- Large volume of solid waste, soil, and sediment to be screened for radiological contamination, sampled for characterization, and transported and treated or disposed of off site
- Extensive controls required to minimize, manage, treat (if necessary), and dispose of contaminated water during excavation and waste segregation processes
- Large volume of imported clean fill required for backfill to restore the site

The excavation of the solid waste throughout the Landfill Area and portions of the adjacent areas would be much more costly than a containment action. The cost and implementation issues for the removal

GRA do not offset the long-term effectiveness of such an action, particularly considering the short-term risks associated with such a large-scale removal action.

For these reasons, removal actions for CERCLA landfills are routinely screened out in evaluations similar to the one performed in this subsection (EPA, 1994), and form the basis of the containment presumptive remedy. As presented in Subsection 8.8.1, the Parcel E-2 Landfill meets all of the criteria specified in EPA guidance for application of the containment presumptive remedy. However, the Navy has agreed to fully evaluate excavation of the landfill as part of this report to provide information to support the community's review of potential remedial alternatives for Parcel E-2. Therefore, removal by excavation and off-site disposal will be retained as a potentially viable process option.

Removal by Excavation and Off-Site Disposal General Screening

- Effectiveness: Moderate-High (short-term risks associated with removal of landfill wastes)
- Implementability: Low-Moderate (multiple issues associated with excavation, transport, and disposal of the large anticipated volume of landfill solid waste and soil)
- Cost: Very High (most costly option screened for this evaluation)
- Retained for Further Analysis: Yes (to support the community's review of potential remedial alternatives for Parcel E-2)

11.7. SUMMARY OF SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The remedial technologies and process options evaluated in the previous subsections are summarized in a flow chart (Figure 11-2). Included in the flow chart are brief descriptions of the evaluated technologies and process options, the results of their evaluation with respect to the three criteria (effectiveness, implementability, and cost), and the determination of whether or not they have been retained for consideration as a remedial alternative.

As discussed in Subsection 11.6, the decision to retain excavation and off-site disposal as a potentially viable process option was made despite the implementation difficulties and very high costs (which, as previously determined by EPA, typically result in the elimination of such an option from consideration (EPA, 1994). In light of feedback from members of the local community, the Navy has decided to fully evaluate excavation and off-site disposal as a remedial alternative to support the community's review of potential remedial alternatives for Parcel E-2.

In addition, several groundwater containment and alternative landfill gas treatment/destruction process options were retained as viable options that may be appropriate to implement in the future; however, these were not included in any of the proposed remedial alternatives (presented in Section 12) because the need for their implementation cannot be supported by existing data. In the case of groundwater containment, a method for translating contaminant concentrations in groundwater to surface water releases into the Bay must be established to determine if existing groundwater conditions pose a risk to aquatic receptors. Because such a method has not been agreed to by the Navy and regulators, it is not possible to determine if groundwater extraction and treatment are required to meet RAOs established for Bay protection. In the

case of landfill gas, additional data are needed regarding the volume and concentrations of gas within the landfill to determine what type of gas treatment or destruction would be most implementable and cost-effective.

11.8. WETLANDS MITIGATION ALTERNATIVES

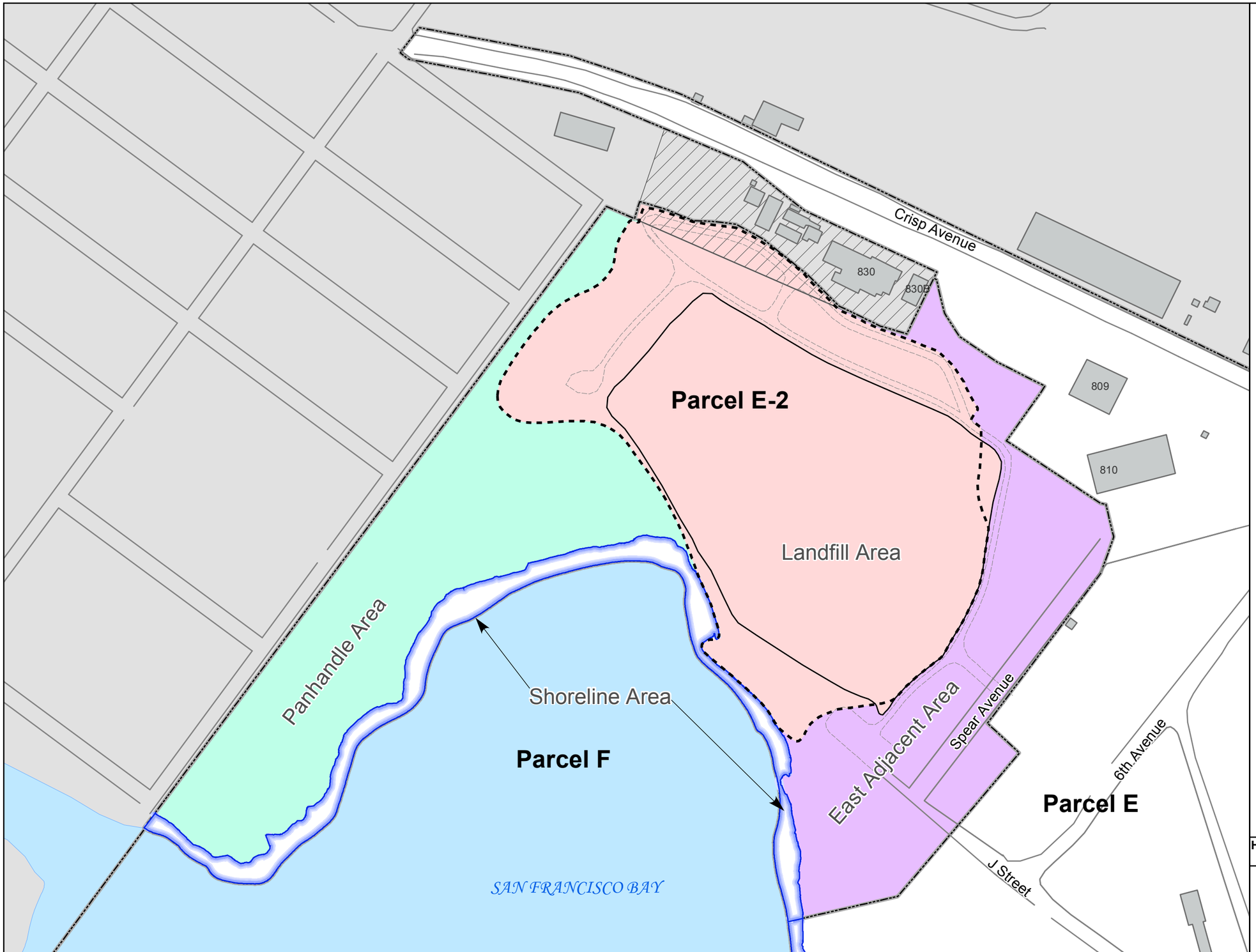
Implementation of any containment or removal action that would alter existing site conditions will impact Parcel E-2 wetlands. Compliance with regulations for wetlands protection (in accordance with the Clean Water Act [Section 404] and the San Francisco Bay Plan [14 CCR, Sections 10110 through 11990]) will require that such impacts be addressed through the established wetlands mitigation process. The mitigation process options and the alternatives available for wetlands mitigation are described in Appendix O and briefly summarized in this subsection.

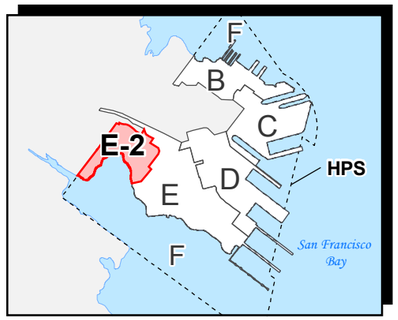
Under the above-listed regulations, the major approaches to addressing wetlands impacts (in order of preference) are avoidance, minimization, and compensation. Due to overlapping distributions of wastes in the landfill and adjacent areas with wetlands, avoidance is not feasible with any of the engineering approaches to site remediation. Minimization of impacts is an approach that will be used and would be part of designing and planning the engineering of excavation or containment of the landfill and adjacent areas. Wetlands mitigation likely will be needed to compensate for the loss of wetlands. The following mitigation approaches have been identified:

- Wetlands banking
- Wetlands restoration within HPS at areas not impacted by chemicals of concern; this could be an area outside of Parcel E-2, or within Parcel E-2 following excavation (that is appropriate to be assembled into an alternative with excavation of the Landfill and the adjacent areas)
- Wetlands restoration in the Panhandle Area of Parcel E-2 on top of a constructed cap (that is appropriate to be assembled into a containment alternative)

Each mitigation approach is discussed and evaluated in detail in Appendix O.

Figures





Location Map

Legend

- Parcel Boundary
- Landfill Area
- East Adjacent Area
- Panhandle Area
- Shoreline Area
- Solid Waste Extent
- Interim Landfill Cap Extent
- Non-Navy Property
- UCSF Compound
- Non-Navy Property within Landfill Area*
- Building
- Road
- Gravel Road
- San Francisco Bay

*Remediation work in area to be performed under easment (to be granted by UCSF.)

N

250 0 250

Scale in Feet

ERRG ENGINEERING/REMEDIATION RESOURCES GROUP, INC.

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 11-1

LANDFILL/PARCEL E-2 LOCATIONS

Remedial Investigation/Feasibility Study for Parcel E-2

2006-03-16 P:\2005_Projects\25-049_Navy_HPS_E-2_RI-FS\N_Maps&Drawings\GIS\Projects\Landfill\Landfill_RI\Parcel_E-2_Location.mxd ERRG-Concord Jeremy Miller

Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Solid Waste and Soil in Landfill, Panhandle, and East Adjacent Areas; Sediment in Shoreline Area	No Action	None	None	No additional action would be taken to address solid waste and soil in the Landfill Area, Panhandle Area or East Adjacent Area.	Required by the NCP and is used as a baseline against which other response actions are compared - would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications); Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of control systems • Maintain the integrity of covers (or access restrictions where covers are not present) • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing); Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (to be used in conjunction with other remediation technologies)
		Site Monitoring	Short-Term Monitoring; Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may disturb contaminated solid waste, soil, or sediment. Long-term monitoring includes operation and maintenance of control systems (such as, inspection and maintenance of caps/covers).	Short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	High	High	Low	Yes
	Containment	Caps/Covers	Low-Permeability Soil Cap	The low-permeability soil cap system (Title 27 cover, prescriptive standard) includes a low-permeability soil layer (such as clay) at least 12 inches thick with a maximum permeability of $1x10^{-6}$ cm/sec or equal to the hydraulic conductivity of the base liner system.	No local source of low-permeability soil; costly to purchase and import suitable low-permeability soils.	High	Moderate-High	Moderate-High	No
			Geosynthetic Cap	The geosynthetic cap system (Title 27 cover, engineered alternative) would include a 60-mil-thick HDPE geomembrane in place of the low-permeability soil layer (typical permeability is $1x10^{-13}$ cm/sec)	Highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate	Yes
			Multilayer Geosynthetic Cap	The multilayer geosynthetic cap system includes a composite low-permeability layer consisting of an HDPE geomembrane at least 60 mils thick over a GCL (typical permeability of GCL is $5x10^{-9}$ cm/sec)	Already installed over a portion of the waste area; highly effective and implementable with proper QA/QC, skilled labor, and appropriate supplies and equipment.	High	High	Moderate-High	Yes
			Evapotranspiration Cap	An evapotranspiration cap is typically a 4- to 6-foot-thick soil layer over a soil foundation layer; it acts to store moisture within the cap thickness, while minimizing infiltration, until the moisture is removed through vegetative uptake or evaporation.	Diminished effectiveness in temperate climates; ideal in arid or semi-arid climates; would require importation of a significant amount of cover soil and may encroach on neighboring property.	Moderate	Low	Moderate to High	No
		Shoreline Protection *	Armoring	Armoring includes seawalls, bulkheads, and protective revetments.	Armoring would protect the containment systems from erosion, provide a termination point for the cap, and allow wetlands to be established in the Panhandle Area.	High	High	High	Yes
			Beach Stabilization Structures	Beach stabilization structures, such as headland and nearshore breakwaters, groins, sills and reefs, and wetlands; moderate the coastal sediment transport processes to reduce the local erosion rate.	Beach stabilization structures would not prevent erosion during greater than average storm events.	Low to Moderate	High	Moderate to High	No
			Beach Nourishment	Beach nourishment can include berms, dunes, feeder beach, nearshore berm, dune stabilization, or structural stabilization.	Inadequate area for proper implementation; would not prevent erosion.	Low	High	Moderate	No
	Removal Actions	Excavation and Off-Site Disposal	RCRA Facility; Non-RCRA Facility; LLRW Facility	Includes the excavation and off-site disposal of all solid waste and impacted soil.	Multiple issues associated with excavation and transport of such a large volume of landfill solid waste and soil.	Moderate-High	Low-Moderate	Very High	Yes (to support community review of potential remedies)
		Excavation and On-Site Disposal	Consolidation in Parcel E-2 Landfill	Eliminated from consideration due to volume of material considered for removal from adjacent areas.		N/A	N/A	N/A	N/A
			Consolidation in other site landfill	Eliminated from consideration because no other landfills are located on site.		N/A	N/A	N/A	N/A

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

Notes:
* Required in Shoreline Area
Acronyms defined on page 4

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FIGURE 11-2
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Landfill Gas in Parcel E-2	No Action	None	None	No additional action would be taken to remove or treat landfill gas.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require maintenance of control systems • Ensure compliance with 27 CCR requirements for construction within 1,000 feet of a landfill, such as the requirement for gas control systems on any installed subsurface structures or other areas in which landfill gas may accumulate	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing)	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (to be used in conjunction with other remediation technologies)
			Traffic Barriers & Perimeter Fencing						
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction that may affect landfill gas migration. Long-term monitoring includes monitoring of gas monitoring probes, subsurface structures, and site structures; also includes operation and maintenance of gas control systems.	Short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	High	High	Low	Yes
	Containment	Landfill Gas Collection	Passive Venting	A passive system at Parcel E-2 would include a series of venting wells extending from below the historic low water table elevation through the cap and discharging to the atmosphere above the surface of the cap.	Diminished effectiveness at landfills with no bottom and sidewall liner system, or landfills with insufficient buffer space between the edge of waste and the compliance points; if NMOC treatment is required at the discharge points, the required treatment systems could restrict landfill gas venting, rendering venting less effective.	Moderate	High	Low	Yes
			Active Collection	Active landfill gas collection uses vacuum blowers to extract landfill gas through vertical extraction wells installed and plumbed together; gases are drawn to a central collection point to create an inward pressure gradient to prevent outward landfill gas migration.	More effective with geosynthetic caps in shallow landfills because geosynthetic materials offer a better barrier against vacuum short-circuiting to the surface.	High	High	Moderate	Yes
	Treatment (gas treatment and/or destruction) *	Adsorption (via GAC and Hydrosil®)	GAC Hydrosil® (permanganate-impregnated zeolite medium)	GAC would remove SVOCs and most VOCs; could be used with either passive or active collection systems. Hydrosil® would remove lighter VOCs such as vinyl chloride; could be used with either passive or active collection systems.	Treatment units could restrict the airflow of passive venting systems, rendering them less effective.	High	High	Low (if NMOC concentrations are low) High (if NMOC concentrations are high, following capping of the entire landfill)	Yes
		Destruction (via combustion)	Enclosed Flare	An enclosed flare would destroy landfill gas, including NMOCs and methane, through combustion; primary chemical by-products from flares are carbon dioxide and nitrogen oxide compounds.	Operating conditions would reduce the possibility of dioxin formation by promoting the destruction of organics, operating at temperatures above those that would allow dioxin formation followed by rapid quenching, and extending the combustion residence time.	High	Moderate to High	Low to Moderate	Yes
			Open Flare	Eliminated from consideration due to poor system controls (relative to enclosed flares).		N/A	N/A	N/A	N/A
			Internal Combustion Engine	Eliminated from consideration because volume of gas generated by the Parcel E-2 Landfill is not anticipated to be sufficient to support the cost-effective implementation of internal combustion engines.		N/A	N/A	N/A	N/A
		Destruction (via non-combustion processes)	Energy Recovery	Energy recovery technologies, such as fuel cells, use landfill gas to produce energy directly.	Effectiveness of energy recovery and gas-to-product systems at Parcel E-2 is unknown due to the lack of information on gas concentration generation rates (assumed moderate to high, depending on implementability).	Likely Low (assumed moderate to high, if implementable at Parcel E-2)	Likely Low (site-specific conditions need to be better defined)	High	Yes
			Gas-to-Product	Gas-to-product conversion technologies focus on converting landfill gas into commercial products, such as compressed natural gas, methanol, purified carbon dioxide and methane, or liquefied natural gas.					

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

Notes:

* Additional data are needed to determine the type(s) of treatment required for landfill gas at Parcel E-2.

Acronyms defined on page 4

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FIGURE 11-2 (cont.)

Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Groundwater in Parcel E-2	No Action	None	None	No action would be taken to remove, contain or treat groundwater; no institutional controls would be established to prevent exposure, and no monitoring would be required.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as subsurface construction • Restrict the use of groundwater within the Parcel E-2 boundaries • Prohibit the installation of wells that have the potential to affect the migration of contaminated groundwater within Parcel E-2.	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and would be required to prevent exposure to groundwater within the Parcel E-2 boundaries.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (to be used in conjunction with other remediation technologies)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring	Short-term monitoring involves outdoor air monitoring during construction of control systems (if needed). Long-term monitoring includes groundwater monitoring and operation and maintenance of control systems (if needed).	Short-term and long-term monitoring would be integral components in any remedial alternative implemented at Parcel E-2.	High	High	Low	Yes
	Containment	Physical Barrier *	Slurry Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Barrier may need to be complemented with extraction wells or phytoremediation to prevent excessive groundwater mounding.	Moderate to High	Moderate to High	Moderate to High	Yes
			Grout Curtain Vertical Geomembrane	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Site-specific conditions limit the implementability of these options.	Moderate to High	Low to Moderate	Moderate to High	No
			Sheet Pile Wall	Physical barrier would be installed to cut off and/or redirect groundwater flow.	Barrier may need to be complemented with extraction wells or phytoremediation to prevent excessive groundwater mounding.	Moderate to High	Moderate to High	Moderate to High	Yes
		Hydraulic Containment *	Extraction from Wells & Off-Site Discharge	System would extract groundwater through pumping wells to contain groundwater and achieve RAOs at compliance points; extracted groundwater could be discharged to the sanitary sewer system, treated and reinjected, or treated and discharged to the Bay.	Groundwater modeling would be required to optimize extraction well placement and pumping rates, and to minimize the volume of water pumped from the Parcel E-2 aquifers; the required level of treatment would greatly influence cost.	Moderate-High	High	High	Yes
			Phytoremediation / Phytohydraulics	Phytohydraulics would use of plants to control rainfall infiltration and/or groundwater levels and movement; plants would remove water through evapotranspiration. In addition to hydraulic control, phytoremediation could potentially help reduce chemical concentrations in subsurface soils and groundwater.	If containment of solid waste, soil, and sediment is selected, then the plants would have to be placed in a previously remediated area that would not need a continuous low-permeability layer to prevent exposure to human or ecological receptors.	Moderate to High	Low to Moderate	Low to Moderate	Yes

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

Notes:

* Additional data are needed to determine the need for groundwater containment.

Acronyms defined on page 4

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FIGURE 11-2 (cont.)

Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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Medium	General Response Action	Remedial Technology	Process Options	Description	Comments	Effectiveness	Implementability	Cost	Retained for Analysis?
Surface Water in Parcel E-2	No Action	None	None	No action would be taken to monitor or manage stormwater runoff and groundwater discharges to wetlands and the Bay at Parcel E-2; no institutional controls would be established to prevent exposure to surface water.	Required by the NCP and is used as a baseline against which other response actions are compared – would not meet RAOs.	Low	High	No Cost	Yes
	Institutional Actions	Institutional Controls	Legal Mechanisms (Restrictive Covenants, Negative Easements, Deed Notifications) Administrative Mechanisms (Land Use Plans, Soil & Groundwater Procedures & Policies, Construction Permitting, Public Notices & Educational Materials)	Legal and administrative mechanisms used in combination to enforce various land use restrictions such as: • Restrict the use of the parcel to open space • Require maintenance of stormwater BMPs • Require development of a soil and groundwater management plan to be implemented during all intrusive site activities (such as, subsurface construction)	Institutional controls would be integral to and highly effective at maintaining the integrity of any final remedy, and are likely to be included as a part of any alternative that leaves landfill solid waste or other hazardous substances in place.	High	High	Low	Yes
		Engineering Controls (i.e. to limit/restrict access)	Signs (Warning & No Trespassing) Traffic Barriers & Perimeter Fencing	Engineering controls are physical mechanisms that serve to restrict access and potential exposure to contaminated media. Process options include warning and no trespassing signs, engineered barriers to vehicular traffic and perimeter fencing to reduce the potential for direct human contact with contaminated media.	Access restrictions conflict with future open space reuse; to be used during implementation of other remedial technologies.	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low (if used as part of a permanent remedy) High (if used during implementation of an active remediation technology)	Low	No (to be used in conjunction with other remediation technologies)
		Site Monitoring	Short-Term Monitoring Long-Term Monitoring Stormwater BMPs	Short-term monitoring involves stormwater monitoring during construction. Long-term monitoring includes surface water monitoring and inspection and maintenance of stormwater BMPs. Monitoring of surface water is used to demonstrate compliance with RAOs designed to prevent unacceptable exposures to aquatic receptors in the bay.	Stormwater BMPs would be incorporated as part of a stormwater monitoring program that would be implemented in conjunction with an inspection and maintenance for any containment systems.	High	High	Low	Yes

Legend

- Retained for use in Remedial Alternatives
- Retained for possible future incorporation (based on future site data)
- Eliminated from consideration

Acronyms

BMP	best management practice
CCR	California Code of Regulations
cm/sec	centimeters per second
GAC	granular activated carbon
GCL	geosynthetic clay liner
GRA	general response action
HDPE	high-density polyethylene
LLRW	low-level radioactive waste
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NMOC	nonmethane organic compound
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
QA	quality assurance
QC	quality control
SVOC	semivolatile organic compound
VOC	volatile organic compound

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FIGURE 11-2 (cont.)
Results of Remedial Technologies and Process Options Evaluation

Remedial Investigation/Feasibility Study for Parcel E-2

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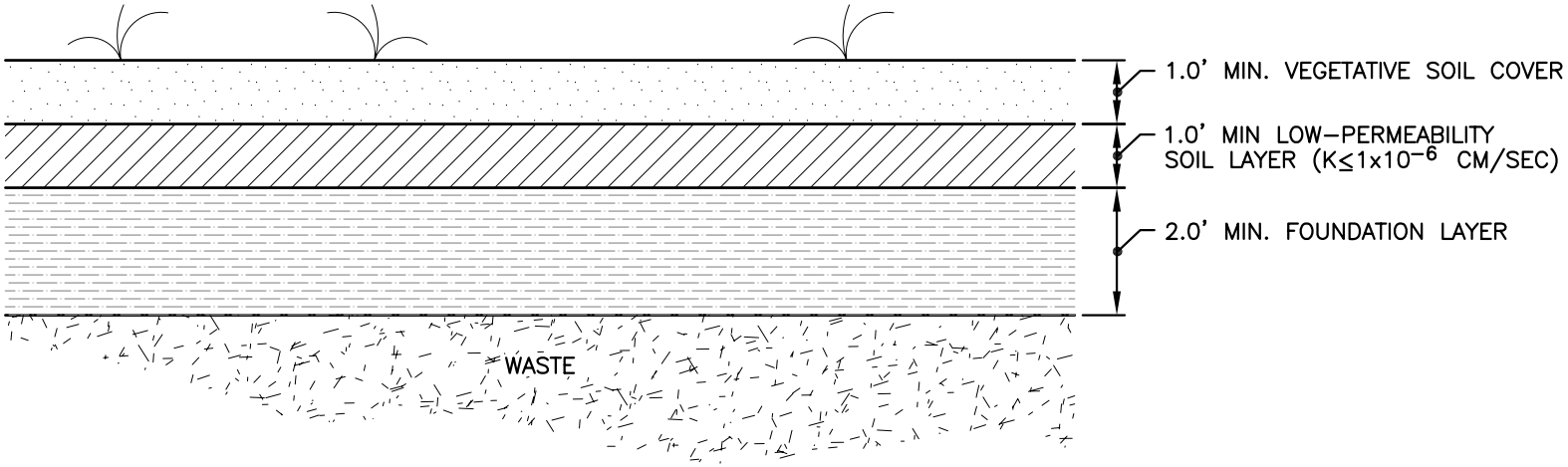


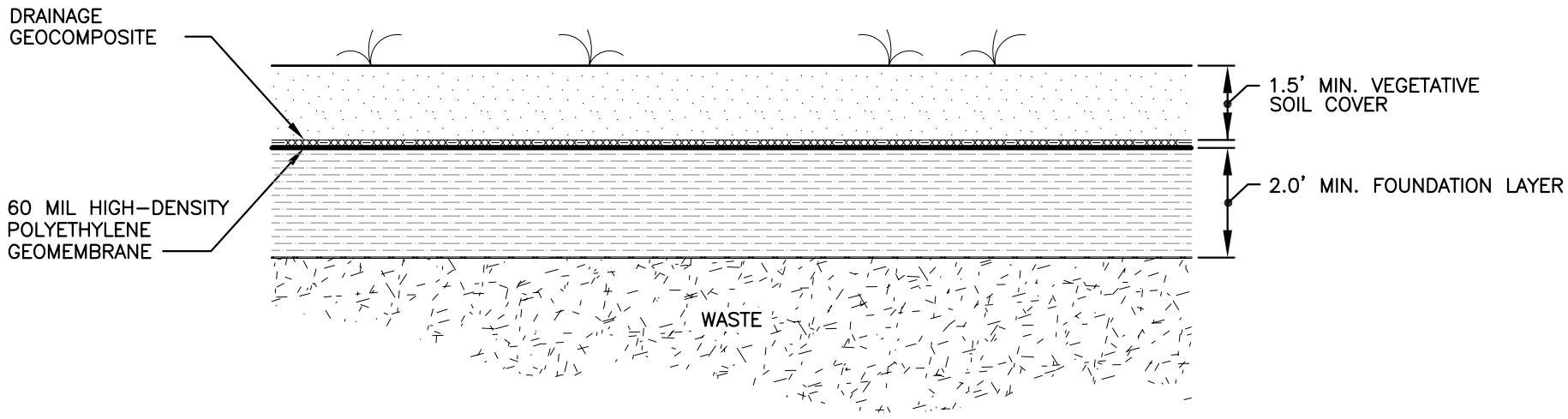
LOW-PERMEABILITY SOIL CAP

SHAW Environmental, Inc.

Hunters Point Shipyard, San Francisco, California
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-3
LOW-PERMEABILITY
SOIL CAP

Remedial Investigation/Feasibility Study for Parcel E-2



GEOSYNTHETIC CAP

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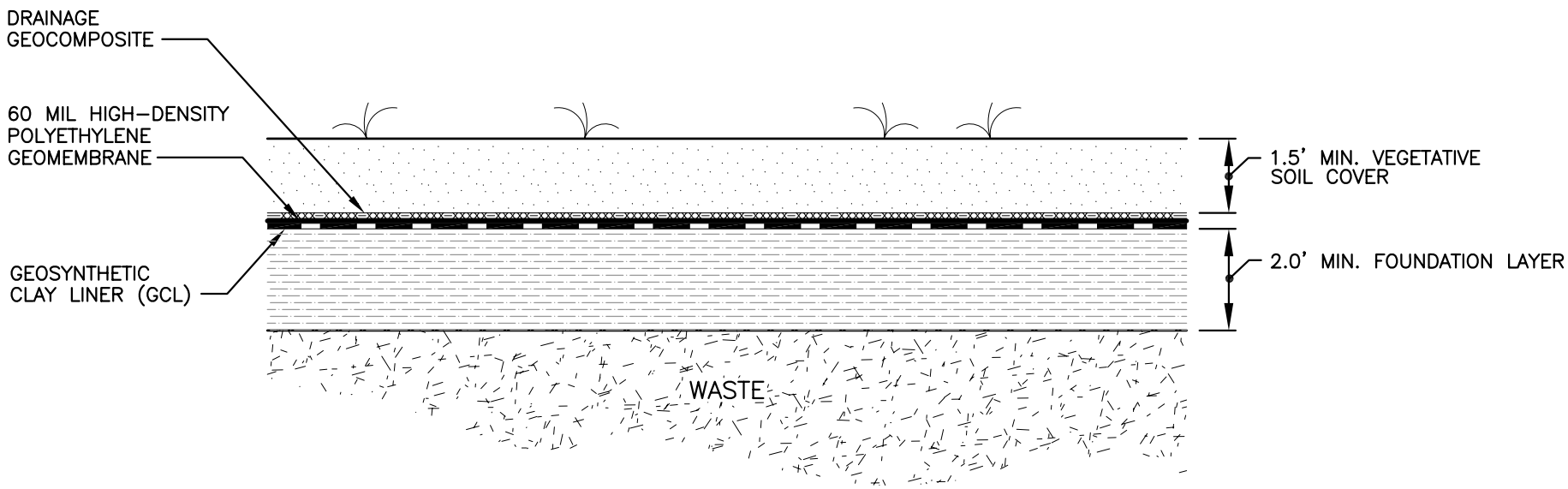
FIGURE 11-4
GEOSYNTHETIC CAP

Remedial Investigation/Feasibility Study for Parcel E-2



MULTILAYER GEOSYNTHETIC CAP

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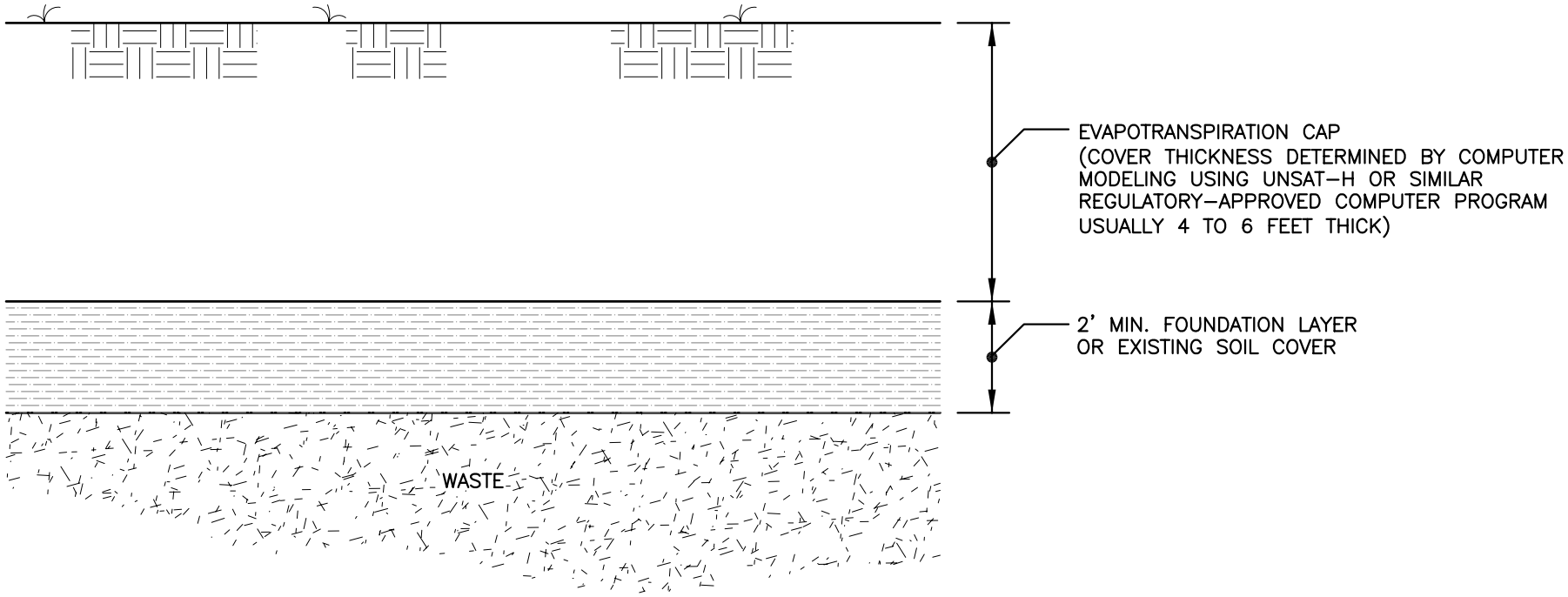
Department of the U.S. Navy, BRAC PMO West, San Diego, California

FIGURE 11-5
MULTILAYER
GEOSYNTHETIC CAP

Remedial Investigation/Feasibility Study for Parcel E-2



EVAPOTRANSPIRATION CAP

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FIGURE 11-6
EVAPOTRANSPIRATION CAP

Remedial Investigation/Feasibility Study for Parcel E-2

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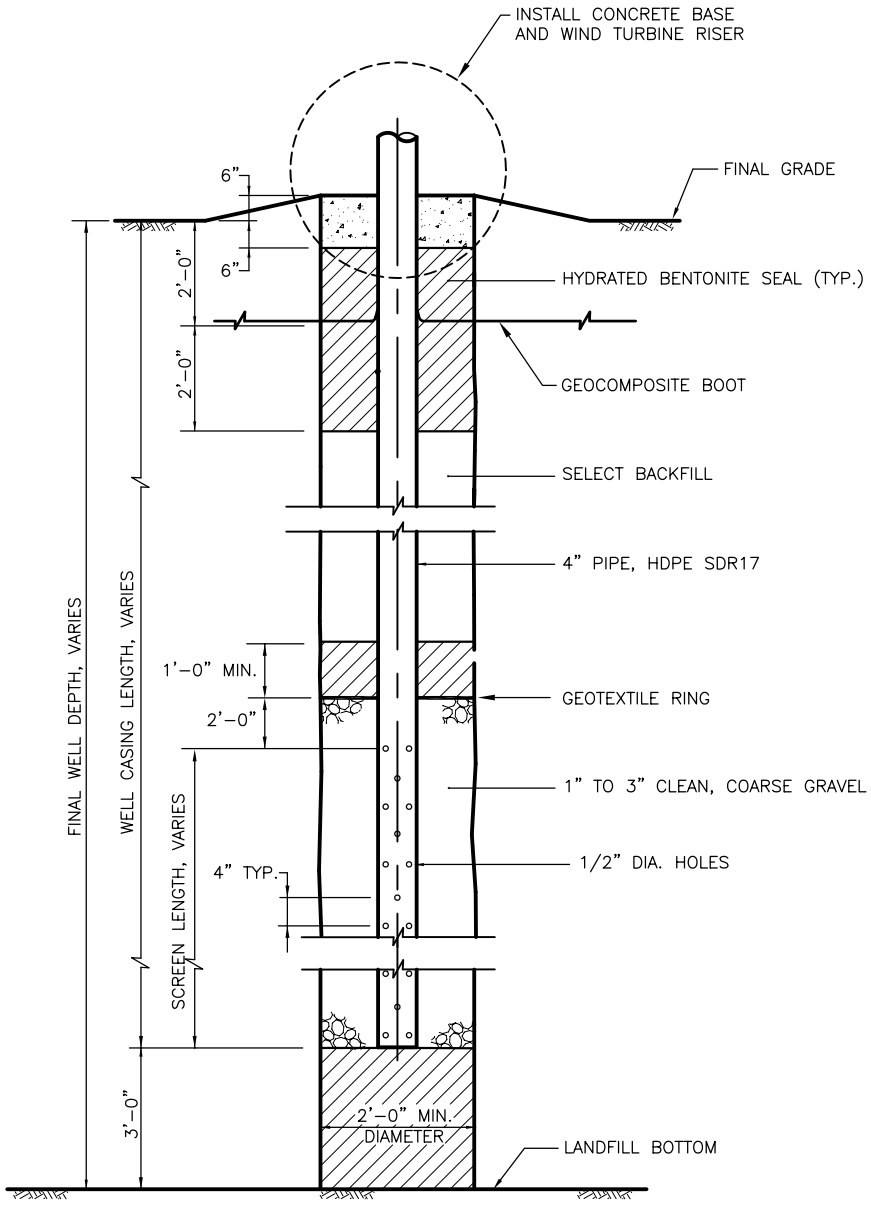
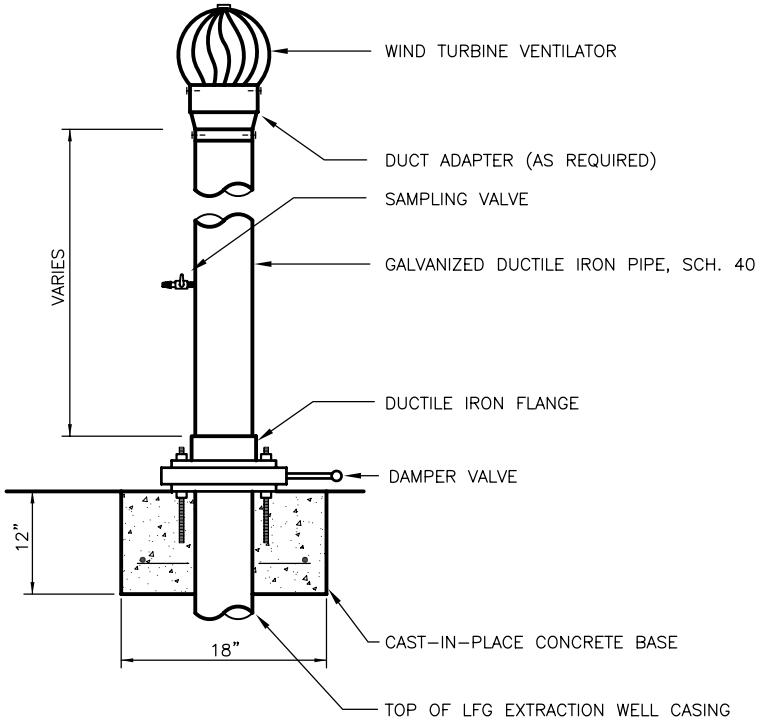


LFG EXTRACTION WELL
NOT TO SCALE



CONCRETE BASE AND WIND TURBINE RISER
NOT TO SCALE

SHAW Environmental, Inc.

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FIGURE 11-7
CONCEPTUAL LANDFILL GAS VENT, EXTRACTION WELL AND WIND TURBINE

Remedial Investigation/Feasibility Study for Parcel E-2

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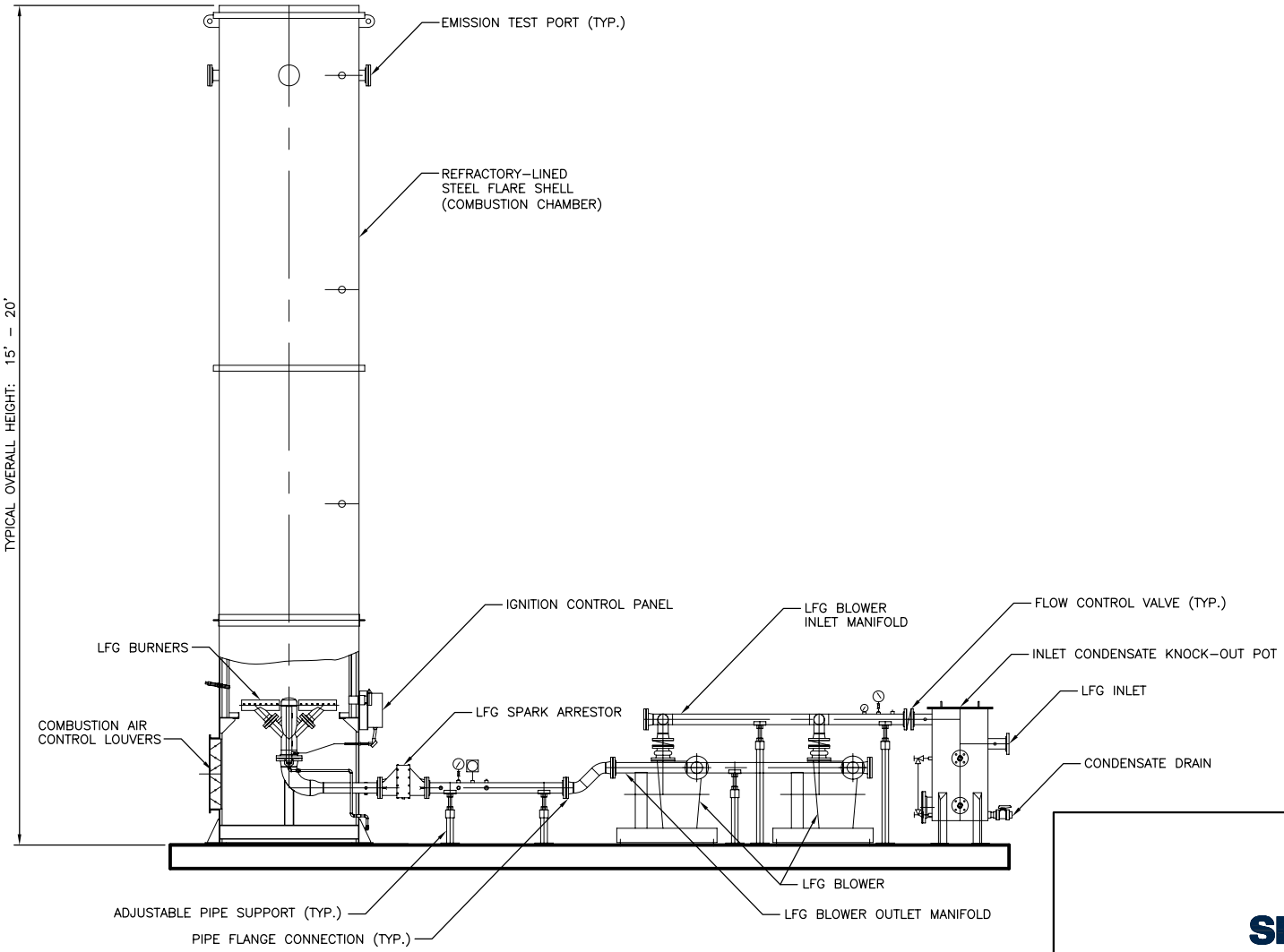

CONCEPTUAL LANDFILL GAS FLARE

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FIGURE 11-8
CONCEPTUAL LANDFILL GAS FLARE

Remedial Investigation/Feasibility Study for Parcel E-2

SOURCE: Bekaert CEB Technologies BV

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FIGURE 11-9
ALTERNATE FLARE

Remedial Investigation/Feasibility Study for Parcel E-2

Tables

Table 11-1 Containment Technology Evaluation
Hunters Point Shipyard Parcel E-2, Remedial Investigation/Feasibility Study

Containment Technology	Evaluation Criteria				
	Proposed End Use	Climate	Performance[1]	Availability of Materials	Cost[2]
Low-Permeability Soil Cap (Title 27 Cover, Prescriptive Standard)	Not Suitable for Irrigated End Use	Suitable	5.70	Availability of Soil Unknown until Construction Occurs	$4.50
Geosynthetic Cap (Title 27 Cover, Engineered Alternative)	Suitable for Irrigated End Use	Suitable	0.03	Availability of Soil Unknown until Construction Occurs. Geosynthetic Components Readily Available	$5.00
Multi-Layer Geosynthetic Cap	Suitable for Irrigated End Use	Suitable	0.03	Availability of Soil Unknown until Construction Occurs. Geosynthetic Components Readily Available	$5.60
Evapotranspiration Cap	Not Suitable for Irrigated End Use	Not Suitable	Not Suitable	Not Suitable	Not Suitable

[1] Inches of infiltration through the cover based on HELP modeling.

[2] Typical unit cost per square foot of cover.