7.0 CONCLUSIONS

This report has been prepared by the Sanitation Districts pursuant to an Enforceable Agreement between the Sanitation Districts and DTSC. The Enforceable Agreement has an effective date of March 31, 1988. The broad overall objective of the remedial investigation is to quantify the extent and magnitude of contamination in the air, surface water and sediment, subsurface soils, and ground water; and to determine if unacceptable risk exists to human health and the environment. This report has been prepared to fulfill the objectives and satisfy the requirements for the remedial investigation as specified in the Enforceable Agreement. In conducting the remedial investigation, various work plans were prepared and approved by DTSC for implementation. This report follows the program of investigation and analyses described in the work plans and subsequent submittals regarding additional field investigations as reviewed by DTSC. The conclusions of the RI are given below.

7.1 AIR INVESTIGATIONS

Several monitoring programs were conducted to characterize the ambient air and landfill gas emissions. These monitoring programs included ambient air, integrated surface gas, boundary probe, neighborhood meter box, surface flux chamber, landfill gas, and flare emissions. In addition, meteorological conditions were monitored and landfill gas samples were collected for analysis. The results of the air investigations are given below.

- The prevailing wind direction at the PVLF is from the west-southwesterly direction.

- Ambient air monitoring locations 1 and 4 were predominantly upwind locations, and monitoring locations 2 and 3 were predominantly downwind locations during both the original and additional ambient air sampling programs.

- There are multiple sources of VOCs that can affect air quality; this produces a complex TAC mix in the ambient air background.

- Qualitative analysis shows that there are no significant differences between the VOC levels at the PVLF (both upwind and downwind) and in the Los Angeles air basin, as measured by SCAQMD both for the overall basin and at the Hawthorne air monitoring station (the closest SCAQMD monitoring location to the PVLF).

- Quantitative analysis using both parametric and nonparametric statistical methods shows that there are no significant differences between upwind and downwind VOC levels at the PVLF.

- No emissions to ambient air attributable to the PVLF were identifiable.

- The results of the additional ambient air sampling program, conducted during June 1994 and July 1994, supported the results of the original ambient air sampling program conducted from September 1990 to August 1991. The upwind and downwind VOC concentrations from the additional ambient air sampling program fell within the range of the those from the original ambient air sampling program.

- The overall gas generation at closed landfills declines over time.

- The production of VOCs, compared to methane levels, at the PVLF is declining over time.

- The current landfill gas control system at the PVLF has an estimated gas collection efficiency of 98.7 percent.

- The average surface gas level 8.1 ppm, measured at the PVLF for the period from September 1990 to August 1991, was within the range of ambient air measurements of TOC as methane, which were 3 to 47 ppm.

- The average surface gas levels, measured as ppm methane, at Ernie Howlett Park and the main site were within the range of ambient air measurements. The average surface gas levels at the South Coast Botanic Garden exceeded both ambient air measurements

and the 50 ppm limit established by SCAQMD for active landfills in Rule 1150.1. As part of the Sanitation Districts' ongoing maintenance activities at the PVLF, additional gas collection wells were installed in December 1991 at the South Coast Botanic Garden to reduce landfill gas emissions.

- The average surface gas levels at selected South Coast Botanic Garden routes decreased an average of 60 percent after the installation of several additional gas collection wells at the South Coast Botanic Garden. The route with the highest surface gas measurements showed one of the largest decreases in measured surface gas levels (87 percent). Since February 1992, the 50 ppm limit established by SCAQMD for active landfills in Rule 1150.1 has not been exceeded at the South Coast Botanic Garden.

- The moving site averages of surface gas measurements for both 3 and 6 month periods do not show large changes over the monitoring period.

- Methane was not detected at the percent level at 210 of the 256 boundary probes during the remedial investigation.

- Corrective actions were taken to reduce detections of methane in boundary probes and a preventative maintenance program has been implemented to augment the existing monitoring and maintenance program to eliminate future methane detections.

- The total number of methane detections in boundary probes have significantly decreased since the implementation of the preventive maintenance program; total number of detections were 48 in 1990, 38 in 1991, 28 in 1992 and two in 1994 through the month of June.

- The neighborhood meter box monitoring program shows that no methane migration and buildup is occurring in these structures. Methane levels have been consistently below 10 ppm and are comparable to the background ambient air readings taken at the same time.

- The weather conditions during the surface flux chamber sampling--partly sunny and dry conditions with mild temperatures (69 to 82° F) and light breezes--were representative of typical summer weather in the PVLF area before the winter rains occur.

- Two of the eight compounds analyzed for, vinyl chloride and 1,2-dichloroethane, were not detected in any of the surface flux chamber samples. The detection limits for these compounds were 0.06 to 0.08 ppb and 0.03 to 0.04 ppb, respectively.

- The remaining six of the eight VOCs analyzed for were identified in at least one of the samples. These compounds include 1,1-dichloroethylene, 1,1-dichloroethane, benzene, trichloroethylene, tetrachloroethylene, and p-dichlorobenzene. However, it should be noted that trichloroethylene and p-dichlorobenzene were also present in the daily method blank at levels similar to those in the field samples.

- Benzene was detected in all of the surface flux chamber samples collected and analyzed, including 30 field locations near the PVLF, two background field samples, and three field blanks.

- The two background surface flux chamber sampling locations were representative of typical urban soil away from the site, and were situated in areas similar in both land use and geologic formation characteristics to the areas near the site being investigated. Two compounds, benzene and tetrachloroethylene, were identified in the background samples.

- In the surface flux chamber samples collected at the six sampling locations over the Hawthorne Boulevard plume, only benzene was identified.

- In the surface flux chamber samples collected at the six sampling locations over the Crenshaw Boulevard plume, two compounds, benzene and tetrachloroethylene, were identified.

- Three compounds, benzene, tetrachloroethylene, and p-dichlorobenzene, were identified in the two samples from the surface flux chamber sample locations beyond the estimated extent of the Hawthorne Boulevard plume. However, it should be noted that p-dichlorobenzene was also present in the daily method blank at levels similar to that in the field samples.

- Two compounds, benzene and tetrachloroethylene, were identified in the two samples from the surface flux chamber sample locations beyond the estimated extent of the Crenshaw Boulevard plume.

- There were fourteen surface flux chamber sampling locations to the northeast of the PVLF. They were selected to investigate potential effects due to landfill gas migration. Six of the eight VOCs analyzed for were identified in these samples. These compounds include 1,1-dichloroethylene, 1,1-dichloroethane, benzene, trichloroethylene, tetrachloroethylene, and p-dichlorobenzene. However, it should be noted that trichloroethylene and p-dichlorobenzene were also present in the daily method blank at levels similar to those in the field samples.

- The percent of non-detected values for all of the compounds analyzed for during the surface flux chamber investigation, with the exception of benzene and tetrachloroethylene, equals or exceeds 90 percent. Benzene was detected in 100 percent of the samples, and tetrachloroethylene was detected in about 50 percent of the samples.

- The trichloroethylene and p-dichlorobenzene detections in the surface flux chamber samples were likely the result of laboratory contamination, since these compounds were found in the method blanks in each batch where they were also identified in the field samples. The levels of these compounds in the method blanks were equivalent to or greater than the levels reported in the field samples.

- Five of the compounds measured by SCAQMD (vinyl chloride, 1,2-dichloroethane, benzene, trichloroethylene, and tetrachloroethylene) in ambient air were also measured as part of the surface flux chamber program. As can be seen on Table 3.1-5, two of

the five compounds, vinyl chloride and 1,2-dichloroethane, were not detected in either the ambient air or the surface flux chamber samples. The other three compounds, benzene, trichloroethylene, and tetrachloroethylene, were detected in both the ambient air and the surface flux chamber samples, but at lower levels in the surface flux chamber samples than in either the Los Angeles air basin or the Hawthorne air station samples.

- The analytical results from the surface flux chamber sampling for benzene and tetrachloroethylene were analyzed quantitatively using the Wilcoxon Rank Sum test. The results of the Wilcoxon test on the surface flux chamber samples show that for benzene the background samples are representative of a population having higher concentration levels than that of the study area samples. For tetrachloroethylene, the results of the Wilcoxon test show that the background and study area populations are statistically equivalent.

- The results of the quantitative analysis of benzene and tetrachloroethylene indicate that the study area results for these compounds collected with the surface flux chamber do not exceed the background values.

- The surface flux chamber sample results indicate that contaminants from the PVLF are not migrating off site in measurable quantities through either off site migration of landfill gas or migration of volatilized compounds from contaminated ground water plumes.

- The surface flux chamber results were of sufficient quality to perform a health risk analysis of the subsurface air migration pathways.

- The levels of TACs in Header 2, the gas collection headerline that collects gas from the central area of the main site, were much higher (on average five to six times higher) than those in Header 1, the gas migration control headerline that controls off site migration of gas at the perimeter of the landfill.

- Collectively, the air emissions at the PVLF have no appreciable impact on ambient air quality.

7.2 SURFACE WATER AND SEDIMENT INVESTIGATIONS

Several investigations were conducted to evaluate and characterize the surface water and sediment runoff from the PVLF. These investigations included (1) the runoff water and sediment sampling program, (2) the Hawthorne Boulevard storm drain investigation, (3) the soil cover sampling program, (4) the South Coast Botanic Garden lake and stream channel water and sediment sampling program, (5) the South Coast Botanic Garden lake and stream channel water balance program, and (6) the surface hydrology study. The conclusions from the surface water and sediment investigations are given below.

- The runoff water samples from the PVLF contained general and metal constituents that would be expected from runoff water in contact with the soil cover.

- The concentrations of the general and metal constituents contained in the down-canyon runoff water samples were similar to those found in the background samples.

- Isolated detections of some volatile or semi-volatile organic compounds were found in the runoff water samples, but these detections appeared to be related to activities outside the landfill (such as vehicular emissions of VOCs) or isolated detections with no apparent pattern of contamination.

- Overall, no runoff water contamination consistent with known contaminant sources from the PVLF (i.e., landfill gas) could be identified.

- The Hawthorne Boulevard storm drain did not contain landfill derived contaminants and is not acting as a pathway for off site migration of contaminants.

- Concentrations of volatile organic vapors in the storm drain were similar to those found in the ambient air.

- The water samples taken from the storm drain contained general and metal constituents at concentration levels that were not indicative of water contamination.

- The concentrations of the general and metal constituents identified in the soil cover were similar to those found in common soils. The soil cover samples contained a few volatile and semi-volatile organic compounds; however, these detections were sporadic with no associated trends.

- The soil cover samples from the equestrian center, South Coast Botanic Garden lake and stream area, and main site horse trail contained no detectable semi-volatiles when analyzed by EPA Method 8270. These samples contained low levels of PAHs when analyzed by EPA Method 8310 (which provides lower detection limits than EPA Method 8270). The PAHs were sporadic with no associated trends.

- The soil cover samples from the area near the third bench access road where PAHs had been previously detected all contained measurable levels of PAHs. These samples were obtained along the edge of an access road incorporating recycled asphalt, and it was noted that all of the samples contained pieces of asphalt. The PAH concentrations found in the soil samples are probably the result of the asphalt from the access road and not the waste disposed at the PVLF.

- Overall, the soil cover samples did not contain contamination consistent with known contaminant sources (i.e., landfill gas) from the PVLF.

- No VOCs, with the exception of trihalomethanes in a tap water sample, were detected in samples from the South Coast Botanic Garden lake and stream channel.

- The South Coast Botanic Garden lake and stream channel water balance study indicated that the lake seepage rate was approximately a half inch per month and the stream channel seepage rate was approximately thirteen inches per month. This indicates that, within the accuracy of this study, the lake releases little if any water into

the subsurface while the stream releases measurable quantities of water to the subsurface. It should be noted that neither of these water bodies overlie refuse fill.

- The majority of the drainage structures are properly sized to accommodate surface runoff during a 100 year storm. Any undersized structures are located on the margins of the PVLF where the surface topography is such that any rainfall overflow would be naturally diverted away from the PVLF and onto the local streets preventing ponding of water on the waste filled areas of the landfill.

7.3 GEOLOGIC INVESTIGATIONS

The main intent of the geologic portion of this investigation was to define the geologic conditions within the study area. The conclusions from the geologic investigations are given below.

- The area of study encompasses two distinct geologic settings: the Palos Verdes Hills and the West Coast Basin.

- The PVLF is located in the Palos Verdes Hills and is underlain by the three members of the Monterey Formation.

- The three members of the Monterey Formation include the Altamira Shale member, the Valmonte Diatomite member and the Malaga Mudstone member.

- Bedrock of the Monterey Formation consists primarily of deep marine deposits of diatomite, diatomaceous siltstone, mudstone, dolostone, and chert. Basalt locally intrudes the Monterey Formation.

- The West Coast Basin is structurally separated from the Palos Verdes Hills by the Palos Verdes fault zone.

- The West Coast Basin is underlain by bedrock of the San Pedro Formation.

- The San Pedro Formation consists primarily of loosely consolidated sandstone, siltstone, and marl of marine origin.

- The Palos Verdes fault zone consists of numerous anastomosing and subparallel faults along which left-lateral displacement may exceed 100 miles and vertical displacement may exceed 3,000 feet.

- The bedrock of the Monterey Formation is intensely fractured, but fractures are typically filled with clay, secondary mineralization, or naturally occurring hydrocarbon deposits (tar).

- The sedimentary bedrock of West Coast Basin and Palos Verdes Hills overlies a metamorphic basement complex of the Jurassic Catalina Schist.

- The Pliocene Repetto and Pico Formations occur locally within the study area.

- Within the study area, the Malaga Mudstone member is lithologically similar to the Repetto Formation.

- Within the study area, the Pico Formation is lithologically similar to the San Pedro Formation.

- Stream alluvium, dune sand, colluvium, mine tailings, and topsoil locally overlie bedrock within the study area.

- Distinct geologic units can be grouped together in the following manner to create a geologic model which represents the principal lithologies within the study area:

Geologic Unit	Geologic Model/Ground Water Flow Model Unit
Catalina Schist	Jc
Altamira Shale member	Tma
Valmonte Diatomite member	Tmv
Malaga Mudstone member and the Repetto Formation	Tmm

Pico Formation and the San Pedro Formation ..... Qus
Alluvium, colluvium, topsoil, dune sand, and mine tailings ..... Qo

- The principal trace of the Palos Verdes fault zone is not clearly defined across the Palos Verdes Peninsula.

- Several mapped surface traces of the Palos Verdes fault zone can be represented as a single fault plane to create a realistic geologic model.

- The geologic model preserves actual geologic data.

- The geologic model accurately portrays, in three dimensions, local and regional geologic structure and stratigraphy.

- A repeat in stratigraphic sequence in M67B (AB8) confirms the location of a splay of the Palos Verdes fault zone at that location.

- An analysis of the microfossil assemblage in a lithologic sample from M70B (AB7) indicate that Woodring's original Malaga-Valmonte contact was placed too far north, and supports the Sanitation Districts' modeled Malaga-Valmonte contact.

- Historic landslides occurred in the vicinity of M69B (AB6) and M70B (AB7).

- The geologic cross sections generated from the geologic model provide a detailed interpretation of the regional geologic structure and stratigraphy based on the available, reliable regional and local geologic data.

- The geologic model developed during for this RI strongly agrees with the general understandings and interpretations of the geologic character of the study area that have been defined and/or described by other professional or academic studies.

7.4 HYDROGEOLOGIC INVESTIGATIONS

The main intent of the hydrogeologic portion of this investigation was to define the ground water flow conditions as they relate to the geologic conditions within the study area. The conclusions from the hydrogeologic investigations are given below. A more detailed listing and discussion of these conclusions is located in Appendix E.2.

- The Palos Verdes Hills are underlain by bedrock of the Monterey Formation which is considered to be non-waterbearing, in the economic sense.

- The West Coast Basin is underlain by thick waterbearing deposits of the San Pedro Formation.

- The San Pedro Formation is a principle aquifer for the Los Angeles area.

- The West Coast Basin is structurally separated from the Palos Verdes Hills by the Palos Verdes fault zone which locally acts as a partial barrier to ground water flow.

- In the Palos Verdes Hills, the fastest ground water flow occurs in shallow canyon alluvium, colluvium and weathered bedrock and is controlled by geology and topography.

- Some ground water, of poor quality, migrates very slowly through the unweathered Monterey Formation bedrock along north-dipping bedding plane and fractures.

- Fractures within the Monterey Formation are commonly filled with clay, secondary mineralization, and naturally occurring hydrocarbons (tar) which limit the transmission of ground water through these fractures.

- The nearest ground water supply well is located 3-1/4 miles to the north of the PVLF in the downtown area of the City of Torrance.

- Six primary flow zones exist within the study area. These "hydrostratigraphic flow zones" are based on geologic and hydrogeologic data and correspond to the geologic model units. The six hydrostratigraphic flow zones include:

  Qo: Quaternary Overburden (alluvium, colluvium, topsoil, etc.)

  Qus: Quaternary Undifferentiated Sand deposits (San Pedro Formation, Pico Formation)

  Tmm: Malaga Mudstone member and the Repetto Formation

  Tmv: Valmonte Diatomite member

  Tma: Altamira Shale member

  Jc: Catalina Schist

- The Qo flow zone has measured hydraulic conductivity values which range from 4.00E-8 cm/sec to 3.55E-3 cm/sec.

- The Qus flow zone has measured hydraulic conductivity values which range from 3.60E-6 cm/sec to 2.10E-3 cm/sec.

- The Tmm flow zone has measured hydraulic conductivity values which range from 1.10E-8 cm/sec to 4.50E-3 cm/sec.

- The Tmv flow zone has measured hydraulic conductivity values which range from 6.97E-8 cm/sec to 2.28E-3 cm/sec.

- The Tma flow zone has measured hydraulic conductivity values which range from 2.09E-7 cm/sec to 1.30E-3 cm/sec.

- No measured hydraulic conductivity values are available for the Jc flow zone. 1.00E-7 is an acceptable and conservatively high hydraulic conductivity value for metamorphic rocks.

- Ground water flow within the Qo and Qus occurs within primary pore spaces (grain to grain vacancies).

- Ground water flow within the Tma, Tmv, Tmm, and Jc flow zones occurs within the secondary pore spaces (fracture spaces).

- Ground water can and does occur in the fractures of unweathered Monterey Formation bedrock.

- Ground water occurs in the primary pore spaces within the San Pedro Formation and within Recent overburden deposits.

- Based on the ground water conditions observed during this investigation, wells M67B (AB8) and M68B (AB9) are screened on the same side of the Palos Verdes fault zone.

- Steep ground water gradients exist near the inferred trace of the Palos Verdes fault zone indicating that the fault zone acts as a partial barrier to ground water flow from the Palos Verdes Hills to the West Coast Basin.

- The steep ground water gradient across the Palos Verdes fault zone is more pronounced near Hawthorne Boulevard, becoming less pronounced to the east.

- Ground water in the Palos Verdes Hills generally follows the topographic gradient, flowing from southwest to northeast.

- Ground water in the West Coast Basin generally flows from west to east.

- The generation of a digital geologic database to derive the database for the ground water flow model is a new approach to ground water flow modeling which allows all geologic data to be preserved throughout the modeling process.

- The single porosity approach is the most technically appropriate method for modeling the hydrogeologic scenario within the study area.

- The ground water flow model demonstrates that ground water flow in the PVLF area (Palos Verdes Hills) is unconfined, topographically driven, and tributary to the regional flow in the West Coast Basin.

- Ground water in the West Coast Basin flows to the southeast, roughly parallel to the Palos Verdes fault zone.

- The highest ground water flow velocities exist in the Qo and Qus flow zones. The maximum horizontal velocity in these layers is on the order of 0.1 foot per day. Horizontal flow velocities in the bedrock flow zones (Tmm, Tmv, Tma, Jc) are one to two orders of magnitude less.

- Vertical communication exists between ground water flow regimes (alluvial and bedrock) but this component of flow is minuscule compared to the horizontal component of flow.

- The ground water flow model demonstrates that there is a zone of limited areal extent, the "zone of particle pathways", within which the particles of ground water emanating from the PVLF will flow.

- The zone of particle pathways is approximately the same width as the PVLF, and follows the general direction of ground water flow from the Palos Verdes Hills to the northeast, eventually passing through the Palos Verdes fault zone, then bending southeast with the regional ground water gradient of the West Coast Basin.

- Particles of water entering the ground water flow system from vertical recharge in the PVLF area move primarily in the shallow canyon alluvium and generally do not migrate below the base of the Qus flow zone in the West Coast Basin.

- Particle tracking exercises indicate that ground water particles originating at the PVLF generally require over 2,000 years to reach the West Coast Basin.

- The calibrated ground water flow model has been demonstrated to be a reasonably accurate simulator of the ground water flow within the study area.

- The driving force for ground water flow is the hydraulic gradient. The similar hydraulic gradients observed in the March/April 1991 ground water elevation data and the first quarter, 1994, data indicate that the ground water flow directions and gradients simulated by the ground water flow model should continue to adequately simulate real world conditions without modifications.

- The ground water flow model developed as a part of this study provides a suitable and appropriate basis for use in conjunction with contaminant transport modeling for purposes of evaluating and predicting future flow and concentration conditions in the PVLF are as input to risk assessment studies.

- Ground water elevations in all wells installed during the additional downgradient hydrogeologic field program except M64B (AB1a) are consistent with the existing ground water flow model results.

- The hydraulic conductivity values from the additional downgradient hydrogeologic field program compare favorably with those used in the calibrated ground water flow model.

- At some wells installed during the additional downgradient hydrogeologic field program, the hydrogeologic data (porosity, transmissivity, and hydraulic conductivity) were found to be greater than the values input into the ground water flow model. Sensitivity analyses conducted on the original ground water flow model indicate that by increasing either the porosity, hydraulic conductivity of the bedrock or hydraulic conductivity of the Qo/Qus flow zones by a factor of two would result in an increase in the maximum chemical concentration at all potential receptor points of less than one order of magnitude.

- On the whole, the hydrogeologic information obtained during the additional downgradient hydrogeologic field program is consistent with the existing hydrogeologic database.

- The ground water and contaminant flow models developed for the purpose of performing a Baseline Risk Assessment at the PVLF remain adequate for that purpose. The conservativeness of the assumptions incorporated into the models provides enough compensation since the hydrogeologic data from the additional downgradient hydrogeologic field program do not alter the conceptual flow model significantly. Therefore, regeneration of these models at this time appears unnecessary.

7.5 SOIL/SEDIMENT INVESTIGATION

The objective of the soil investigation was to determine the conditions of the subsurface soils/sediments in the vicinity of the PVLF. The conclusions from the soil/sediment investigation are given below.

- Metals were detected in all of the soil samples. The metals detected occur naturally in soils, and the soil concentrations observed were typical to those found in common soils.

- The qualitative and quantitative analyses of the metals levels showed that any differences between the background and down-canyon metal sample populations were a result of random fluctuations in soil quality and not an indication of landfill contamination.

- Oil and grease, hydrocarbons, and BTEX compounds were detected in both the background and down-canyon soil samples. Because the Monterey Formation is a source rock for oil in the Los Angeles area, the detections of these compounds were not unexpected. The distribution of these compounds in the soils in relation to the PVLF boundary did not show a pattern that was characteristic of contamination

emanating from the landfill. These detections do not indicate contamination from the PVLF.

- Chlorinated VOCs were detected at low concentrations in a random pattern at isolated locations. A comparison of these detections with those found in ground water samples showed that there was no correlation between the VOC detections in the soil samples and those found in the ground water. These sporadic detections may potentially be a result of landfill gas migration or not related to the landfill at all.

- PAHs were detected at low concentrations in a few of the subsurface soil samples. Because the PAHs were detected sporadically, and because the distribution of PAH compounds in relation to the PVLF boundary was not characteristic of landfill contamination, the Sanitation Districts do not believe the detections indicate landfill effects.

7.6 GROUND WATER INVESTIGATIONS

The Sanitation Districts has extensively monitored ground water quality at the PVLF since the mid 1980's. The objective of the ground water monitoring program was to identify the extent and type of ground water contamination surrounding the PVLF. Ground water quality at the monitoring wells has remained relatively consistent over the life of the individual monitoring wells. Based on the water quality results gathered over the period January 1, 1987, through June 30, 1994, the Sanitation Districts conclude:

- The bedrock underlying the PVLF originates from deep marine sediments. The natural water quality in these sediments is poor. Elevated levels of dissolved solids, metals, and organic compounds are naturally occurring.

- Upgradient ground water monitoring wells at the PVLF do not provide background water quality for the downgradient ground water monitoring wells. This is due to the orientation of PVLF with respect to the structural orientation of the underlying strata.

- In lieu of background ground water quality, other available data may be used to evaluate the landfill's effect on downgradient ground water quality. These include contaminant isopleth maps, results of soil equilibrium and mineral leaching studies, and results of statistical trend analyses.

- General water quality parameters seem to have been affected by the landfill in on site ground water monitoring wells M06A, M06B, M07A, P4-6, P410, M49A, M43A, and M53B (RFB16) and off site wells M23A, M24A, PV-3, M25A, and M63B (AB2). However, because of the naturally poor water quality of the ground water in the PVLF area (the water does not meet secondary drinking water standards), and because these parameters are not health based contaminants, elevated levels of these constituents are not a concern.

- Low pH levels were observed at wells M39A and M53B (RFB16). These levels are consistent with those seen in the soil equilibrium studies for some samples of Malaga Mudstone. Wells located several hundred feet downgradient of M39A and M53B (RFB16), with near neutral pH levels, do not show any indication of elevated metals levels.

- Metals concentrations in ground water monitoring wells are measured as total metals. Suspended solids in the ground water can significantly affect the observed metals concentrations, causing artifacts in the measurement data that are not meaningful or indicative of water quality. Beginning in January 1993, the Sanitation Districts began measuring both total and dissolved metals concentrations. The analysis of the metals results is primarily focused on the dissolved metals concentrations.

- Based on the results of the isopleth maps and trend analysis for arsenic, a plume of arsenic contaminated ground water with the PVLF as its most likely source is moving off site of the PVLF near Hawthorne Boulevard.

- Although statistical comparisons for other metals besides arsenic often show higher concentrations in the downgradient wells than those found in the upgradient wells,

other evidence did not confirm a metals contamination problem. The isopleth maps of these metals concentrations did not generally indicate the landfill as a source of metals contamination. The trend analysis for these dissolved metals rarely showed an increasing trend. Also, the dissolved metals concentrations seen in the downgradient wells were generally within the ranges observed in the soil equilibrium and mineral leaching studies.

- VOCs are detected in nearly all on site downgradient monitoring wells, the exception being the northeast boundary monitoring wells. The highest on site VOC concentrations are found in the barrier monitoring wells.

- VOCs are consistently detected as far off site as wells M24A and M63A (AB2) on the Hawthorne Boulevard side of the landfill and M37A on the Crenshaw Boulevard side of the landfill. No VOCs are consistently detected in wells located in the West Coast Basin.

- VOC concentrations are lower in off site wells than in on site wells. This could be due to degradation, dispersion, low transport rates, or other contaminant transport effects.

7.7 NATURE AND EXTENT OF CONTAMINATION

Section 4.0 presents a summary of the nature and extent of contamination occurring in the air, surface water and sediments, subsurface soils, and ground water at the PVLF. The conclusions from this section are as given below.

- Two different plumes of contamination exist in the ground water (see Exhibits 4.1-3 through 4.1-6). One plume of contamination occurs near the northern corner of the main site and Hawthorne Boulevard and the other, consisting of two components occurs near the eastern corner of the main site along Crenshaw Boulevard and near the eastern corner of the South Coast Botanic Garden along Rolling Hills Road. Both plumes extend off site and contain VOCs. The VOCs have three characteristics

indicating that the source of contamination is from the PVLF. First, the VOC contamination includes several chlorinated VOCs that are associated with the landfill. These chlorinated compounds include trichloroethylene, tetrachloroethylene, and dichloroethylenes. Secondly, several of the VOCs are present in the ground water as opposed to isolated detections of one of the compounds. Third, the VOC contamination is contourable and shows a pattern of contamination that would be expected from the landfill (i.e., greater concentrations of VOCs at and near the landfill, and decreasing levels further from the landfill). In addition, the Hawthorne Boulevard plume contains levels of arsenic above background levels.

- There is limited interaction of VOC contamination between the environmental media analyzed (air, surface water and sediment, soil, and ground water). Although geologic cross sections with chemical data included did show the ground water contamination in the plumes near Hawthorne and Crenshaw Boulevard, detections of VOCs in the subsurface soils were random and sporadic. Also, most of the VOCs found in the plumes of ground water contamination were not present in the surface flux chamber samples over the VOC contaminated plume areas.

7.8 CONTAMINANT TRANSPORT MODELING

The objective of the contaminant transport model was to develop an analytical tool based on the geologic and geochemical conditions around the PVLF such that current and future concentrations of chemicals in the ground water can be reasonably estimated and then used for a baseline health risk assessment. The conclusions of the contaminant transport modeling are given below.

- The model tends to overestimate the concentrations of chemicals of concern due to conservative assumptions.

- Results from a preliminary verification of the transport model, based on the maximum concentrations between 1986 and 1991, indicate that the model agrees reasonably well with the chemical data available. However, it also tends to overestimate all of the

principal chemicals (chemicals used in the modeling study) by a factor ranging from 1.09 to 69.

- For relatively mobile principal chemicals, both inorganic and organic, the overestimation factor ranges from four to 69. This suggests that the model tends to be conservative on a short-term basis. Because of the conservative assumptions and parameters used in the long-term predictive analysis, the model is also expected to be conservative in the long-term predictive mode.

- The migratory pattern of chemical plumes emanating from the assumed chemical sources within the PVLF follows the direction of the general hydraulic gradient. Once the plumes reach the Palos Verdes fault zone they tend to migrate in a direction parallel to the fault axis.

- It is possible that a small amount of chemical may migrate through the Palos Verdes fault zone to the West Coast Basin after tens of years, as very low simulated chemical concentrations (a small fraction of μg/L) are estimated for potential receptors in the West Coast Basin. This estimation is consistent with the hydrogeologic hypothesis that the Palos Verdes fault zone functions as a partial hydrogeologic barrier.

- For most of the principal chemicals, the maximum or steady state levels modeled at the potential receptor point were found to occur sooner than or at approximately 200 years after the starting point of the long-term predictive analysis.

- Several sensitivity analysis cases with a range of flow and transport parameters and hydrogeologic conditions were performed using vinyl chloride as the principal chemical to quantify the range of uncertainty in predicting concentrations at potential receptors. The range of concentration uncertainty spreads over three orders of magnitude or approximately 1.5 orders of magnitude about the Base Case.

- In general, the model is found to be sensitive to the variability of adsorptive properties, fault zone hydraulic properties, and effective porosity.

- Since the contaminant transport model is a reasonably conservative predictor of chemical concentrations at the potential receptors, the results of the predictive analysis can be used as input into the baseline health risk assessment for the PVLF.

7.9 BASELINE RISK ASSESSMENT

The purpose of the risk analysis was to use the available site characterization data to estimate potential health and environmental risks posed by the site in the absence of remedial measures. The risks were quantified under two scenarios: A reasonable maximum exposure (RME) scenario as required by the EPA and DTSC, and an average exposure (Average Case) scenario which considered more site-specific exposure parameters. In addition, risks due to the vapor inhalation pathway were calculated assuming a 95 and a 75 percent gas system collection efficiency.

The risk analysis considered various exposure pathways, potential receptors, and time scenarios. The complete exposure pathways considered included the (1) outdoor air pathway (vapor and dust inhalation), (2) indoor air pathway (ground water to soil gas to indoor air), (3) indoor air pathway (landfill gas to soil gas to indoor air), (4) surface soil pathway (incidental ingestion and dermal absorption), and (5) ground water pathway (inhalation, dermal, and inhalation in shower). The potential receptors included off site residents, on site workers, and recreation visitors. The risk assessment was done for both current and future time scenarios. The chemicals of potential concern were identified, and the exposures of these chemicals to the important receptor population were calculated utilizing monitoring data or estimates based on air or ground water modeling. The carcinogenic and non-carcinogenic risks were calculated based upon the estimated exposures, and utilizing toxicity constants defined by EPA and DTSC. The conclusions from the risk assessment are given below.

- The assumptions that were used in developing the baseline risk assessment were made to produce a conservative, health protective bias. The risk levels estimated can be considered upper bound values, where the actual risk is most likely less and could even be zero.

- Ground Water: Under current operating conditions, there is no exposure to ground water. However, ground water downgradient of the site contains chemicals of potential concern at concentrations that are elevated above naturally-occurring background levels. Two plumes of contaminated ground water originating from the site appear to be moving approximately northeast towards the West Coast Basin.

  Under a future exposure scenario, use of this ground water by an off site resident was assumed to occur. Most of the excess cancer risk (approximately 95 percent) could be attributed to potential exposure to arsenic which was predicted by ground water modeling at concentrations some one-thousandth of the Maximum Contaminant Level (MCL). The MCL is the maximum amount of a chemical legally allowed in public drinking water supplies.

- Soils: All areas of the landfill containing hazardous wastes are covered by a cap of several feet of clean soil which is regularly inspected and maintained. Thus there is no exposure to chemicals of potential concern contained in the landfill. However, discrete areas of the landfill soil cover (restricted to maintenance access roads on the main site) contain concentrations of polynuclear aromatic hydrocarbons (PAHs) that appear to be above anthropogenic (man-made) background levels for surface soil but are within the range found in urban road dust. These PAH-containing roadways are covered by gravel thereby minimizing the potential for direct contact. For the purposes of the risk assessment, exposure to these PAHs was assumed for the on site worker and the recreational visitor under both current and future scenarios.

- Air: The PVLF has an extensive gas collection system which is regularly monitored. The gas capture efficiency is estimated to be in excess of 98 percent. Ambient air sampling at the PVLF has not shown any statistically discernable impacts in downwind air quality or in integrated surface gas testing at a height of approximately six inches above the landfill surface.

  For the purposes of this risk assessment, gas collection efficiencies were estimated to range between 75 percent and 95 percent which is less than (or significantly less than)

the estimated efficiency of 98 percent. It should be noted that for the principal contributor (some 70 percent) to excess cancer risk estimates, benzene, the upwind ambient air concentration was approximately ten times higher than releases modeled from the landfill. Analytical detection limits for chlorinated volatile organic compounds, such as vinyl chloride, in ambient air were more than ten times the predicted releases.

- Current Off Site Resident: Residents living near the site can be exposed to air releases of volatile compounds in landfill gas, and PAHs in dust from landfill maintenance roadways. More than 90 percent of the estimated excess cancer risk is from modeled landfill gas releases. The risks from landfill gas vary by a factor of five, depending on the landfill gas collection system capture efficiency assumed (75 percent or 95 percent). The overall range of excess cancer risks calculated for the off site resident is 1.4×10^{-6} (Average exposure case at 95 percent landfill gas collection efficiency) to 1.3×10^{-5} (RME case at 75 percent landfill gas collection efficiency). The risk is less than three per million (3.0×10^{-6}) for all scenarios with a 95 percent landfill gas collection efficiency.

- Current On Site Worker: Maintenance workers at the PVLF can be exposed to volatile compounds and dust in air, and through direct contact with PAHs in the maintenance road soil on the main site. Direct contact with roadway soil accounts for a large portion of the calculated excess cancer risk to workers; for the RME scenario more than 90 percent of the estimated risk is from direct contact with roadway soil based on a landfill gas collection efficiency of 95 percent. The range of calculated risks to workers is 2.5×10^{-6} (Average exposure case at 95 percent landfill gas collection efficiency) to 1.5×10^{-5} (RME case at 75 percent landfill gas collection efficiency).

- Current Recreational Visitor: Visitors at the PVLF can potentially be exposed by the same pathways as workers, i.e., to volatile compounds and dust in the air, and through direct contact with roadway soils on the main site. The calculated excess cancer risk to visitors is in the range of 1.4×10^{-6} (Average exposure case at 95 percent landfill gas collection efficiency) to 1.2×10^{-5} (RME case at 75 percent landfill gas collection

efficiency). Direct contact with roadway soil on the landfill during six years of early childhood accounts for a large portion of the estimated risk to visitors. For the RME scenario more than 95 percent of the estimated risk is from direct contact with roadway soil if the landfill gas collection efficiency is 95 percent; approximately 90 percent of the risk is from direct soil contact if the landfill gas collection efficiency is 75 percent.

- Future Off Site Resident: Under a future exposure scenario, use of ground water by an off site resident was assumed to occur. The nearest potential locations for a productive water supply well are approximately 300 feet from the landfill. Two locations for potentially productive water supply wells, Receptor Well 2 and Receptor Well 5, were evaluated for risks. Receptor Well 2 is a *hypothetical* well placed as close as technically feasible to the PVLF; Receptor Well 5 is a currently existing well used for industrial purposes only. In addition, future residents at a potential well location could be exposed to volatile compounds and dust from the landfill. Total excess cancer risks to the future resident using ground water are estimated to be in the range of 9.8 x 10^{-6} (Average exposure case at Receptor Well 5 and 95 percent landfill gas collection efficiency) to 3.4 x 10^{-5} (RME case at Receptor Well 2 and 75 percent landfill gas collection efficiency). Approximately 95 percent of this excess cancer risk is attributed to potential exposure to arsenic, which was predicted by ground water modeling at concentrations some one-thousandth of the MCL. As noted before, the MCL is the legally allowable maximum in public drinking water supplies.

- Future On Site Worker: Potential exposures and excess cancer risks to maintenance workers at the landfill are expected to remain the same in the future.

- Future Recreational Visitor: Increased recreational use of the main site is likely, since development plans for the site are being considered which include continued equestrian use, a golf course, a park, or other open space alternative. Calculated excess cancer risks for the future recreational visitor are in the range of 1.4 x 10^{-6} (Average exposure case at 95 percent landfill gas collection efficiency) to 1.7 x 10^{-5}

(RME case at 75 percent landfill gas collection efficiency). Direct contact with roadway soil accounts for more than 90 percent of this excess cancer risk.

- The hazard indices calculated for the PVLF were less than unity for all cases. In fact, non-carcinogenic risks were less than 0.1 for all receptors except for the off site resident, for whom it ranged between 0.02 and 0.46 for the current RME case, and between 0.082 and 0.29 for the future RME case. These values indicate a low probability of adverse non-carcinogenic effects.

- An environmental evaluation was performed to qualitatively characterize the potential for adverse effects to ecological receptors. This evaluation indicated that exposures to ecological receptors are expected to be minimal.

- Based on the risks estimated for the pathways identified as complete, the potential exposures and estimated risks do not appear to exceed DTSC threshold levels.