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EPA Superfund Record of Decision:

FRESNO MUNICIPAL SANITARY LANDFILL
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Record of Decision

Fresno Sanitary Landfill
Fresno, California

September 30, 1996

U.S. Environmental Protection Agency
Region IX, San Francisco

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RECORD OF DECISION

Fresno Sanitary Landfill Superfund Site
Fresno, California
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PART II - DECISION SUMMARY

1.0 Site Name, Location, and Description

The Fresno Sanitary Landfill is located four miles southwest of the City of Fresno in Fresno County, California. The landfill consists of approximately 145 acres and is bounded on the north by Jensen Avenue, on the east by West Avenue, on the south by North Avenue and west by agricultural fields. The landfill stands approximately 60 feet above the surrounding flat grade and extends approximately 30 feet below the surrounding grade. The landfill is fenced. The groundwater underneath the site is part of a sole-source aquifer used as drinking water and irrigation water for the residents of Fresno. Eight water supply wells and many domestic wells are within 3 miles of the site.

2.0 Site History and Enforcement

The Fresno Sanitary Landfill was owned and operated solely by the City of Fresno from 1935 to 1987, and is reported to be the oldest compartmentalized landfill in the Western United States. Operations began in the north section in 1935 as short trenches were dug to a depth of three feet and eventually increased to 25 feet. Waste was then dumped into the trench by collection trucks and the pile was leveled off and compacted. A second trench was dug adjacent to the first trench, and the dirt from the second trench was used to cover the waste fill. The landfill was never lined.

The Fresno Sanitary Landfill was first evaluated by EPA pursuant to a CERCLA Section 103(c) notification to the City of Fresno Solid Waste Management Division filed on May 27, 1981. The California Department of Toxic Substances Control (DTSC) (formerly, California Department of Health Services) conducted a preliminary inspection of the site in 1984 in response to complaint letters from nearby residents. The state inspectors found off-site migration of methane and also reviewed the documentation of volatile organic compound (VOC) contamination of the groundwater.

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The Fresno Sanitary Landfill site was added to the National Priorities List on October 1989. EPA sent a General Notice letter of liability in April 1990. On June 22, 1990 EPA sent the City a Special Notice letter asking the City to submit a good faith offer to conduct the remedial investigation and feasibility study for the Fresno Sanitary Landfill. On September 21, 1990, EPA and the City signed an Administrative Order on Consent (EPA Docket 90-22) wherein the City agreed to conduct the remedial investigation and feasibility study.

In 1988, the City of Fresno installed two methane barriers on the north and south side of the landfill to prevent the exposure of the nearby residents to migrating landfill gases. In 1990, EPA held discussions with the City of Fresno regarding the continuing landfill gas migration away from the landfill. Subsequently, with the consent of the City, EPA issued a Unilateral Order (US EPA Docket No. 90-19) to install a vacuum system on the barriers and to install a landfill gas extraction system in the landfill. After the Order, it was determined that a landfill gas extraction system would need to be designed in conjunction with the landfill cover. EPA then directed the City to implement a landfill gas monitoring program to ensure that residents near the landfill were not being exposed to vinyl chloride (a potent carcinogen in the migrating landfill gas) in their homes. The City tested the in-home air of seven potentially affected residences. No vinyl chloride was detected in any of the homes on three different occasions (November 1991, March 1992 and November 1992). The monitoring system showed high levels of vinyl chloride up to 700 feet away from the landfill in the soil gas.

From September 1990 to August 1991, the City installed the vacuum system on the existing methane barriers. During the operation of these systems, it was discovered that the existing methane barriers were not designed for a vacuum extraction system. EPA determined that the operation of the vacuum system would be inappropriate because it did not stop the landfill gases from migrating past the barriers.

Concurrent to the landfill gas work, the City began its investigation of the landfill trash prism and the groundwater plume migrating from the site. During the soil gas investigation, the City requested that the investigation for the landfill trash prism and the landfill gas be separated from the groundwater investigation in order to speed the decision for that unit. Thus the investigation at the site was divided into two operable units: the source control operable unit which addressed the landfill trash prism; and the groundwater operable unit which addressed the groundwater impacted by the landfill contaminants. The feasibility study for the source control operable unit was completed in September 1992. In March 1993, EPA released a proposed plan for the source control operable unit which included a landfill cover consisting of a geomembrane material, a soil foundation layer and a soil cover layer; a landfill gas extraction and destruction system and a storm water run-off collection system. The Record of Decision for this proposed plan was signed in September 1993.

The Administrative Order on Consent between the City and EPA was amended on December 17, 1993 (EPA Docket 94-07) to include the design of the landfill cap and other components of the system. The design is nearly 90% complete and is scheduled to be finished in February 1997.

Concurrent to the landfill source control operable unit remedial investigation and feasibility study work, the City initiated the remedial investigation and feasibility study for the groundwater operable unit. The Remedial Investigation for the groundwater operable unit was completed in May 1994. The Risk Assessment was completed in September 1994. The Feasibility Study was completed in July 1996.

3.0 Highlights of Community Participation

The Remedial Investigation Report, the Feasibility Study and the Proposed Plan for the groundwater operable unit at the Fresno Sanitary Landfill Superfund site were released to the public in July 1996. These three documents were made available to the public in both the Administrative Record and the EPA Records Center in Region IX and at the Fresno County Library in Fresno, California. The notice of the availability of the Administrative Record was published in the Fresno Bee on July 22, 1996. A public comment period was held from July 24, 1996 through August 23, 1996. In addition, a public meeting was held on August 1, 1996. At this meeting, representatives from EPA and the State of California answered questions about the site and the remedial alternatives under consideration. A response to the comments received during this period is included in the Responsiveness Summary, which is part of this Record of Decision. This decision document presents the selected remedial action for the groundwater operable at the Fresno Sanitary Landfill Superfund Site, in Fresno, California, chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. The decision for this site is based on the documents in the Administrative Record.

4.0 Scope and Role of Operable Unit

As with many Superfund sites, the problems at the Fresno Sanitary Landfill are complex and varied. As a result, EPA organized the work into two operable units. These are:

Operable Unit 1: Source Control Operable Unit
Addresses the trash prism and landfill gas

Operable Unit 2: Groundwater Operable Unit
Addresses the groundwater contamination

EPA has selected a remedy for the first operable unit. The remedy is in the design phase and construction is planned for late spring 1997. This second and final operable unit addresses the threat of groundwater contamination in the sole source aquifer surrounding the facility.

5.0 Summary of Site Characteristics

A remedial investigation (RI) was conducted at the Fresno Sanitary Landfill by the City of Fresno as required by the Administrative Consent Order. Hydrogeologic investigation activities included the review of regional and previous site investigation reports, collection of water level measurements, performance of aquifer hydraulic tests, and evaluation of nearby irrigation-related recharge and pumping. These investigations indicated that regional groundwater flow near the Fresno Sanitary Landfill is to the southwest. Factors affecting regional flow directions include a drawdown cone within the City of Fresno due to municipal groundwater pumping, a recharge mound at the Fresno Regional Wastewater Facilities located several miles west of the site, and irrigation pumping from deep wells farther to the west and south. Regional water levels have decreased over time due to groundwater pumping that is in excess of recharge. Local groundwater flow rates and direction are affected by nearby agricultural pumping wells. Pumping of agricultural wells near the site induces downward vertical gradients that are not present during non-pumping months.

Four hydrostatigraphic units were identified including (in descending order) a shallow sandy A aquifer at the water table, a silt and clay B aquitard, a B aquifer with interbedded silts and discontinuous sands, and a continuous sandy C aquifer at approximately 250 feet below the site. Shallow groundwater is unconfined beneath the site, and flow directions range from the southwest to west-northwest. Deeper groundwater present in the B and C aquifer units is under semi-confined conditions. All the groundwater zones are sources of drinking and/or irrigation water.

The remedial investigation included chemical analysis of groundwater from domestic wells, monitoring wells and irrigation wells. Organic compounds detected at the site which may pose a risk are tetrachloroethylene, trichloroethylene, vinyl chloride, trans-1,2-dichloroethene; cis-1,2-dichloroethene; 1,1-dichloroethane; 1,2-dichloroethane; 1,2-dichlorobenzene; 1,4-dichlorobenzene; benzene; 1,1-dichloroethene; 1,2-dichloropropane; chloroform; dichlorodifluoromethane; trichlorofluoromethane; toluene; and chlorobenzene. The highest concentrations and the greatest lateral extent were found in the A aquifer. Detections of volatile organic compounds in groundwater extend to approximately 1,300 feet downgradient of the landfill. Concentrations of volatile organic compounds detected in the monitoring wells screened in the B aquifer are at least an order of magnitude lower than the A aquifer. No analytical detections of the contaminants of concern were found in the C aquifer.

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Residential domestic wells are located to the north, east, and south of the landfill. These wells tap into the A and the B aquifers. The chemical concentrations at these wells do not exceed their respective maximum contaminant levels (MCLs) in drinking water, with the exception of one well located south of the site (2168N) which exceeded the MCLs for tetrachloroethylene (5 µg/l) with one result of 8.6 µg/l in August 1993. This well is targeted for decommissioning.

Several agricultural irrigation wells are located downgradient of the landfill. These wells are apparently completed within the B and C aquifers. Operation of these wells is intermittent. Irrigation well I6 (otherwise known as U16) is located on the west central edge of the landfill. Operation of this well may be responsible for drawing volatile organic compounds down from the A aquifer into the B aquifer, and potentially the C aquifer. Irrigation well I6 is targeted for decommissioning. Downward vertical hydraulic gradients are only apparent during summer months when the irrigation wells are in operation.

The City of Fresno instituted a sampling program for the monitoring wells and nearby domestic and irrigation wells in July 1992. The range of chemical concentrations detected is as follows:

Chemicals of Concern in Groundwater	Range of Concentrations (7/92 - 5/95)
Tetrachloroethylene (PCE)	Not detected to 110 □g/l
Trichloroethylene (TCE)	Not detected to 83 □g/l
Vinyl chloride	Not detected to 150 □g/l
1,1-Dichloroethane	Not detected to 26 □g/l
1,2-Dichloroethane	Not detected to 2.1 □g/l
1,2-Dichlorobenzene	Not detected to 4.4 □g/l
cis-1,2-Dichloroethene	Not detected to 560 □g/l
trans-1,2-Dichloroethene	Not detected to 19 □g/l
1,1-Dichloroethene	Not detected to 1.3 □g/l
1,2-Dichloropropane	Not detected to 11 □g/l
1,4-Dichlorobenzene	Not detected to 14 □g/l
Benzene	Not detected to 6.1 □g/l
Chlorobenzene	Not detected to 4.8 □g/l
Chloroform	Not detected to 2.7 □g/l
Dichlorodifluoromethane	Not detected to 290 □g/l
Trichlorofluoromethane	Not detected to 33 □g/l
Toluene	Not detected to 7.2 □g/l

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6.0 Summary of Site Risks

EPA prepared a risk assessment for potential exposure to chemicals detected in groundwater at the Fresno Sanitary Landfill. The EPA risk assessment looked at two potential exposure pathways: ingesting contaminated drinking water; and inhaling chemicals during showering. Exposure to toxic compounds may occur as an individual showers with water contaminated with volatile organic compounds. Contaminants dissolved in the potable water supply may be released into the air during showering and inhaled by the individual. Inhalation exposures are modeled by estimating the rate of chemical release into the air, the buildup and the decay of volatile organic compounds in the shower room air, and the amount of airborne volatile organic compounds inhaled while the shower is both on and off. Based on the risk assessment, the potential risk associated with this pathway was much less than the drinking water exposure pathway.

The risk assessment evaluated potential human health risks under both current conditions and reasonable future conditions. The risk assessment evaluated potential carcinogenic and non-carcinogenic risks to off-site residential receptors. Excess lifetime cancer risks are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g. 1x10-6). An excess lifetime cancer risk of 1x10-6 indicates that as a plausible upper bound, an individual has a one in a million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under specific exposure conditions at the site.

Concern for potential noncarcinogenic effects of a single contaminant in a single medium is expressed as the hazard quotient (HQ) (or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's reference dose). The reference dose is an estimate of the maximum quantity of a contaminant to which a person can be exposed over a long period of time and still show no adverse health effects. By adding the HQs for detected contaminants within a medium and across media to which a given population may be reasonably exposed, a hazard index (HI) can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

For the current land use conditions, it was assumed that the site was in its present physical state, and there were no workers present. Groundwater analytical data collected during the remedial investigation from residential wells was used to estimate potential risks to off-site residents. Under the current land use scenario, the average and reasonable maximum exposure (RME) cancer risk associated with drinking water ingestion were estimated as follows:

Adult Average:	2 x 10-7	Adult RME:	1 x 10-6
Child Average:	3 x 10-7	Child RME:	6 x 10-7

Potential noncarcinogenic risks, as expressed in terms of the hazard index, were estimated as follows:

Adult Average:	0.05	Adult RME:	0.1
Child Average:	0.1	Child RME:	0.2

For the future land use scenario, it was assumed that the facility is inactive, the landfill is fenced-off, and a low permeability cap is installed. This is consistent with the 1993 Record of Decision. It also assumed that the concentration levels would not change over time, i.e. the source of leachate is not a continuing source and no dilution would occur. Groundwater monitoring well data from the remedial investigation was used to calculate concentrations for the groundwater ingestion pathway. Nine chemicals of potential concern, both organic and inorganic compounds, were evaluated in the risk analysis. These include 1,1-dichloroethane, methylene chloride, tetrachloroethylene, trichloroethylene, trichlorofluoromethane, vinyl chloride, barium, manganese, and selenium.

Potential excess cancer risks associated with drinking water ingestion under future land use scenario were estimated to be as follows:

Adult Average:	1 x 10-5	Adult RME:	8 x 10-5
Child Average:	2 x 10-5	Child RME:	4 x 10-5

Potential noncarcinogenic risks, as expressed in terms of the hazard index, were estimated to be as follows:

Adult Average:	0.2	Adult RME:	0.4
Child Average:	0.4	Child RME:	1

As shown above, the potential excess cancer risks quantified in the risk assessment for the ingestion pathway involving groundwater exposure were approximately in the 10-5 and 10-7 range for the future and current land use scenarios, respectively. The largest noncarcinogenic risk was equal to 1, for the child reasonable maximum exposure future groundwater ingestion pathway. All other noncarcinogenic risks were below an Hl of 0.5.

An additional consideration when evaluating the site is whether contaminant concentrations in a drinking water aquifer exceed safe drinking water standards. The groundwater zones impacted by the chemicals associated with the landfill are currently being used for domestic and irrigation purposes. Currently, the closest domestic wells still in use, are near the edge of the plume. If no action is taken at the site, the contaminant plume would migrate to the domestic wells. Several concentrations of contaminants detected within the current plume exceed maximum safe drinking water standards including those for trichloroethylene, tetrachloroethylene and vinyl chloride. Vinyl chloride is a known human carcinogen. Currently at the site, the average concentration of vinyl chloride along the point of compliance is 64 □g/l and the maximum detected concentration is 150 □g/l. The safe drinking water standard for vinyl chloride is 0.5 □g/l. The chemical specific standards which define acceptable risk levels (e.g. State and Federal drinking water maximum contaminant levels, MCLs) have been exceed at this site, and warrant the need for remedial action. Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

7.0 Applicable or Relevant and Appropriate Requirements

The following federal regulations have been determined to be applicable or relevant and appropriate requirements at the Fresno Sanitary Landfill:

- Safe Drinking Water Act 40CFR 141.61: MCLs, Provides maximum contaminant levels (MCLs) for drinking water.

- Safe Drinking Water Act 40CFR 144: Underground Injection. Provides Requirements for Underground Injection Program.

- Clean Water Act 33 CFR Part 301 &302: Effluent Limitations. Requires establishment of technology-based discharge limits for point sources of pollution

- Clean Water Act 33 CFR Part 307: Toxic & Pretreatment Standards. Requires the establishment of pretreatment standards for the control of pollutants to POTW.

- Clean Air Act 40 CFR 61: National Emission Standards for Hazardous Air Pollutants. Identifies and establishes emission standards for specific chemicals.

The following state of California regulations have been determined to be applicable or relevant and appropriate requirements at the Fresno Sanitary Landfill:

- Water Quality Control Plan (Basin Plan) for the RWQCB, CCR: Establishes water quality objectives, including narrative and numerical standards, that protect the beneficial uses and water quality objectives of surface and ground waters in the region.

- Title 23, Division 3, Chapter 15, Article 123 CCR 2511(d): Actions taken by or at the direction of public agencies to clean up or abate conditions of pollution or nuisance resulting from unintentional or unauthorized releases of waste or pollutants to the environment are exempt from the requirements in the chapter; provided that wastes, pollutants, or contaminated materials removed from the immediate place of release shall be discharged according to Article 2 of this Chapter; and further, that remedial actions intended to contain such wastes at the place of release shall implement applicable provisions of this subchapter to the extent feasible.

- Title 23, Division 3, Chapter 15, Article 123 CCR 2510(g): Since the waste at the site will be contained, the requirement that persons responsible for discharges at waste management units which are closed, abandoned, or inactive on the effective date of these regulations may be required to develop and implement a monitoring program in accordance with Article 5 of this chapter is applicable.

- State Water Resources Control Board Resolution No. 92-49 III G.(As amended April 21, 1994): Establishes requirements for investigation and cleanup and abatement of discharges that impact or threaten water quality. Dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality or the best water quality that is reasonable if background is not technically and economically feasible.

- State Water Resources Control Board Resolution No. 88-63 ("Sources of Drinking Water Policy") (as contained in the RWQCB's Water Quality Control Plan) Specifies that, with certain exceptions, all ground and surface waters have the beneficial use of municipal or domestic water supply.

- Title 23, CCR, §2550.6: Requires monitoring for compliance with remedial action objectives for three years from the date of achieving cleanup levels.

- Title 23, CCR, §2550.7: Requires general soil, surface water, and groundwater monitoring.

- Title 23, CCR, §2550.9: Requires an assessment of the nature and extent of the release, including a determination of the spatial distribution and concentration of each constituent.

- Title 23, CCR, §2550.10: Requires implementation of corrective action measures that ensure that cleanup levels are achieved throughout the zone affected by the release by removing the waste constituents or treating them in place. Source control may be required. Also requires monitoring to determine the effectiveness of the corrective actions.

- Title 22, CCR, Division 4, Chapter 15, Articles 4, 5.5, and 8: Requirements for public water systems. Includes maximum contaminant levels (MCLs).

- Health and Safety Code §25249.5; Title 22, CCR, Division 2, Subdivision 1, Chapter 3: Prohibits the discharge or release to water or to land of a significant amount of any chemical known to the State of California to cause cancer or reproductive toxicity when the chemical will probably pass through a source of drinking water.

- Title 22, CCR, Division 4.5, Chapter 14, Article 6, §66264.90-66264.101: Groundwater Protection. Creates broad groundwater monitoring and compliance standards. Includes concentrations standards, monitoring requirements and corrective action requirements.

- Title 22, CCR, Division 4.5, Chapter 14, Article 7, §66264.117: Closure & Post Closure. States that monitoring, maintenance and reporting requirements must continue for 30 years past closure.

- Title 22, CCR, Division 4.5, Chapter 14, Article 9, §66264.170-66264.178: Containers. Requirements for facilities that store containers of hazardous waste.

- Title 22, CCR, Division 4.5, Chapter 14, Article 10, §66264.190-66264.200: Tanks. Outlines design and management standards for tanks.

8.0 Description of Alternatives

Four alternatives, including a limited action alternative were developed for the groundwater near the site. All the alternatives have some of the same components, referred to as common elements.

8.1 Common Elements

A description of each of the common elements is presented below. The institutional controls, well decommissioning and groundwater monitoring program are elements common to all alternatives. A more elaborate groundwater monitoring program is required in the active alternatives (alternative 2, 3 and 4). Groundwater treatment and managing the treated groundwater are common to the active alternatives only.

Institutional Controls. Institutional controls are non-engineering methods by which access to contaminated environmental media is restricted. Most institutional controls are in the form of use or access restrictions. Institutional controls anticipated at the Fresno Sanitary Landfill will consist of restricting the installation of water supply wells in the impacted aquifer and limiting site access. Controls on the use of the groundwater pumped from the contaminated aquifer by existing wells will be considered. These institutional controls can be enforced by the County governmental agency or by zoning and deed restrictions.

Well Decommissioning. A series of groundwater supply and monitoring wells in the vicinity of the site may be allowing cross-contamination between upper and lower aquifer units, and have been proposed for decommissioning. The wells fall into three categories.

- Former Residential Supply Wells. The four targeted residential supply wells are located south of the landfill at homes recently purchased by the City (2100, 2142, 2168, and 2188 North Avenue). These wells are no longer needed.

- Groundwater Monitoring Wells. The two targeted groundwater monitoring wells are screened across multiple aquifer units and do not provide useful environmental data (Wells EW-1 and Ow-1).

- Water Supply Wells. Three irrigation supply wells are located within or adjacent to the groundwater plume west of the landfill. Water level measurements collected during the remedial investigation show that when in operation, these wells create a downward gradient of flow may result in which drawing contaminants into deeper aquifer layers. In addition, there are two water supply wells located on the landfill. Collectively, the use of these wells presents the potential for increasing exposure to contaminants in the groundwater and could draw contaminants from the upper A aquifer into the underlying groundwater units (Wells U-16, I-4, I-5, 19H-1, and 19H-2).

Groundwater Treatment. The extracted groundwater will be treated to remove contamination prior to the ultimate disposition of the treated effluent. Treatment of the groundwater will be performed either at a treatment plant that would be located on-site at the landfill or at the Fresno Regional Wastewater Facilities (RWWF). The City of Fresno has proposed using a two-stage treatment process. The first stage will consist of an air-stripping unit for removal of volatile organic compounds from the groundwater. This will be followed by a granular activated carbon (GAC) unit for adsorption of volatile organic compounds from the off-gas stream. The treatment system will also include storage tanks, piping, mechanical equipment, and other materials necessary to process the extracted groundwater. It is anticipated that the treatment system will be located on City property adjacent to the landfill in the vicinity of the contaminant plume.

Management of Treated Groundwater. Options for the treated effluent are:

- Irrigation either through direct use on the landfill or by farmers in the vicinity of the landfill, or as a source of water for the irrigation canals.
- Discharge into the Fresno drinking water supply distribution system.
- Off-site disposal at the Fresno RWWF.
- Aquifer recharge through either reinjection or percolation ponds.

Initially, the City of Fresno intends to dispose of the contaminated groundwater to the Fresno RWWF. Ultimately, after the landfill cap is constructed and there is vegetation on the landfill, the City intends to use the treated groundwater as irrigation water for the landfill cover. Effluent standards of the treated water varies depending on ultimate disposal. The effluent standards are as follows:

- Discharge to the Fresno RWWF is considered an off-site discharge which must comply with the pretreatment requirements of the RWWF.
- Discharge to irrigation canals are considered an off-site discharge and would require an NPDES permit.
- Discharge of treated groundwater for re-injection outside of the plume must meet non-detect effluent levels.
- Use of the treated water for irrigation or for percolation ponds must meet the effluent limits for land disposal.
- Use of treated water for drinking water must meet the requirements of Safe Drinking Water act. Where appropriate, discharge levels should be set at drinking water standards including taste and odor requirements.

8.2 Alternative 1- Limited Action

As part of Alternative 1, all components described in common elements will be implemented. No further remedial actions will be taken to control groundwater flow either beyond the landfill perimeter or beyond the current off-site contaminant plume. Continuing migration would not be prevented in any way as a result of actions undertaken as part of this alternative other than through natural attenuation.

The groundwater monitoring program currently underway will be continued as a way of quantifying the impacts associated with no remedial response action. The monitoring program is described in detail in the Semi-Annual Groundwater Monitoring Program (CDM, 1995a), as modified by EPA comments dated May 2, 1995. The groundwater monitoring program under Alternative 1 consists of the following elements:

- Semi-annual groundwater monitoring - Periodic sampling of the groundwater will be conducted. The groundwater monitoring system includes 33 groundwater monitoring wells and 9 residential wells. No new wells will be drilled under this alternative.

- Quarterly water level measurements - Water level measurements will be made on a quarterly basis. Quarterly water level measurements are carried out on all of the groundwater monitoring wells.

- Reporting - Reports will be prepared on a semi-annual basis and will summarize the analytical laboratory results of the semi-annual groundwater monitoring event and the two previous water level measurement events.

- Periodic evaluation of the monitoring program - The groundwater monitoring program will be evaluated after 5 years of operation. Modifications to the program may be proposed based on the monitoring data obtained.

The costs associated with the Limited Action alternative are only those required to perform the monitoring and periodic review of data from the existing groundwater monitoring well network. Annual O&M costs are estimated to be $68,000 which result in a total present worth value of $1,018,000 over a 30-year post-closure period.

The Limited Action alternative will not meet the clean-up standards for contaminated groundwater established under either Federal or State requirements based on existing contaminant concentrations in the A and B aquifers.

8.3 Alternative 2 - Landfill Perimeter Plume Containment and Off-site Plume Monitoring

Organic compounds are introduced into the groundwater as the leachate formed in the trash prism infiltrates through underlying soil into the groundwater below the landfill at the site. The primary objective of Alternative 2 is to isolate this source of groundwater contamination from impacting downgradient waters. This is accomplished by creating a hydraulic barrier along the downgradient, western perimeter of the landfill in the A and B aquifers, and C aquifer, if contamination is found in the C-zone during the monitoring program. Such a barrier system effectively prevents the contaminated groundwater located beneath the landfill from mixing with downgradient waters. In containing the impacted groundwater along the perimeter of the landfill, Alternative 2 is consistent with the presumptive remedy component of the groundwater remedial action.

The point of compliance in this alternative is the landfill boundary. This is the point where leachate-contaminated groundwater will be contained.

Once the landfall perimeter extraction wells are installed and operating, pumping in a given aquifer will draw down the water in that layer and will create cones of depression centered around each well. These cones of depression will cause water to flow toward the extraction wells, from locations both upgradient and downgradient of the wells. Water downgradient (west-southwest) of a perimeter extraction well can flow toward the well because of the reversed hydraulic gradient.

Naturally-occurring processes such as volatilization, sorption and biodegradation play a role in the attenuation of contaminants existing in the off-site aquifer. In the past, the attenuation rate of these natural processes has not been sufficient to keep pace with the plume migration rate. However, once the perimeter extraction system is in operation, there are two factors that are likely to increase the importance of natural processes in the attenuation of off-site contamination: no additional contaminant mass will be introduced into the off-site aquifer plume; and, as the plume migration rate is reduced, naturally occurring processes have more time to act on and attenuate the existing plume.

This alternative will also include the common elements described in earlier sections. The groundwater monitoring program currently underway will be enhanced to include additional monitoring wells and a more comprehensive sampling frequency of the wells. The purpose of the monitoring program is to verify the extent of the plume, to verify the effectiveness of the landfill containment wells and to include additional domestic wells in the sampling program, if needed. The monitoring program shall also include reporting to participating oversight agencies and notification of potentially impacted residents. The details in this monitoring program will be described in detail in a groundwater monitoring plan. The groundwater monitoring program will be evaluated after 5 years of operation and during the installation and operation of the phasing of remedy for alternatives 3 and 4. Modifications to the program may be proposed based on the monitoring data obtained.

In accordance with EPA guidance for the preparation of feasibility studies (EPA, 1988), costs were developed for a 30-year operating period. The capital cost for implementing the institutional controls and constructing the perimeter extraction monitoring and treatment systems is $3,714,000. Annual operation and maintenance (O&M) costs are estimated to be $453,000 which results in a present worth value of $6,774,000 over the 30-year remediation period. The total 30-year present worth value of the Alternative 2 extraction and monitoring systems is $10,488,000. Landfill perimeter wells may have to be operated for a period greater than 30 years.

Federal or State applicable or relevant and appropriate requirements governing groundwater clean-up levels will not be achieved within a reasonable time frame under Alternative 2, because the objective of this alternative is source control and not clean-up. Volatile organic compounds above regulatory allowable limits will remain in the plume downgradient of the zone of capture of the perimeter extraction system for some time prior to being attenuated below the regulatory limits.

Alternative 2 is the presumptive remedy established in EPA guidance on landfill CERCLA sites (EPA, 1992a; EPA, 1992b).

8.4 Alternative 3 - Landfill Perimeter Plume Containment and Off-site Plume Containment

The primary objective of the Alternative 3 remedial action is to prevent contamination of currently uncontaminated portions of the aquifer system. This is accomplished by preventing the groundwater plume from expanding in both a lateral and vertical direction. Plume containment is achieved by installing two systems of groundwater extraction wells. The extraction well systems, designed to act as hydraulic barriers to groundwater flow, will be constructed adjacent to the western boundary of the landfill (as in Altemative 2) and along the downgradient edge of the off-site contaminant plume.

There are two points of compliance in this alternative. The landfill boundary is the point of compliance where leachate-contaminated groundwater will be contained. The current extent of the plume, as defined in the remedial investigation, is the point of compliance where currently contaminated water will be contained.

The landfill perimeter extraction system component of this alternative will intercept groundwater passing underneath the landfill and is identical to that described for Alternative 2. This system will limit additional contaminant mass from impacting groundwater downgradient of the landfill. The purpose of the plume boundary extraction system is to limit the movement of the groundwater plume in a downgradient (southerly and westerly) direction in the A and B zones. The C zone will be monitored and included in the extraction system, if necessary. The lateral and vertical extent of the plume is contained such that downgradient water quality is not impacted.

A groundwater monitoring program will be instituted as described in Alternative 2. The purpose of the monitoring program is to verify the extent of the plume, to assess the effectiveness of the landfill containment wells and the effectiveness of the plume containment wells, and to include additional domestic wells in the sampling program, if needed.

As described above in Alternative 2, once the groundwater extraction systems begin operation, natural attenuation processes, such as volatilization, sorption, and biodegradation, will begin to play a more important role in the attenuation of the off-site contamination. Natural attenuation becomes more important because no additional mass will be introduced into the off-site aquifer and, as the plume migration rate is reduced, the naturally occurring processes have more time to act on and attenuate the existing plume.

In addition to the landfill perimeter extraction wells, it is estimated that 4 groundwater extraction wells from the A aquifer and 4 wells for extraction of groundwater from the B aquifer will be located to prevent expansion of the off-site plume. These will be co-located, single completion wells drilled, installed, and completed as described for the landfill perimeter extraction wells. No estimate for C aquifer wells was included. However, if contamination associated with the site is found in the C aquifer above levels of concern, extraction wells will be installed and operated.

In accordance with EPA guidance for the preparation of feasibility studies (EPA, 1988), costs were developed for a 30-year operating period. The capital cost for implementing the institutional controls and constructing the perimeter extraction, monitoring and treatment systems and plume boundary containment and monitoring systems is $6,375,000. Annual operation and maintenance (O&M) costs for these extraction and monitoring systems are estimated to be $598,000 which result in a present worth value of $8,940,000. The total 30-year present worth value for the Alternative 3 extraction and monitoring system is $15,315,000.

Alternative 3 will not comply with the State ARAR that requires dischargers to clean up and abate the effects of discharges in a manner promoting attainment of either background water quality or the best reasonable water quality if background quality is not technically or economically feasible as determined in accordance with State regulations. Although Alternative 3 will remove significant contaminant mass over time as a result of the combination of the perimeter extraction wells and the plume boundary extraction wells, the primary objective of this alternative is not to clean up and abate the effects of the discharge in the water downgradient of the landfill and upgradient of the plume boundary containment wells.

8.5 Alternative 4 - Landfill Perimeter Plume Containment and Off-site Plume Restoration

The primary goal of Alternative 4 is to actively restore the contaminated aquifer downgradient of the landfill to levels that comply with regulatory standards which are maximum contaminant levels (MCLs) at this site. This is accomplished by extracting the contaminated groundwater in the region west of the landfill within the existing off-site plume, in conjunction with landfill boundary extraction wells. This action will allow the aquifer to be flushed with clean groundwater. Isolating the groundwater flowing underneath the site with the perimeter extraction system will result in no additional contaminant mass being added to the off-site plume, thus facilitating restoration of the aquifer within the off-site plume.

The point of compliance in this alternative is the landfill boundary. This is the point where leachate-contaminated groundwater will be contained. All groundwater past this point will be restored to beneficial use.

The extraction well system for this alternative is more extensive than the system developed under Alternative 3. Additional extraction wells are placed within the plume for the aquifer restoration remedial action. A groundwater monitoring program as described in Alternative 3 will also be implemented in Alternative 4.

Alternative 4 was divided into 2 subalternatives in the Feasibility Study. The division was made based on the clean-up goal, either background or maximum contaminant levels (MCLs). State regulations (CCR, Title 23, Chapter 15, Article 5) state that groundwater clean-up goals established for corrective action measures cannot exceed background water quality unless it is shown that background is technically or economically infeasible, but in no case can the clean-up levels be set higher than MCLs. At the Fresno Sanitary Landfill, background levels would be non-detect. In the Feasibility Study, an analysis was completed on potential clean-up levels following the process outlined in the state of California regulation, Section 2550.4 of Article 5, Title 23. The analysis showed that it was technically and economically infeasible to establish a non-detect level for clean-up. The potential for the aquifer to be cleaned up to background levels within a reasonable time period is low. This was demonstrated by evaluating the historical performance of many pump and treat systems. The general ineffectiveness of pump and treat systems to reach low cleanup levels are a function of aquifer characteristics which prevent flushing of specific zones and the difficulty of desorbing the entire contaminant mass from the aquifer soil particles. Groundwater with volatile organic compounds at maximum contaminant levels (MCLs) do not represent a risk to public health or the environment greater than the risks associated with background levels. The cost of and the length of time to clean-up the aquifer to background levels was estimated to be approximately 3 times greater and

3 times longer than cleaning up to MCLs.

Costs were developed for a 30-year operating period. The capital cost for implementing the institutional controls and constructing the extraction, monitoring and treatment systems under alternative 4 is $7,948,000. Annual O&M costs for the extraction and monitoring systems are estimated to be $624,000 which results in a present worth value of $9,329,000. The total 30-year present worth value of the Alternative 4 extraction and monitoring systems is $17,277,000.

Alternative 4 whose goal is to clean up the groundwater plume to maximum contaminant levels (MCLs) complies with all applicable or relevant and appropriate requirements.

8.6 Phased Implementation of the Remedial Action

In an effort to streamline the Superfund process, EPA has begun to encourage adoption of a new strategy for implementation of remedial action called phasing. An important benefit of this approach is that data generated during early phases can be used to refine and enhance later phases of the remedial action. A phased remediation approach can make best use of site-specific hydrogeologic and geochemical data collected during early phases of the site remediation program to implement later actions in the most efficient and effective manner possible. The remedial alternatives identified and evaluated as part of the feasibility study were designed to facilitate this concept of phased implementation. The remedial activities in the lower-numbered alternatives will be implemented first, before components of the next remedial alternative are implemented. Data will be collected during the operation of each phase to ensure the objectives of each phase are achieved (e.g. plume is contained for phase II), and to collect data to optimize the design of the next phase.

1 - Phase I - landfill perimeter extraction wells

Phase I includes installation and operation of the extraction wells along the perimeter of the Fresno Sanitary Landfill in order to contain the contaminated groundwater below the landfill. Groundwater monitoring beyond the landfill perimeter and beyond the off-site plume will also be undertaken. All other common elements described above will be implemented in this phase. The data to be collected and analyzed are as follows:

- Water level data to assess whether the landfill perimeter extraction wells are containing all of the contamination groundwater beneath the landfill.
- Water level and water quality data from the monitoring wells and extraction wells to assess the downgradient extent of the off-site groundwater plume.
- Drawdown data in monitoring wells surrounding the extraction wells to evaluate the capture zone in order to optimize the design of the phase II wells, if needed.
- Drawdown data in monitoring wells surrounding the extraction wells to evaluate the efficiency in the capture zone of the landfill perimeter extraction wells.
- Water level data from extraction and monitoring wells to evaluate the impact of the extraction wells and the effect of on-land discharge of the treated water on aquifer water levels.

It is anticipated that operation of this phase before moving on to phase II will be between one to two years.

2 - Phase II - plume control extraction wells

This second phase of the remediation includes the installation and operation of the wells to contain the movement of the contaminated groundwater plume. The landfill perimeter extraction wells from phase I will still be operated. After phase II of the remedy is fully implemented, the contaminated groundwater plume is fully contained. Data to be collected and analyzed during this phase is as follows:

- Water level data to assess whether the off-site plume is being contained by the extraction wells.

- Water quality data from the monitoring wells and extraction wells to assess rate of contaminant removal and determine the most effective way to install and operate phase III wells, if needed.

- Water level and quality data from the monitoring wells and extraction wells to assess rate and amount of contaminant removal from the phase II wells to determine effectiveness of the phase II system in terms of timely removal of contaminant.

- Drawdown data in monitoring wells surrounding the pumping wells to assess influence of different pumping rates to efficiently design the aquifer restoration wells (phase III).

- Water quality data from the monitoring wells and extraction wells around the lateral edges of the contaminated portion of the aquifer near the site to assess the rate of contaminant removal where groundwater is flushed through the aquifer system.

The collection of chemical desorption rates is a more time involved process; therefore, phase II will be operated longer than phase I. It is estimated that phase II could take between 2 and 5 years to collect surf[dent data during phase II before moving to phase III.

3 - Phase III - aquifer restoration

This third and final phase of the remediation includes the installation and operation of the wells to complete restoration of the aquifer to beneficial use. Phase I and phase II extraction and monitoring wells will still be operated. The data to be collected and analyzed are as follows:

- Water level and quality data from the monitoring wells and extraction wells to determine effectiveness of the phase III system.

9.0 Summary of Comparative Analysis

The purpose of this section is to present a comparative analysis of the alternatives that were developed to remediate the groundwater. The comparative analysis was made based on nine criteria. This section is organized by evaluation criteria. The extent to which each of the four alternatives satisfies the criteria will be compared and contrasted.

9.1 Overall Protection of Human Health and the Environment

Alternatives 2 through 4 (also referred to as the "active alternatives") are relatively more protective of human health and the environment than the Limited Action alternative, because contaminants are removed from the aquifer under alternatives 2 through 4 which reduces the plume toxicity and volume. For instance, as compared to alternative 1, alternative 2 adds a further level of protection providing source control and more extensive monitoring of the off-site. Alternative 3 will provide a higher level of protection, via active containment of the off-site plume. This will prevent the off-site plume from migrating into clean portions of the aquifer and will not lead to exposure of currently unexposed populations. Alternative 4 provides the most extensive level of protection because it restores the aquifer to beneficial use and does not rely on institutional controls to protect public health.

9.2 Compliance with Applicable or Relevant and Appropriate Requirements

The plume containment achieved under Alternatives 3 and 4 satisfies the remedial action objective of preventing the plume from moving downgradient and impacting previously uncontaminated groundwater resources. Alternatives 3 and 4 also establish the conditions where additional groundwater resources will not be impacted. Alternative 4 is the only alternative that complies with the federal and state of California's requirement to restore sole-source aquifers to beneficial use.

9.3 Long-Term Effectiveness and Permanence

The perimeter extraction system specified in Alternatives 2 through 4, and the plume boundary containment system specified in Alternatives 3 and 4, will likely meet performance objectives. These systems will effectively isolate the off site plume from the contaminant source and will limit the plume from expanding in a westerly direction.

The institutional controls in the first three remedial alternatives are not as reliable in preventing access to contaminated groundwater over the long term as restoring the aquifer to beneficial use (alternative 4). The technologies associated with groundwater extraction and treatment are dependable when properly operated and maintained. Alternatives 2, 3, and 4 will require long term operation of the extraction and treatment systems.

No long-term effectiveness is accomplished with Alternative 1 because no controls on contaminant movement are implemented under the Limited Action alternative. The perimeter extraction system (Alternative 2) prevents additional contaminant mass from being added to the groundwater downgradient from the site. However, the volatile organic compounds may spread over a greater area under Alternative 2 because the plume limits are not actively contained.

9.4 Short-Term Effectiveness

The perimeter extraction and plume boundary containment system specified in the active alternatives will effectively isolate the contaminant plume within approximately 3 months of operation. The time frame for operating the landfill perimeter wells is unknown because it is not known how long leachate will continue to be formed. The time frame for reaching the clean-up goals established under Alternatives 4 is also unknown and will be determined during phase II of the remedial action.

Implementation of all four alternatives will have minimal impacts on the residential community and will have equivalent minimal impacts on workers in the short-term. The systems proposed are at a substantial distance from the local residences. Portions of Alternatives 2, 3 and 4 will be constructed on private property and implementation of these three alternatives will interfere with the agricultural operations occurring on these properties.

9.5 Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction of toxicity, mobility and volume will be achieved to some degree within the contaminated portions of the aquifer under each of the alternatives, due to natural attenuation (including compound dispersion, adsorption, and biodegradation) which reduces contaminant mass, and therefore contaminant toxicity and volume. Alternatives 2 through 4 reduce contaminant toxicity and volume to successively higher degrees since they remove increasing amounts of contaminated water from the aquifer. Alternatives 2 through 4 also reduce the toxicity and volume of contaminated groundwater to successively higher degrees through treatment of extracted water. Alternatives 3 and 4 will reduce off-site plume contaminant volumes more so than Alternative 2 due to the greater number of wells located in the off-site plume and higher initial pumping rates under Alternatives 3 and 4.

Alternative 2 reduces contaminant mobility to a moderate degree compared to Alternative 1 since the perimeter containment wells capture some of the off-site plume.

The hydraulic gradient in the off-site plume area is also reduced by operation of the perimeter containment wells; this will decrease groundwater flow rates and therefore also reduce the migration rate of the off-site plume. Alternatives 3 and 4 reduce contaminant mobility to about the same degree in the off-site plume.

9.6 Implementability

The Limited Action alternative is readily implemented, requiring the least number of permits, access easements, or controls to institute. The existing monitoring well network will be sampled on a periodic basis in a similar manner as being performed currently.

Alternatives 2, 3, and 4 require the same relative amount of coordination with the regulatory community. The State agencies governing groundwater clean-ups, the Central Valley Regional Water Quality Control Board and Department of Toxic Substances Control, are presently involved in the identification and development of remedial actions at Fresno Sanitary Landfill.

Alternatives 2, 3, and 4 will be progressively more difficult to implement, due to the increased number of wells, higher production rates, more extensive piping and treatment systems required and larger operations and maintenance efforts involved. Implementation of the three active alternatives require access to private property located west of the landfill to install and operate plume extraction and monitoring wells. Plume boundary monitoring wells may be installed up to approximately 1,500 feet west of the site. For Alternatives 3 and 4, an extraction well system will be constructed on private property in addition to the downgradient monitoring well network, while the extraction wells for Alternative 2 will be located on City property. Negotiating construction access agreements and long-term easements, while feasible, will require effort.

The extraction and treatment technologies specified for Alternatives 2, 3, and 4 use standard well drilling techniques and treatment processes. Air strippers are commonly used for water treatment applications similar to the Fresno Sanitary Landfill project. Multiple contractors are available locally with the capability of providing the services necessary to construct and operate the three active alternatives.

Another element of the implementability criterion is technical feasibility of achieving the stated remedial objective for each of the alternatives. Because they are expected to achieve their respective remedial objectives, Alternatives 2 and 3 are considered to be technically feasible. Although Alternative 4 is a known technology, it is technically uncertain at this time when the aquifer can be restored to maximum contaminant levels (MCLs).

The monitoring well networks proposed for Alternatives 2, 3, and 4 will be similar for all three alternatives, with well points located immediately downgradient of both the landfill perimeter extraction system and the downgradient plume boundary. They are therefore equally implementable.

9.7 Cost

The EPA has defined a 30-year time period on which to calculate costs for the remedial systems. While costs have been estimated for this time period, it should be emphasized that the landfill plume containment systems in alternatives 2,3 and 4 may need to operate for periods longer than 30 years, the plume containment wells in alternatives 3 and 4 may need to operate for longer than 30 years and alternative 4 may or may not achieve its goal of aquifer restoration within 30 years. The total present worth life cycle costs for the Limited Action alternative are minimal compared to the three active alternatives. The $1,018,000 cost is for the semi-annual groundwater monitoring is conducted using the existing well network, and contains no capital costs.

Capital costs for the alternatives 2, 3, and 4, range from $3,714,000 for Alternative 2 to $7,949,000 for alternative 4. Annual costs for the active alternatives range from $453,000 for Alternative 2 to $624,000 for alternative 4. Annual costs (in terms of present worth) represent approximately 55 to 65 percent of the total present worth value of the three active alternatives.

Fresno Sanitary Landfill Feasibility Study
Alternatives Cost Summary

	Description	Capital Costs	Annual O&M Costs	Present Worth
Alternative 1	Limited Action	$0	$68,000	$1,018,000
Alternative 2	Source Control	$3,714,000	$453,000	$10,488,000
Alternative 3	Source Control & Off-site Plume Containment	$6,375,000	$598,000	$15,315,000
Alternative 4	Source Control & Off-site Aquifer Restoration	$7,948,000	$624,000	$17,277,000

Note: Costs shown in the table are based on a 30-year period of operation.

9.8 State Acceptance

The Department of Toxic Substances Control, as the lead State agency, concurs with this remedy. The Regional Water Quality Control Board has submitted comments during the public comment period and EPA's response to these comments are included in the Responsiveness Summary.

9.9 Community Acceptance

Comments made by the community during the public meeting centered on the quality of their drinking water and the health effects associated with the landfill. The community did not state any opposition to alternative 4.

The City of Fresno made a comment at the public meeting supporting the phasing in of the alternative and their preference for alternative 3. The City of Fresno also submitted comments in writing expressing their reasons for supporting alternative 3.

10.0 The Selected Remedy

The selected alternative for the groundwater is Alternative 4, aquifer restoration. This is because it is protective of human health and the environment and complies with applicable or relevant and appropriate requirements.

The major components of this remedy are:

- Groundwater monitoring;
- Abandonment of certain wells;
- Institutional Controls during remediation;
- Phasing-in of the groundwater extraction system;
- Installation and operation of phase I groundwater extraction wells (landfill perimeter containment);
- Installation and operation of phase II groundwater extraction wells (plume containment);
- Installation and operation of phase III groundwater extraction wells (aquifer restoration);
- Analysis of each phase of the groundwater remedy; and
- Treatment system for the extracted groundwater and all necessary piping.

One of the reasons to phase in the remedy is to collect data to optimize the design. Design elements such as number of wells, location of wells and pumping rates will be determined during the remedial design and the remedial action phases. For cost estimating purposes, it was estimated that ten pumping wells (each tapping into A aquifer and B aquifer) would be needed; phase I would require 3 extraction wells; phase II would require 4 additional wells and phase III would require 3 more wells. preliminary pumping rates for this remedy consist of initially pumping the A aquifer at 1,500 gpm and decreasing to approximately 320 gpm during the 30-year operational period. The B aquifer will be initially pumped at 1650 gpm, decreasing to approximately 400 gpm during the 30-year operational period.

The objective of this remedy is to restore the aquifer to beneficial use in a timely and cost-effective manner. The aquifer is considered to be restored to beneficial use when levels are at or below maximum contaminant levels (MCLs). The MCLs for the chemicals of concern are as follows:

Clean-up Goals for Contaminants of Concern in the Aquifer

Constituent	MCL Concentration µg/l (micrograms per liter)
Trichloroethylene	5.0 µg/l
Tetrachloroethylene	5.0 µg/l
Vinyl chloride	0.5 µg/l (1)
1,1-Dichloroethylene	6 µg/l (1)
1,2-Dichloroethane	0.5 µg/l (1)
trans-1,2 Dichloroethene	100 µg/l
cis-1,2 Dichloroethene	6 µg/l (1)
1,2-Dichloropropane	5 µg/l
1,2-Dichlorobenzene	600 µg/l
1,4-Dichlorobenzene	5 µg/l (1)
Benzene	1 µg/l (1)
Chlorobenzene	70 µg/l
Chloroform	100 µg/l
1,1-Dichloroethane	5 µg/l
Trichlorofluoromethane	150 µg/l
Toluene	150 µg/l

(1) State MCL is more stringent

11.0 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with applicable or relevant and appropriate requirements, and is cost-effective. This remedy utilizes permanent solutions, to the maximum extent practicable, and satisfies the statutory preference for remedies that reduces toxicity, mobility, and volume as a principal element.

A five-year review, pursuant to Section 121(c) of CERCLA, 42 U.S.C. §9621(c), will be conducted at least once every five years after the initiation of the remedial action to ensure the remedy provides adequate protection of human health and the environment.

11.1 Protection of Human Health and the Environment

The selected remedy is protective of human health and the environment. The objective of the remedy is to restore the aquifer to beneficial use, so human health is protected. It does not rely, in the long term, on institutional controls to protect human health. It also intercepts the leachate before it leaves the perimeter of the landfill, thereby protecting the environment from future degradation.

11.2 Applicable or Relevant and Appropriate Requirements (ARARs)

The selected remedy will be designed to comply with the identified applicable or relevant and appropriate requirements. These applicable or relevant and appropriate requirements include federal, and more stringent, promulgated state and local environmental and public health regulations.

11.3 Cost-Effectiveness

The selected remedy is the most cost effective remedy which is protective of human health and the environment, and complies with applicable or relevant and appropriate requirements. In order to minimize cost of construction and operation of the aquifer restoration system, EPA has proposed phasing-in the remedy, in order to collect data which would result in the most cost-effective design and operation.

11.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy provides for a permanent solution, one that ultimately does not rely on institutional controls to protect human health and the environment.

12.0 Documentation of Significant Changes

The proposed plan for the Fresno Sanitary Landfill site was released for public comment in July 1996. The proposed plan identified alternative 4, aquifer restoration, as the preferred alternative. EPA reviewed all written and verbal comments submitted during the public comment period. Upon review of these comments, it was determined that no significant changes to the remedy, as it was originally identified in the proposed plan, were necessary.

RECORD OF DECISION

Fresno Sanitary Landfill Superfund Site
Fresno, California
EPA ID # CAD980636914

PART III - Responsiveness Summary

1.0 Summary of Major Comments

The theme of several written comments centered on the maximum contaminant levels (MCLs) for clean-up levels. The State of California, Regional Water Quality Control Board stated a preference for operating a full aquifer restoration system before establishing clean-up levels because they believe levels lower than maximum contaminant levels (MCLs) may be achievable. The City of Fresno submitted several comments in support of alternative 3, arguing that MCLs as a clean-up level could not be achieved.

Comments and questions during the public meeting centered on the impact of the contaminants and of the remedy on their domestic or irrigation wells. No comments were made in opposition or in support of the proposed remedy except for representatives of the City of Fresno who stated a preference for alternative 3.

The specific comments and EPA's responses are presented in the following section.

2.0 Comprehensive Response to All Comments

Comment made by California Regional Water Quality Control Board, Central Valley Region

1 We have reviewed the July 1996 Proposed Plan (Plan) for addressing affected ground water at the subject site. The Plan states that the "... preferred remedy calls for restoring the aquifer to drinking water standards." We consider USEPA's decision to establish ground water cleanup levels which allow pollutants to remain in ground water to be premature, since sufficient information has not yet been provided to demonstrate that it is not economically or technically feasible to restore the ground water to background levels.

We suggest that USEPA consider developing an interim ROD with cleanup levels at background concentrations, until sufficient information is provided by the City to support cleanup levels that are technically and economically feasible. Once this information has been developed, a final ROD may be prepared that includes ground water cleanup levels that have been demonstrated to be feasible.

EPA Response: EPA acknowledges the uncertainty in setting the clean-up levels. EPA has learned from other pump and treat aquifer restoration sites that the optimum technical and economical clean-up level is site-specific and difficult to predict before remedial action has begun.

When a remedy is selected and documented in a Record of Decision (ROD), EPA certifies that the remedy selection was carried out in accordance with CERCLA and to the extent practicable, with the NCP. The NCP requires that the remedy be protective of human health and the environment, and that it complies with the applicable and relevant and appropriate requirements ("ARARs'). These ARARs, i.e., federal and more stringent State requirements, help set cleanup levels. Setting these cleanup goals in the ROD is necessary for enforceability and also because ARARs are frozen at the signing of the ROD.

The State ARAR (Resolution 92-49) that requires cleanup of discharges to attain background water quality allows for cleanup to best reasonable water quality if background is not technically or economically feasible. EPA believes the City of Fresno has provided the necessary demonstration that cleanup to background water quality is not technically and economically feasible for this site. Based on this demonstration and site specific information, EPA believes that MCLs are the best reasonable water quality cleanup level for Fresno Sanitary Landfill.

The State has suggested that EPA consider an interim ROD for this site. The NCP allows EPA to sign interim Record of Decisions. These documents are for the purpose of speeding up certain parts of the project and moving into remedial action phase while the investigation continues on other, more complex parts of the site. However, interim Record of Decisions must be consistent with the final remedy (NCP §300.430 (a)(ii)(B)). Signing an interim ROD for the groundwater with the intent of signing a final ROD after remedial action has been implemented and operated for a long period of time appears to circumvent the NCP requirement which freezes ARARs at the time of the signing and misinterprets the NCP's intended use of interim RODs.

Most importantly, EPA believes a clean-up level of MCLs restores the aquifer to beneficial use and is protective of human health and the environment.

Verbal comments made after public meeting by a community resident:

2 How will the pumping at the landfill affect the levels of groundwater at my well? It seems that over time, downgradient water levels will drop and I will have less water available to me.

EPA Response: The groundwater flow in the vicinity of the landfill is can be affected by the pumping rates of the many wells in the vicinity, while the groundwater level is dependent on the volume of water the wells pump, and on the amount of groundwater recharge through surface water and recharge ponds. With so many variables, it is uncertain how additional wells in the area will affect the water table. However, based on the groundwater modeling conducted by the City of Fresno's consultant, the drawdown from the extraction wells probably will not extend to the commentor's well. EPA will strive to operate a groundwater extraction and treated water recharge system that minimizes the impact on adjacent wells.

3 - Comments made by the City of Fresno:

3a The City of Fresno (City) has been working with the U.S. Environmental Protection Agency (EPA) since 1990 on the closure of the Fresno Sanitary Landfill (FSL) under the Superfund process. The City has been responsible for the performance of all the technical work at the site including the development of the field investigation activities, preparation of the Remedial Investigation Report that describes the nature and the extent of contamination at the site, and the formulation of the groundwater remediation alternatives documented in the July 3, 1996 Feasibility Study Report. The City will continue to take primary responsibility for the cleanup of the landfill as it procures construction contractors to install the selected environmental control systems at the landfill.

The City is providing this written comment on EPA's proposed plan for groundwater cleanup at the FSL because, based on the technical work we performed in developing, evaluating, and comparing remedial alternatives against the established criteria, we identified Alternative 3 as the selected for implementation and not Alternative 4 as EPA is proposing. The rationale for the City's determination is provided below.

The overall goal of a groundwater cleanup system is to protect public health and the environment by isolating the contaminated groundwater from exposure to humans and mixing with impacted groundwater aquifers. This is accomplished in the following ways:

i. Public Health Protection

Provision of alternate water supplies.
Prohibition of pumping from the plume for drinking water or agricultural purposes.

ii. Environmental Protection
Create a barrier that prevents the plume from expanding in either a lateral or vertical direction.

Alternative 3, Groundwater Containment, achieves these goals to a similar degree as EPA's proposed plan Alternative 4, for a cost of approximately $2,000,000 less over the 30-year time frame examined under the Superfund process. The cost difference is even greater when it is considered that Alternative 4 will take at least twice as long as the 30-year period to reach its goal of aquifer restoration, if restoration is possible at all.

EPA Response: EPA recognizes the effort and the cooperative spirit that the City of Fresno has put forth on this project. The City's concern for the protection of the community is evident in the willingness the City has shown in supplying filters or alternative drinking water to residents even when their well water met safe drinking water standards.

The City is correct that a primary concern in selection of the remedy is protection of human health and the environment. The NCP has established protection of human health and the environment as a threshold criteria. The other threshold criteria is compliance with applicable or relevant and appropriate regulations. These two criteria must be met by the alternative in order to be eligible for selection. (NCP §300.430(f)(i)(A)). EPA contends that alternative 4 is more protective to human health because it does not rely on institutional controls (see EPA's response to comment 3c). More importantly, alternative 4 is the only alternative that meets the other threshold criteria, compliance with applicable or relevant and appropriate regulations. Therefore, alternative 3 does not meet the threshold criteria to a similar degree as alternative 4.

The NCP also contains a list of expectations that EPA shall consider when selecting a remedy (NCP §300.430 (a)(iii)). Two expectations applicable to the Fresno Sanitary Landfill deal with institutional controls and usable groundwater. The NCP states " The use of institutional controls shall not substitute for active response measures (e.g., treatment and/or containment of source material, restoration of groundwater to their beneficial uses) as the sole remedy unless active measures are determined not to be practicable..." The NCP also states "EPA expects to return usable groundwater to their beneficial uses, wherever practicable..." EPA believes active measures are practicable and warranted for this aquifer which is heavily used for many purposes. (See EPA response to comment 3e) Based on the direction given in the NCP, EPA has determined that restoration should be the goal of the remedy.

EPA also questions whether alternative 4 would actually be more expensive than alternative 3 for the entire life of the project. The City would be required to contain the plume for as long as levels exceed safe drinking water levels. Under alternative 4, active restoration would result in a shorter time where the City would be required to operate plume containment wells. Also, not included in the City's claim that alternative 3 is more cost-effective, is the cost of the loss of resource (useable groundwater) as well as the additional cost incurred by the residents when they must drill deeper wells with additional casing or seals to avoid the contaminated water.

3b The risk assessment prepared by EPA dated September 1994, entitled "Human Health Risk Assessment for the Fresno Sanitary Landfill Superfund Site" identified ingestion of contaminated groundwater as the contaminant pathway with the greatest risk to public health. There is no greater risk associated with ingestion of contaminated groundwater under Alternative 3, as compared to Alternative 4, over the 30-year time period.

EPA Response: The risk assessment looked at current exposure and future reasonable maximum exposure. It assumed, in the future scenario that a drinking water well would draw water from the contaminated plume. Under this scenario the excess cancer risk was calculated to be 8 x 10-5. However, the risks may have been underestimated. The analytical data used in the risk assessment was from data collected from the remedial investigation at the time of the risk assessment. The purpose of the remedial investigation was to define the extent of the plume. At the Fresno Sanitary Landfill, the PCE and TCE contaminants are the most mobile; therefore, they were used to define the extent of the plume. Most of the remedial investigation monitoring wells were installed at the edge of the PCE/TCE plume and these wells were frequently sampled. There is evidence that the vinyl chloride plume is not as extensive as the PCE/TCE plume. Since vinyl chloride is a known human carcinogen, the reasonable maximum exposure levels should focus on areas where vinyl chloride is detected. The future reasonable maximum exposure level was biased towards the part of the plume where the concentrations were lowest.

The purpose of estimating a concentration for a reasonable maximum exposure is to ensure that the true mean of the entire site is not underestimated. Typically the 95% upper confidence level concentration is used to estimate the mean of the entire site. This mean can be underestimated if the samples are biased to the edge of the plume. The diluting out of the hot-spots is most evident in the calculation of risk associated with vinyl chloride. Current EPA risk assessment practice suggests that samples used in the risk assessment should be carefully selected to prevent diluting out the hot-spots. Therefore, for the concentration term in groundwater risk assessments, a simple average in the hot-spot can be used in calculating risk. The average concentration of vinyl chloride along the point of compliance is 64.6 □g/l and the maximum concentration detected is 150 □g/l. The risk assessment used 2.6 □g/l as the concentration for vinyl chloride in the future scenario drinking well.

The other component to risk is exposure. What is the likelihood that someone would drink vinyl chloride at 2.6 □g/l? Under alternative 4, the aquifer is restored to safe drinking water levels (0.5 □g/l for vinyl chloride). Therefore, it is improbable that there is human exposure to the contaminants. Alternative 3 relies on institutional controls to prevent someone from drilling a drinking water well in the contaminated zone. As discussed in EPA's response to comment 3c, it is possible for this system to fail; consequently, it is possible for human exposure to vinyl chloride under alternative 3. Therefore, there is a slightly greater risk associated with drinking contaminated groundwater under alternative 3 then there is under alternative 4.

3c The EPA and state regulators will not allow the installation of new wells for either potable water or agricultural purposes within the plume. Existing agricultural wells within the plume are scheduled for destruction prior to implementation of the groundwater remedial action. Residents with a water supply that may be impacted by the landfill have already received either bottled water or a system filter to assure clean water is available for potable purposes. The City has purchased properties surrounding the landfill, creating a buffer zone that reduces the number of residents in close proximity to the site. These actions are instituted for both Alternative 3 and Alternative 4. Public health is equally well protected under both alternatives.

EPA Response: EPA appreciates the efforts the City has made to protect the public's health. The effort to install filters or supply alternative water when chemicals associated are detected in the domestic wells, even when they are well below safe drinking water standards, demonstrates the City's good faith effort.

However, EPA disagrees that both alternative 3 and alternative 4 are equally protective. Alternative 4, in the long run, does not rely on institutional controls to protect human health.

Neither the state of California nor EPA have jurisdiction over installation of wells in the Fresno Sanitary Landfill vicinity. The government entity with authority to issue permits and thereby restricting well placement and well construction is the County of Fresno. Since this Record of Decision calls for institutional controls during the restoration phase, the City of Fresno will be responsible for notifying the County of Fresno of the necessary restrictions to protect human health and of any changes in necessary restrictions. It is assumed that, since the County of Fresno is responsible to protect the waters of its domain and to protect the health of its citizens, it would abide by the recommendations by the City of Fresno.

The reliability of the institutional controls are dependent on several factors. It is dependent on the communication between the City and the County regarding the present site conditions and well permit applications in the vicinity. It is also dependent on the County to impose the necessary restrictions and, in some cases, deny a well permit. It is also dependent on the citizen applying for the permit to follow permitting requirements that would not be imposed if the groundwater was restored to beneficial use. As the City is aware, this process has broken down in the recent past when a well was installed southeast of the landfill.

3d Environmental Protection

There is no greater potential for the contaminant plume to expand beyond its boundaries under Alternative 3 than Alternative 4. Both remedial systems are designed to contain both the lateral and vertical limits of groundwater contamination. Both alternatives consist of landfill perimeter extraction wells to intercept contaminant mass migrating from the landfill source and off-site plume containment wells to prohibit the plume from moving further downgradient. The Alternative 4 extraction wells within the center of the plume, which constitute the sole difference between Alternatives 3 and 4, are designed to restore the aquifer and do not contribute to plume containment.

EPA Response: EPA concurs that the uncontaminated portion of the aquifer is equally protected under alternative 3 and alternative 4. However, in addition, alternative 4 goes beyond containing the plume, it restores the contaminated portion of the aquifer (i.e., environment) to beneficial use.

3e "Alternative 4 Objectives Are Unachievable"

The City would view the selection of the Alternative 4 remedy differently if the aquifer could be restored to drinking water standards within a reasonable time period. Converting a contaminated water supply to a useable resource is a positive goal. However, it is estimated that it would take 63 years to cleanup the A aquifer to drinking water standards based upon groundwater modeling work documented in the Feasibility Study Report. This time period assumes that all groundwater pumped was contaminated. In actuality, the pumping system will recover uncontaminated groundwater as well as the contaminated groundwater. Because the volume of clean water was included as part of the total flushing volume estimates, the actual clean-up time will be longer than the 63 years.

A review of the history of pump-and-treat systems indicated that cleanup to maximum contaminant levels (MCLs) may not be attainable ever. As documented in Appendix A of the Feasibility Study report, many studies have been performed evaluating the effectiveness of pump-and-treat technologies in an attempt to identify the conditions in which the system applications are most effective. Two studies, The Effectiveness of Groundwater Pumping as a Restoration Technology by C.B. Doty, 1991 and the EPA's 1992 Evaluation of Ground-Water Extraction Remedies, Phase II, evaluated 28 separate sites. Seventeen of the 28 sites had aquifer restoration as the cleanup goal, defined as cleanup to, or below, the MCLs. The conclusion of the studies is that cleanup times were underestimated by three times the original estimate. In addition, only one of the 28 sites was demonstrated to have achieved aquifer restoration, with the other sites unable to achieve the cleanup goals established at MCLs and lower.

Several factors have been identified which may inhibit the attainment of the low cleanup goals established at the FSL for Alternative 4.

- Heterogeneous aquifers have zones of high permeability that develop preferential pathways for the flushing water. Contaminants in low permeable materials do not come in contact with the volume of water contacted in the higher permeability zones. Contaminant transport from the low permeability materials is then driven by diffusion mechanisms which result in much slower contaminant release than through flushing action.

- Zones of immobile water exist within the soil grain. These zones are present independent of a material's permeability, and are a function of the soil grain structure. Once again, contaminants from these areas of immobile water move by diffusion and not by flushing action.

- A portion of the contaminant is released very slowly from the aquifer material. The contaminant adheres strongly to the soil particles and desorbs at very slow rates, if at all.

In conclusion, significant evidence exists that the aquifer restoration goals established under Alternative 4, cleanup to MCLs, are difficult to attain in a reasonable time period; or may not be achievable at all. Therefore, there is no incremental bene§t to Alternative 4 over Alternative 3, since both alternatives contain the plume to the same extent.

EPA Response: The commentor cites two reasons supporting the assertion that MCLs cannot be achieved at the site, the results of their modeling and two studies, The Effectiveness of Groundwater Pumping as a Restoration Technology by C.B. Doty, 1991 and the EPA's 1992 Evaluation of Ground-Water Extraction Remedies, Phase II. While it is generally accepted that aquifer source areas cannot, under many circumstances, be restored to beneficial use, it has been demonstrated at pump and treat sites (including the sites in these studies) that the distal portions of the plume can be restored to safe drinking water standards, especially in situations where the source was removed. The situation at the Fresno Sanitary Landfill has many factors that promote the likelihood that MCLs can be achieved beyond the boundary of the landfill:

- The source will be contained at the boundaries of the landfill and will no longer act as a source of groundwater contamination downgradient of the landfill. This will be achieved by extraction wells along the perimeter of the landfill which will intercept leachate contaminated groundwater before it can migrate to the aquifer. Restoration is not required in the groundwater directly beneath the landfill. It was this type of area (source area) that the aforementioned studies indicated could not be restored to beneficial use.

- The concentrations of TCE and PCE in the off-site contaminated groundwater plume are relatively low compared to their solubility. When concentrations of contaminants are high relative to their solubility, it is more likely that the chemicals move or diffuse to the less mobile portions of the aquifer. This is due to the higher concentration gradient present with high concentrations. Low concentrations tend to stay soluble in the groundwater

- Most of the contaminants of concern are chemically-structures such that they are less likely to sorb on to soil particles and prefer to remain soluble in water.

The commentor also cited the modeling effort which indicated 63 years time frame for restoration. EPA has always questioned the predictive quality of the groundwater model for this site. The data collected for the remedial investigation has been sparse and the geological cross-sections have been greatly simplified to support a comprehensive model. A more apt use of this groundwater model is to aid in the design of the well extraction system.

In conclusion, as the commentor mentions, there are some general conclusions in literature that tend to suggest attaining MCLs would be difficult to achieve, but there are also factors at the site that indicate MCLs are a reasonable goal. Lack of site-specific information and inconclusive general information suggests that a phased approach to aquifer restoration will provide site-specific data needed to predict time frames to restoration and how best to achieve them.

3f The City should not be required to implement a remedial action with an objective which cannot be achieved. It is irresponsible for the City to burden its citizens with the financial responsibility of a program whose success is in doubt from the start.

It is recommended that Alternative 3 be selected as the proposed plan because it is equally protective of public health and the environment as Alternative 4, at a 30-year cost of approximately $2,000,000 less than Alternative 4.

EPA Response: EPA is sensitive to the City's dual responsibility of financial prudence and protecting the health of the people of Fresno. As discussed in EPA's response to the previous comment, there is uncertainty in how the aquifer system will respond during remediation. There are factors that indicate restoring to MCLs may not be feasible and there are factors that indicate restoration is possible. That is one of the reasons why EPA has proposed phasing in the remedy. If, as the City presumes, the aquifer cannot be restored, the data collected in the plume containment phase would show that active restoration phase is not practicable. At that point, the City could apply for a technical impracticability waiver. More importantly, the City would not have spent any more money than if alternative 3 had been chosen.

EPA also questions whether alternative 4 would actually be more expensive than alternative 3 for the entire life of the project. The City would be required to contain and monitor the plume for as long as levels exceed safe drinking water levels. Under alternative 4, active restoration would result in a shorter time that the City must operate the plume containment wells. Also, not included in the calculating the cost of alternative 3 is the cost of the loss of resource (useable groundwater) and the additional cost incurred by the residents when they must drill deeper wells with additional casing sealed to avoid the contaminated water.

Restoring the aquifer to unrestricted use is the best way to protect the health of the community. EPA believes that the most cost-effective plan would be to phase in the remedy, in order to optimize the design in each subsequent phases.

3g The City is in agreement with the EPA that the selected remedy should be implemented in a phased approach. Observations of the aquifer response to the pumping of the source control extraction wells will provide information valuable in siting additional wells. Operational data developed during the initial stage of the remedy such as optimum pumping rates, well draw down, and zone of capture, can be used to effectively develop subsequent phases of the system. It is important that a sufficient length of time is allowed for operation of the initial phase of the project to allow the necessary information to be obtained. It is especially critical to obtain operational field data which supports an achievable cleanup goal prior to construction of the entire Alternative 4 system. Appropriate phasing of the project will result in the construction of a system which can fulfill project goals, protection of public health and the environment, in a cost-effective manner.

The City is committed to continue working with the EPA on the closure of the FSL in a manner which protects public health and the environment. Efforts to accelerate the schedule for the installation of the groundwater remedial action, and other construction aspects of the projects, should be encouraged.

EPA Response: EPA concurs with the City and looks forward to working on the remedial design and remedial actions at the site with the City. EPA encourages all efforts to accelerate the project and will help the City achieve this objective, wherever possible.

4 - Comment made by a neighbor during the public meeting

What is in my well? How does the contamination get to me while I shower? I don't think the City has changed the filter on my system

EPA Response: The information that EPA has for your well indicates that it was sampled in July 1992, March 1993, August 1993, May 1994, May 1995 and November 1995. Your well water was tested for a full range of chemicals. Three chemicals have been detected in your well at levels below safe drinking water levels. These chemicals are tetrachloroethylene (PCE), trichlorofluoromethane and dichlorodifluormethane. PCE is a suspected human carcinogen, which means there is some evidence that PCE may cause cancer. The levels of PCE in your well have been consistently 3 □g/l; the safe drinking water level is 5 □g/l. The other two chemicals, trichlorofluoromethane and dichlorodifluormethane, are less hazardous chemicals. Trichlorofluoromethane has been found at a maximum concentration of 14 □g/l in your water and *the safe drinking water level for this chemical is 150 □g/l. Dichlorodifluormethane has no* legal safe drinking water standard; however, a safe level recommended by scientists has been established at 390 □g/l. Dichlorodifluoromethane has been detected at about the 10 □g/l range.

The well water is collected for sampling before it runs through the filter. So the chemical levels discussed above are not the levels that are in your drinking water. The City of Fresno has informed EPA that they have installed a filter at your wellhead and established a frequent service program for that filter system. The filter was last serviced on June 1, 1996 and is scheduled for the next service on September 1, 1996. Having the water filtered before it enters your home, protects you from all types of contact including drinking water and showering.

The chemicals at the Fresno Sanitary Landfill are volatile. That means during showering, the chemicals in the shower water can easily evaporate and the person showering can breathe the chemicals. EPA looks at all possible exposures, not just drinking water, when evaluating the impact on humans. Therefore, we included showering in the analysis. We found out that the drinking water pathway of exposure is a far greater health concern than showering. Again, the filter on your wellhead will protect you from both types of exposure.

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