APPENDIX D

CENTRAL LANDFILL EXPANSION CAPACITY STUDY PHASE I

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CENTRAL LANDFILL

EXPANSION CAPACITY STUDY
PHASE I

SONOMA COUNTY, CALIFORNIA

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Job No. EB92-353

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EXPANSION CAPACITY STUDY
PHASE I

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INTRODUCTION

The Sonoma County Department of Public Works, Integrated Waste Division operates the Central Landfill. Capacity projections for the existing permitted fill area range between February 2004 and January 2006. The County is considering a plan to expand the existing site and extend the operating life of the landfill.

This study provides a conceptual expansion design and resulting site life projections based on the landfill volumes calculated from the design drawings included in Appendix A. This phase does not consider the economic viability of the potential expansion scenarios.

The designs presented in this preliminary study have been prepared to conform with currently known constraints at the site, and are considered reasonable alternatives at this time under current regulations. Additionally, further site specific analysis will be required to determine if geologic, hydrogeologic or other environmental fatal flaws exist with regard to the proposed expansions.

Additional capacity, beyond that shown in the designs presented in this report, may be available if the existing site constraints (discussed later) are addressed. The approximate volumes and resulting site life estimates for these other additional capacity possibilities are also given in this report.

EXPANSION DESIGN

The anticipated expansion would incorporate a north-south trending canyon, located directly east of the existing waste management unit (WMU), as well as a smaller canyon to the west of the current WMU. See Figure 1 on the following page for delineation of the existing permitted landfill unit and location of the East and West Canyon Expansion areas.

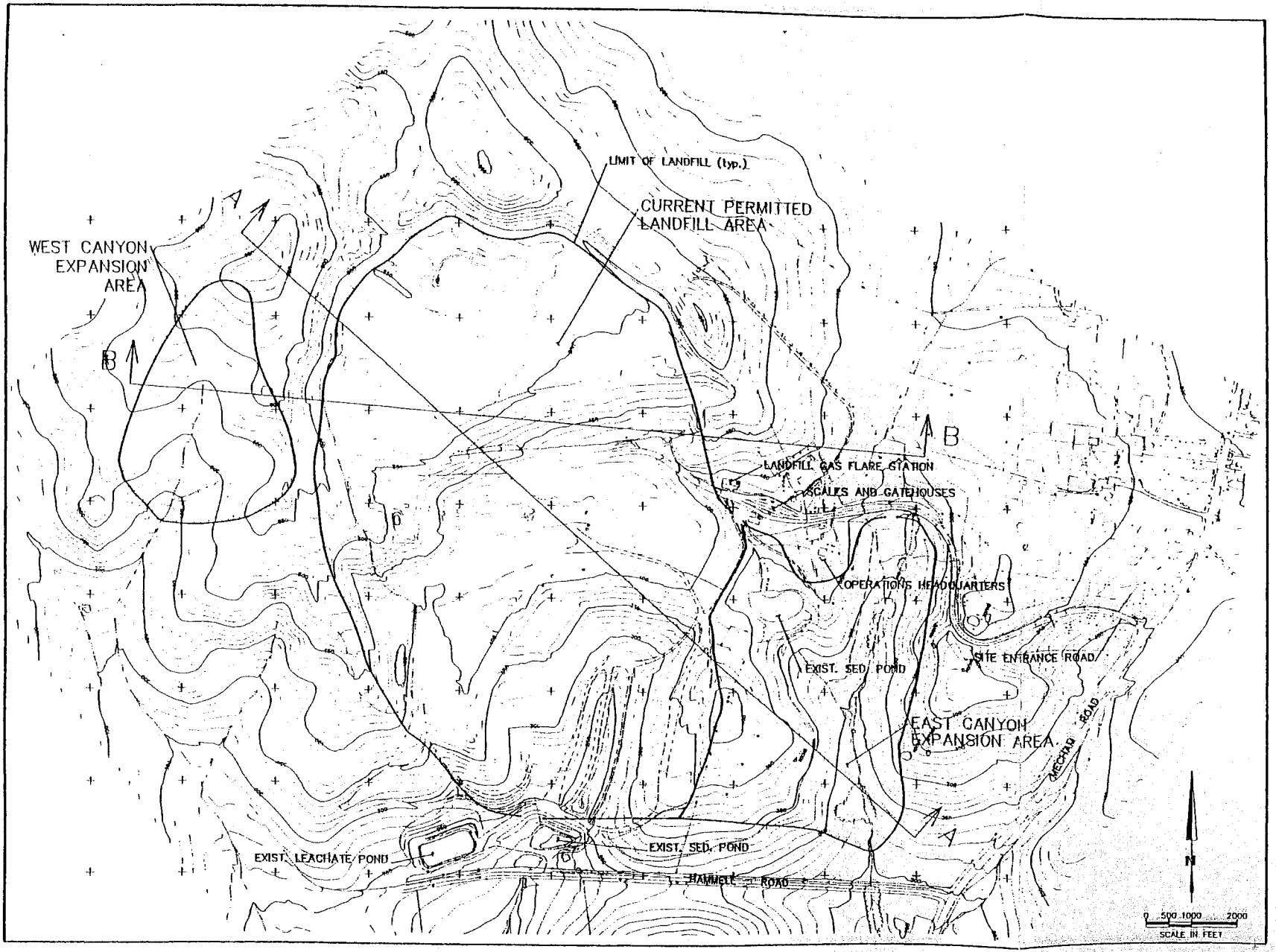

FIGURE 1

MAY 1992
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CENTRAL LANDFILL EXPANSION
SONOMA COUNTY

PROJECT MAP

BA

A. Site Constraints

The design presented in this report represents a scenario which can be achieved without mitigating the restrictions listed below.

1. Onsite Facilities

Moving of the facilities located above the East Canyon would provide a larger expansion area, and consequently greater landfill volume. The facilities in question include the operations headquarters building, the recycle area, scales and gate house, and the landfill gas flare station. The additional site life gained is discussed in Section IV.

The design shown in this report does not affect the existing facilities with the exception of a 21 KV distribution power line which crosses the East Canyon.

2. Limit of Height of Fill

The preliminary closure plan for the currently permitted area, prepared by County staff, shows a top of landfill configuration which will not obstruct the view from the residence located directly north of the site. The top of the existing WMU is currently planned to reach an elevation of approximately 565 mean sea level (msl).

The design presented in this report utilizes the top of landfill configuration from the existing preliminary closure plan over the existing landfill area. Additional site life gained by raising the ultimate landfill height is discussed in Section IV.

B. Seismic Stability Conditions

Initial slope stability analyses of proposed landfill refuse slopes under both static and seismic loadings were performed for the Central Landfill site. Stability analyses involve the calculation of a safety factor for assumed failure surfaces through representative slope sections. The static safety factor is defined as the ratio of the forces that act to preserve stability in the slope (resisting forces) with forces and moments acting to make the slope unstable (driving forces). A factor of safety of unity (1.0) indicates the resisting forces are in a state of equilibrium with the driving forces, and that a threshold condition of imminent slope failure prevails. A factor of safety of 1.5 is the generally accepted minimum value for long-term landfill slope stability. Static safety factors of 1.3 to 1.5 are generally accepted as minimum values for short-term slope stability.

The landfill refuse stability was analyzed using the two dimensional limit equilibrium STABL computer program (Purdue, 1991). Possible failure modes included circular and irregular surfaces. In addition, irregular surfaces were generated by forcing the failure surface through zones of weakness such as the proposed clay/HDPE liner. Circular failure surfaces were analyzed by the Simplified Bishop's Method. Irregular surfaces were analyzed by the Simplified Janbu Method.

Seismic analyses were performed for landfill refuse slopes using the Newmark Method. This method evaluates slope stability in terms of permanent slope deformations expected from assumed seismic loadings. The method is based on the assumption that a slope will move and permanently displace when the yield acceleration is exceeded. The ratio between the yield acceleration and the horizontal and vertical coefficients of ground acceleration is used to scale earthquake forces relative to the weight of the sliding mass and calculate the expected amount of permanent deformation.

Analysis Conditions-

The slope sections considered in our preliminary stability analyses include a final 3:1 south-facing slope to elevation 500 feet MSL (based on the existing landfill closure design) and a critical west-facing slope in the East Canyon expansion area filled to an intermediate elevation of 430 feet MSL.

The analyses assumed the following conditions:

- Final fill slope of 3.5:1 (horizontal:vertical) with 20-foot-wide benches at 50-foot-vertical intervals.
- Unsaturated conditions.
- A proposed lining system consisting of a minimum 2-foot-thick clay liner with a high density polyethylene (HDPE) geomembrane liner overlying the clay liner. An increase in clay liner thickness was assumed on the steeper side slopes in order to facilitate placement of the clay in horizontal lifts during construction.
- Native bedrock design values of 20° internal friction angle, a cohesion value of 2,000 pounds/square foot (psf), and a unit weight of 130 pounds/cubic foot (pcf)
- Refuse strength parameters of 30° internal friction angle, a cohesion of 200 psf, and a unit weight of 70 pcf
- Liner strength parameters consisted of 20° friction angle, zero cohesion, and a unit weight of 110 pcf. The estimated values used for the clay liner and clay/geomembrane interface strength should be confirmed by laboratory testing after a clay borrow source is identified.

- Leachate barrier/buttress consists of engineered fill with an assumed internal friction angle of 29°, a cohesion of 150 psf, and a unit weight of 120 pcf.

- Assumed seismic loadings range from 0.45g to 0.38g.

- Refuse fill sequencing in the eastern expansion area would not be symmetrical within the canyon and, therefore, no buttress effects would be realized.

Results of the initial stability analysis indicate the factor of safety for long term loading of the existing closure configuration in the main canyon and of the eastern expansion area exceeds the minimum acceptable value of 1.5. Under seismic loading conditions yield accelerations of approximately 0.25g were calculated. Based on an assumed ground acceleration of 0.45g, the resulting estimated permanent displacement of landfill slopes is less than 1 foot.

C. Soil Rippability

A seismic refraction survey was conducted to evaluate the depth, variability and rippability characteristics of subsurface materials and to assist in selection of landfill expansion design criteria. The seismic refraction survey consisted of nine individual seismic refraction lines, and a "calibration" line with a combined spread length of 3,645 lineal feet. Each seismic refraction line consisted of twelve geophones spaced at equal intervals of 25 to 50 feet along a straight line and monitored simultaneously while small explosive charges were detonated off each end of the alignment. A summary of the seismic refraction survey is presented below and a detailed discussion of the methods and results is presented in Appendix C.

In general, moderate to slightly weathered subsurface materials at the site are characterized by seismic velocities of 8,000-12,500 feet/second. In the eastern expansion area, bedrock materials ranging in velocity from 8,000 to 12,500 feet/second occur 20 to 40 feet below the surface. In the western expansion area, bedrock materials with a velocity of 10,000 to 12,500 feet/second occur as little as 5 feet and as much as 50 feet below the surface. These results are similar to work performed in 1970. This previous work indicated bedrock velocities ranging from 7,000 to approximately 16,800 feet/second occurs at 30 to 60 feet below the surface.

Based on rippability charts published by Caterpillar Tractor Co., sedimentary and metamorphic rocks, such as the Franciscan Formation underlying the site, are generally considered marginal to rip with a D9L Ripper or equivalent in the compression wave velocity range of 9,000 to 11,000 feet/second. Based on this information, a range of excavation to subgrade from 5 to 50 feet below existing ground surface was used in developing the landfill expansion conceptual design.

D. Regulations

The expansion design for the landfill liners and final landfill slopes considered the requirements included in Title 23, California Code of Regulations (CCR), Division 3, Chapter 15, Title 14, CCR, Division 7, Chapters 3 and 5, and new Federal regulations recently adopted in 40 Code of Federal Regulations (40 CFR), Part 257 and 258 (a.k.a. Subtitle D).

The following is a list of pertinent tasks and requirements to permit an expansion of the Central Landfill based on current regulations;

- Determine Geotechnical/Hydrogeologic constraints and/or fatal flaws (Phase II of expansion study);
- Conduct Environmental Studies to determine constraints and fatal flaws;
- Prepare a Master Development Plan which includes, but is not limited to, engineering design, environmental monitoring programs, operations criteria, and closure and post-closure measures;
- Satisfy the California Environmental Quality Act (CEQA);
- Prepare a Report of Waste Discharge (after CEQA determination) to submit to the California Regional Water Quality Control Board in order to obtain Waste Discharge Requirements for the Site; and
- Prepare a Report of Facility Information to submit to the California Integrated Waste Management Board. This along, with adopted Waste Discharge Requirements, will allow for preparation of a Solid Waste Facilities Permit.

EXPANSION CAPACITY

This section discusses the volume capacity potential for the site. Figure 2 on the following page shows cross sections which delineate both the restricted and unrestricted design scenarios.

A. Restricted Design

The design presented in the drawings in this report represents a potential expansion scenario which conforms to the restrictions imposed by current site constraints discussed in Section II. The drawings for the conceptual design are included in Appendix A.

1. West Canyon

The air space volume calculated for the West Canyon WMU is 1,080,000 cubic yards (CY). The available volume for refuse and daily cover soil is 955,295 CY excluding the volume for the closure section.

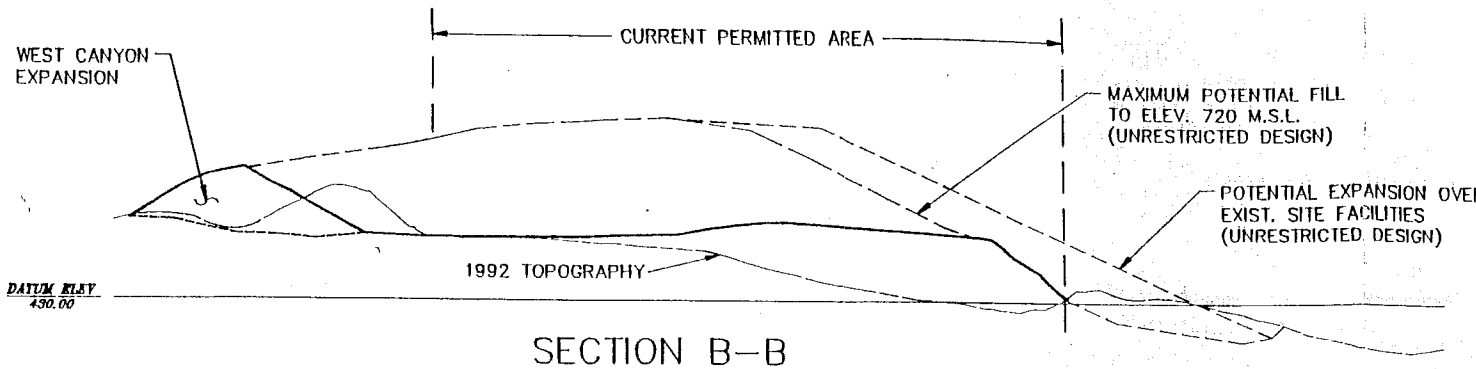
2. East Canyon

The air space volume calculated for the East Canyon WMU is 5,933,613 cubic yards. The available volume for refuse and daily cover soil is 5,672,708 CY excluding the volume for the closure section.

3. Existing Fill Area

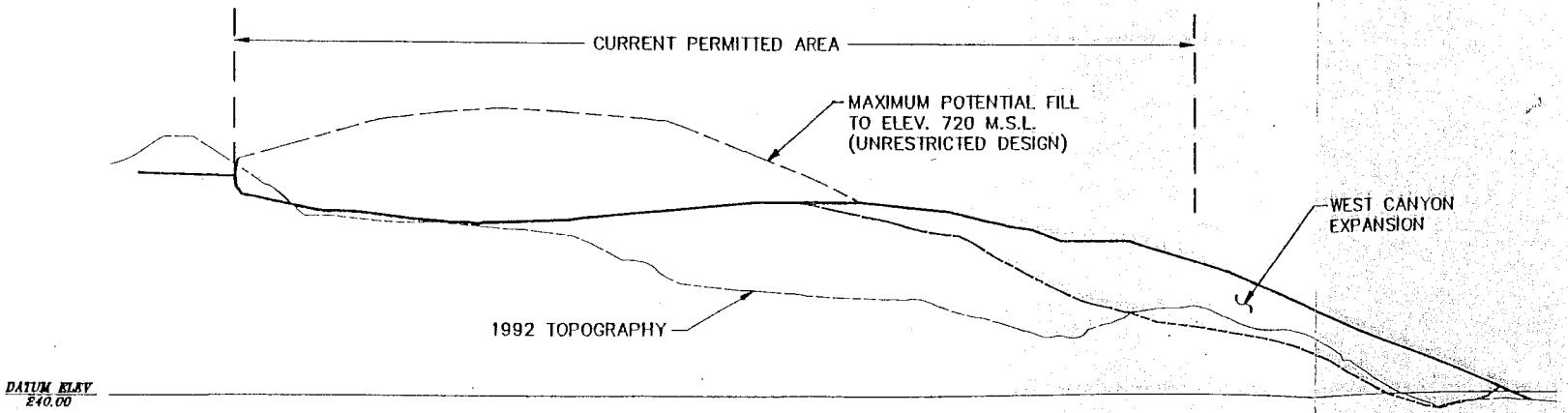
Estimates made by EBA were based on existing cross-sections prepared by the County. The sections were checked for consistency with the proposed design for the existing fill area. The current topography was then plotted on the cross-sections in order to estimate the remaining volume in the current fill area as of January 1992. The remaining landfill capacity in the existing WMU was calculated to be approximately 11,527,736 CY from January 1992.

County staff had previously estimated that approximately 12.1 million CY of capacity was available as of October 1990. EBA's review of the cross-sections confirmed this value. Slight changes in the footprint of the current permitted area since October 1990 have created some additional volume. Therefore, a correlation between the difference in remaining capacity between the October 1990 and January 1992 estimates and incoming tonnage cannot be made.



SECTION B–B

H: 1" = 400'
V: 1" = 200'



SECTION A–A

H: 1" = 400'
V: 1" = 200'

FIGURE 2

JUNE 1992 35PNGZ.DWG

CENTRAL LANDFILL EXPANSION
SONOMA COUNTY

CROSS SECTIONS

EBA

The following table presents the estimated volumes for the WMUs based on the conceptual designs presented in this report.

Table 1. Estimated Landfill Expansion Volumes (Restricted Design)

Waste Management Unit	Air Space Volume (includes landfill cap)	Landfill Volume (refuse + daily cover)
Existing Fill Area	-	11,527,736 CY
East Canyon Expansion	5,933,613 CY	5,672,708 CY
West Canyon Expansion	1,080,000 CY	955,295 CY
Total Site Capacity	-	18,155,739 CY

1. Volumes are in cubic yards.
2. Existing Fill Area volume was calculated below the closure section.
3. Design of Existing Fill Area has been modified since previous County estimate.

B. Unrestricted Design

The volumes presented here reflect additional expansion capacity which could potentially be obtained by addressing the current site constraints.

1. Raise Maximum Height of Fill

By raising the height of the landfill from a maximum elevation of 565 msl to approximately 720± msl, the capacity of the site can be increased by approximately 11 million CY over and above the total volume of the restricted design. If the height of the landfill is raised without expanding into the West Canyon an approximate capacity of 6 million CY would be available in conjunction with the East Canyon Expansion.

Further capacity obtained by filling higher over the existing WMU will also allow for additional capacity over the expansion areas. The additional capacity realized by all three WMUs is reflected in the number given above.

2. Relocate Onsite Facilities

The footprint of the East Canyon expansion area could be enlarged over the existing onsite facilities to provide an additional landfill volume of approximately 2.5 million CY to 5 million CY depending on if the ultimate height of the landfill is raised. This enlargement would be contained on the County owned parcel.

An alternative to this enlargement would be to expand, off County property, further north to the top of the East Canyon. Expansion to the head of the drainage area would provide a better design and additional capacity.

SITE LIFE PROJECTIONS

A. Current Refuse Tonnage

The Central Landfill is currently receiving approximately 500,000 tons of refuse per year. Gate records for the years of 1990 and 1991 show that the incoming tonnage to be disposed at the landfill has decreased. The County has indicated that the drop in tonnage is primarily due to a decrease in debris box tonnage from 1990. Records for tonnage received at the Central Landfill for the past five years are:

1987	483,000 Tons
1988	531,000 Tons
1989	539,000 Tons
1990	522,000 Tons
1991	498,000 Tons

These tonnage values, taken from the gate records, are for waste which is disposed at the landfill and do not reflect the total amount of wastes generated. The current 1991 diversion rate for the Central Landfill wasteshed is approximately 17% (County Summary Report, Agenda Item #52, 2-11-92), therefore using 498,000 tons of waste disposed at the landfill, yields a total of approximately 600,000 tons generated in 1991. This value, 600,000 tons, is used as the basis for projected annual waste generation estimates.

B. Landfill Volume Factors

1. Refuse Density

Previous gate records from October 1990 to January 1992 were reviewed for the purpose of relating the incoming tonnage to actual landfill volume occupied during the period between the aerial survey dates. The actual amount of soil cover material used could not be determined from the available data. This was due to the clean-fill projects (liner construction, tipping pads, barrier dikes, etc.) which have been completed over the past year. Therefore, since the actual inplace density of the refuse can not be calculated, an assumed value consistent with industry standards was used.

A refuse density of 1200 pounds per cubic yard (PCY) was used in this study. The landfill compactors and dozers used at the site are capable of achieving this level of compaction with moderate effort.

2. Cover Ratio

The site operations manager estimates that approximately 400 CY of cover material per day is used on an average. At 360 days per year, about 144,000 CY of cover soil is used per year. Utilizing a refuse density of 1200 PCY for 500,000 tons of refuse per year yields a 5.8:1 waste to cover ratio.

For this study, a waste to cover ratio of 5:1 was used in the site life estimates. This ratio was selected to account for areas receiving intermediate cover before reaching final grade and clean fill projects within the landfill air space.

It should also be noted that alternative cover types could be used to minimize the amount of soil being incorporated into the landfill. Possible alternatives for daily cover, currently used elsewhere, include foam applications and synthetic fabrics. Alternative cover materials are not considered in this study.

C. Population Projections

This report utilizes population projections to estimate increases in waste generation amounts throughout the study period. The percent increase in population is applied annually to the 1991 waste generation value. The County has requested that three population based projections be used. These include the Association of Bay Area Governments (ABAG), California Department of Finance (CDF), and the sum of the County General Plan and eight cities in the County. The population projections for these bases are shown in the following table.

Table 2. Population Projections

Population Base	Growth Rate			
	1990 - 1995	1996 - 2000	2001 - 2005	2006 -
ABAG	1.62%	1.52%	1.44%	1.44%
Dept. of Finance	2.86%	2.02%	1.82%	1.82%
General Plans	2%	1.85%	1.7%	1.6%

1. Growth rates for General Plans are typically between 1% and 2%.
2. Values beyond 2006 are not available.

D. Expected Diversion Goals

The County has requested that three scenarios for diversion goals be utilized. The anticipated diversion goals are expressed as a percent reduction of the total waste generated in the County. Diversion measures include, but are not limited to recycling, composting and source reduction. The first two scenarios presented here meet state mandated diversion goals.

1. Optimistic Scenario (Linear Increase)

This scenario utilizes an annual increase from the current diversion rate of 17% to 25% in 1995, to 50% in 2000. The annual increase would be 2% per year between 1991 and 1995, and then 5% per year between 1996 and 2000. After 2000, the diversion rate would remain constant at 50%.

2. Less Optimistic Scenario (Step Increase)

This scenario would maintain the current diversion rate of 17% until 1994, then step to 25% in 1995, remain constant at 25% through 1999, and then step to 50% in 2000. After 2000, the diversion rate would remain constant at 50%.

3. Least Optimistic Scenario (Linear Increase to 40%)

This scenario utilizes an annual increase from the current diversion rate of 17% to 25% in 1995, to 40% in 2000. The annual increase would be 2% per year between 1991 and 1995, and then 3% per year between 1996 and 2000. After 2000, the diversion rate would remain constant at 40%.

Diversion rates and subsequent diverted tonnages are shown in the site life projection tables in Appendix B for the three scenarios and each of the three different population based generation projections.

E. Site Life Projections

The tables in Appendix B show site life projections for the three diversion scenarios (linear and stepped). Each diversion scenario is shown using the three different population projections as the basis for increases in waste generated each year. The tables in Appendix B reflect the landfill capacity volumes estimated from the designs presented in this report. Tables for additional site life gained by implementing one or more of the unrestricted design options are not given, but estimates are discussed later.

Based on the restricted height expansion designs presented in this study, a potential range of site life from approximately August 2010 to May 2014 (18 to 22 years) could be achieved at the Central Landfill. The following table shows the estimated site life projections for each diversion scenario and various population projections.

Table 3. Summary of Site Life Projections (Restricted Expansion Design)

Waste Management Unit	End of Site Life		
	ABAG	Dept. of Finance	General Plan
Current Permitted Area			
Step Diversion Rate	Dec-2004	Feb-2004	Aug-2004
Linear Diversion Rate(50%)	Jan-2006	Mar-2005	Sep-2005
Linear Diversion Rate(40%)	Oct-2004	Jan-2004	Jun-2004
East Canyon Expansion			
Step Diversion Rate	Mar-2012	Nov-2010	Aug-2011
Linear Diversion Rate(50%)	Mar-2013	Oct-2011	Aug-2012
Linear Diversion Rate(40%)	Dec-2010	Sep-2009	May-2010
West Canyon Expansion			
Step Diversion Rate	May-2013	Nov-2011	Sep-2012
Linear Diversion Rate(50%)	May-2014	Nov-2012	Sep-2013
Linear Diversion Rate(40%)	Dec-2011	Aug-2010	Apr-2011

Appendix B contains tables showing the site life projections including waste generated, diversion rates, diverted tonnages, landfilled tonnages, daily cover volumes, landfill volume occupied, and remaining landfill volume.

F. Additional Site Life Capacity

The site life estimates for the potential scenarios discussed here refer to the unrestricted design options discussed in Section III-B. The site life estimates are given in ranges from worst case to best case scenarios of the generation and diversion options discussed previously. Other potential capacity options are discussed in terms of volume only.

1. Raise Maximum Height of Fill

Raising the maximum elevation of the landfill beyond 565 msl could provide a site life range from approximately January 2020 to May 2026. If the height of the landfill is raised, and the West Canyon is not utilized, the site life would range from approximately February 2015 to February 2020.

2. Relocate Existing Facilities

Enlarging the footprint of the East Canyon will increase the total site life range from approximately November 2023 to March 2031 using the maximum fill height in conjunction with the expansion design presented in this report.

If the height of the landfill is not raised, but the East Canyon expansion is enlarged over the existing onsite facilities, the total site life would range from approximately December 2012 to April 2017.

3. Excavate Bedrock Materials

Mining of the bedrock materials under the proposed expansion area could be accomplished to create greater volumes within the landfill expansion canyons. It is estimated that the East Canyon liner design grades could be modified to excavate as much as 1,000,000 cubic yards of additional material.

4. Redesign Expansion Design with Steep Slopes

Additional capacity may also be achieved by modifying the designs presented in this study. A more detailed stability analysis utilizing site specific field data could substantiate steeper criteria for the final landfill slopes. It is estimated that as much as 500,000 cubic yards of additional capacity in the East Canyon expansion could be achieved if final slopes steeper than 3:1 were utilized in the design.

5. Convert to Balefill Operation

Converting the site to a balefill could be a viable method to help reduce the amount of cover soil utilized in the landfill.