

Commonwealth Energy Biogas/PV Mini-Grid
Renewable Resources Program

***Making Renewables Part of an Affordable and
Diverse Electric System in California***

Contract No. 500-00-036

**Waste Characterization Report For
San Bernardino County Mid-Valley Landfill**

Project No. 2.1 Program Planning and Analysis

Task 2.1.1a Final Report

Prepared For:
California Energy Commission
Public Interest Energy Research Renewable Program

Prepared By:

CH2MHILL

3 Hutton Centre Drive, Suite 200
Santa Ana, CA 92707

And

Legal Notice

This report was prepared as a result of work sponsored by the California Energy Commission (Commission). It does not necessarily represent the views of the Commission, its employees, or the State of California. The Commission, the State of California, its employees, contractors, and subcontractors, make no warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the Commission nor has the Commission passed upon the accuracy or adequacy of the information in this report.

Itron, Inc.
1104 Main Street, Suite 630
Vancouver, WA 98660

August 2003



**Printed on
Recycled and
Recyclable
Paper**

Contents

Section	Page
Preface.....	v
1 Introduction	1-1
2 Waste Decomposition and Gas Production in a Typical Landfill	2-1
3 Feedstock Characterization for San Bernardino County Mid-Valley Landfill	3-1
3.1 Composition of the Waste Stream.....	3-1
3.1.1 Data Sources	3-1
3.1.2 Biodegradable and Non-biodegradable Wastes.....	3-2
3.1.3 Moisture Content.....	3-3
3.2 Quantities of Waste	3-4
3.2.1 Current Quantities and Projections.....	3-4
3.2.2 Physical and Operating Parameters of the Mid-Valley Landfill Unit 3	3-5
Appendixes	
A 1999 Materials Disposed by Residential Sector, Estimated from Statewide Composition Data, Sorted by Total Disposal	
B 1999 Overall Commercial Waste Stream Sorted by Material Types for San Bernardino County - All Types	
Tables	
3-1 San Bernardino County - County-wide Solid Waste Disposal	3-1
3-2 San Bernardino County Fontana Mid-Valley Landfill Total Disposed Waste Tonnage by Quarter	3-4
Figure	
2-1 Anaerobic Digestion in a Landfill.....	2-1

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/ Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research

What follows is the inventory report for the **California Energy Commission, Public Interest Energy Research Program, Contract Number 500-01-036**, conducted by the **Commonwealth Energy Team**. The report is entitled **Waste Characterization Report for San Bernardino County Mid-Valley Landfill**. This report contributes to the **Renewable Energy** program.

For more information on the PIER Program, please visit the Commission's Web site at: <http://www.energy.ca.gov/research/index.html> or contact the Commission's Publications Unit at 916-654-5200.

SECTION 1

Introduction

In June 2001, the Commonwealth Energy Team was awarded a project under the California Energy Commission's Public Interest Energy Research (PIER) Program to conduct research on strategies for making renewable energy more affordable in California. The Commonwealth Energy approach is to look at the combined potential of biogas and photovoltaic (PV) resources in a defined study area and identify how these resources could be developed in a complementary and cost-effective manner. The Commonwealth Energy team conducted this research in a real world setting so that the findings could be applied elsewhere in California and thereby benefit more California ratepayers. The local area Commonwealth Energy selected for its renewable energy research activities is the Chino Basin, referred to in this report as the "study area."

The first steps in the initial phase of the Landfill Gas-to-Energy part of the PIER Program was to assess the landfills in the area that might make suitable hosts for a bioreactor. This effort was reported in the *Inventory Report for Potential Landfill Bioreactors*.

Subsequent to that report, the San Bernardino County Mid-Valley Landfill was selected as the preferred site for a landfill bioreactor as discussed in the Prioritization Report. These reports were done under the Planning and Analysis Project (Project 1.1).

San Bernardino County's Mid-Valley Landfill has been identified as the preferred potential host landfill for the PIER program's bioreactor landfill demonstration project. It was selected through a process of identifying and ranking all of the operating and permitted landfill sites in a four-County¹ area in Southern California. The four-County area was selected so as to have similar climatic characteristics to that of the "mini-grid" on which the PIER renewable energy demonstration project focused. The "mini-grid" is located in the Chino Hills area and contains only a single potential host landfill site, which was not considered to be a suitable host site. The process of evaluating and ranking potential host sites is described in more detail in the *Inventory Report for Potential Landfill Bioreactors*.

Discussions with San Bernardino County Solid Waste Management Department since the completion of the inventory report have indicated that the County may be interested in making the Mid-Valley Landfill a host site for the demonstration project. The discussions with the County, its landfill operating contractor and its design engineering consultant have indicated that the landfill will be suitable for conversion to bioreactor operation. The project contemplated is conversion of the currently operational landfill cell into a bioreactor operation. Only a small portion of the total capacity of the cell has been filled to date, and a large portion of the cell bottom has not yet received any waste. Conversion of this area to bioreactor operation will allow a full commercial scale demonstration of the bioreactor concept.

This report documents the characteristics of the waste being placed in the landfill.

¹ San Bernardino, Riverside, Los Angeles and Orange Counties.

SECTION 2

Waste Decomposition and Gas Production in a Typical Landfill

As previously discussed in the Inventory Report for Potential Landfill Bioreactors, Figure 1 illustrates the process of decomposition undergone by organic materials in a landfill. The organic materials that contribute to biogas production are primarily cellulosic materials and food waste. Cellulosic materials include paper, cardboard, woodwaste, and debris, which typically make up just over half of MSWs by weight. Food wastes are an important component of solid wastes with respect to gas production because they decompose quickly and result in large volumes of biogas relative to the volume and weight of landfill materials they represent.

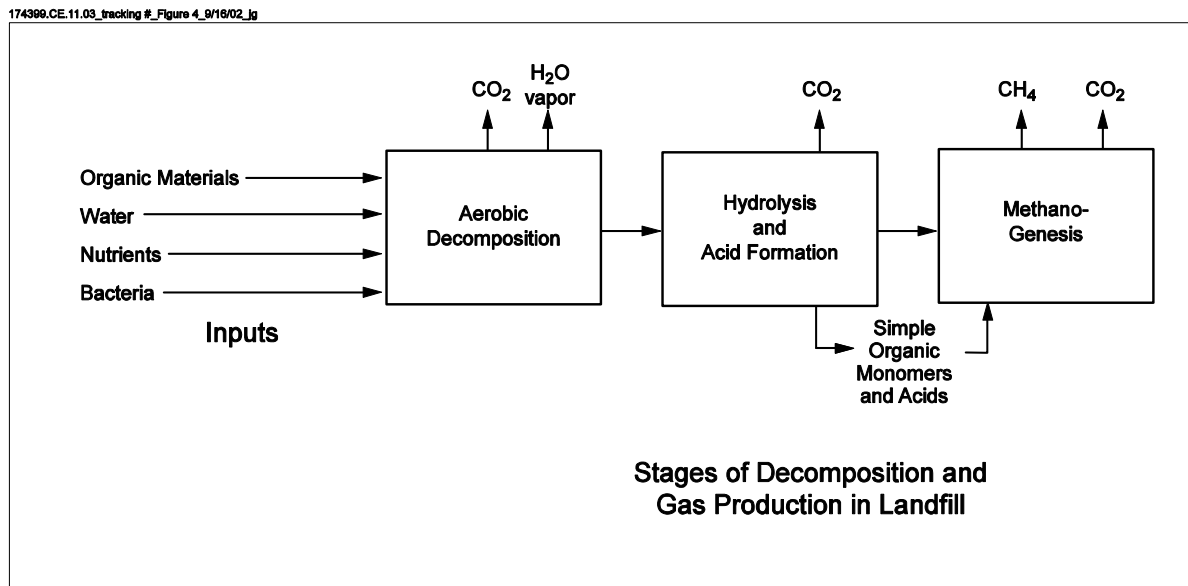


FIGURE 1
Anaerobic Digestion in a Landfill

The process of decomposition is similar to what occurs in sewage treatment plant digesters, except that it occurs more slowly. Initially, the materials are invaded by aerobic bacteria and fungus, which begin the decomposition process, producing carbon dioxide and water. After these organisms deplete the oxygen in the buried wastes, anaerobic bacteria begin to dominate. The first groups of anaerobic bacteria are those that are also tolerant of aerobic conditions. This group of bacteria hydrolyze the cellulosic materials, breaking them down into simple sugars that are more easily decomposed by other bacteria. Other bacteria in this group of oxygen-tolerant anaerobic bacteria decompose the sugars and other organic materials, forming acids and carbon dioxide. Finally, the methanogenic bacteria, which cannot tolerate oxygen, become dominant and the methane production reaches a peak in a given area of the landfill. This process can take up to 2 years before the methane production reaches its peak. It then slowly declines over time as the feed materials are used up.

Feedstock Characterization for San Bernardino County Mid-Valley **Landfill**

3.1 Composition of the Waste Stream

3.1.1 Data Sources

The San Bernardino County Solid Waste Management Department was contacted regarding the availability of its most recent waste characterization study. Waste characterization is a normal part of the planning process for solid waste management systems, including collection routes, disposal, processing and diversion facilities. San Bernardino County advised using the data on waste disposal tonnage and composition that they report to the California Integrated Waste Management Board (CIWMB).

The County indicated that the data available on waste composition for the entire County (labeled “County-wide” in the state database) would be representative of the composition of waste arriving at the Mid-Valley Landfill. The latest data available is for year 1999. The residential and commercial waste streams are reported separately. The raw waste composition data is presented in the Appendix.

The commercial and residential data were combined to arrive at a percentage of the total waste for each category of waste, as shown in Table 3-1. The categories of waste listed in Table 1 are those typically used for solid waste planning. While they are not designed for precisely measuring the biodegradable vs. non-biodegradable fractions of the waste and other parameters useful for designing a bioreactor landfill operation, they can be used to estimate the biodegradable and non-biodegradable fractions. In fact, because of the general availability of this kind of data, it is often used in estimating the biodegradable fraction of municipal wastes for the purpose of estimating landfill gas production.

TABLE 3-1
San Bernardino County - County-wide Solid Waste Disposal

Category	Annual Tonnage Residential	Annual Tonnage Commercial	Annual Tonnage Total	Percent	Percent Adjusted for ADC	Percent Typical US
C&D	31,019	91,818	122,837	9.95%	8.12%	8.70
Glass	27,954	23,081	51,035	4.13%	3.37%	5.50
Metal	32,046	47,164	79,210	6.41%	5.23%	7.80
Mixed Residue	27,715	4,650	32,365	2.62%	2.14%	
Other Organic	182,166	193,040	375,206	30.38%	24.79%	29.90
Paper	190,122	251,085	441,207	35.72%	29.15%	37.40
Plastic	61,271	71,882	133,153	10.78%	8.80%	10.70
ADC					18.40%	
TOTAL	552,293	682,720	1,235,013	100.00%	100.00%	100.00

Notes:

1. Small quantities of hazardous wastes reported and "special wastes" have been removed from the disposal data listed above. It is assumed that these materials are or will be removed from the waste stream before landfilling. These wastes account for less than 3% of total waste, so do not significantly affect overall composition.
2. ADC is alternative daily cover - reported for Mid-Valley Landfill only, vs. County-wide.
3. "Leaves and grass" and "prunings and trimmings" have been removed from the Other Organic category to avoid double counting, since these are diverted, ground and used as ADC.
4. Typical US percentage is as reported by USEPA (www.epa.gov/eaposwer/non-hw/muncpl/facts.htm).
5. C&D is defined as Construction and Demolition waste.

Small quantities of hazardous waste reported (see Appendix) and "special wastes" have been removed from the disposal data listed in Table 3-1. It is assumed that these materials are or will be removed from the waste stream before being placed in the landfill. These wastes account for less than 3percent of total waste, so do not significantly affect overall composition.

Table 3-1 also lists the percentages of each waste category for typical US mixed municipal solid waste (MSW), as reported by USEPA². A comparison to San Bernardino County's waste shows there is relatively good alignment between the data reported by San Bernardino and typical US mixed municipal solid waste.

3.1.2 Biodegradable and Non-biodegradable Wastes

Biodegradable wastes shown in Table 3-1 include paper and "other organics." Glass, metal and plastics are non-biodegradable. While small amounts of biodegradable wastes may be found in mixed construction and demolition (C&D) wastes and in "mixed residue," it is likely that any biodegradable components of these categories would constitute less than 1

² www.epa.gov/eaposwer/non-hw/muncpl/facts.htm

percent of the total waste stream. The San Bernardino Solid Waste Management Department confirmed that C&D wastes are freely accepted at the Mid-Valley Landfill, so this category is included as reported for overall county-wide data.

Another biodegradable category of wastes reflected in Table 3-1 is the shredded and ground green waste used as alternative daily cover (ADC). Normal landfill practice is to cover the wastes at the end of each day with soil. At the Mid-Valley Landfill, as performed at an increasing number of solid waste landfills, an alternative material is used to cover the wastes. At Mid-Valley Landfill, the only alternative daily cover material used is shredded and ground green waste. This is leaves and grass, prunings and trimmings. When suitably processed, it prevents odors, rodent and insect breeding as well as soil. ADC use has been tracked by San Bernardino County at the Mid-Valley Landfill and reported as a percentage of the total waste stream. The average percentage by weight over the 1999 to 2001 period was 18.4percent by weight. No trend was apparent: the percentage was 17.3percent in 1999, 21.7 percent in 2000, and 16.3 percent in 2001. In order to avoid double-counting, the materials reported as “leaves and grass” and “prunings and trimmings” were deleted from the raw disposal data listed in the Appendix when compiling the totals listed in Table 3-1. It is assumed that these materials reported in the raw data are diverted and processed to produce the ADC.

The C:N (carbon to nitrogen) ratio of the waste will be similar to or lower than that for typical MSW, given the composition reported in Table 3-1. The typical C:N ratio for MSW is in the range of 34 to 80.³ The relatively good correspondence between San Bernardino County MSW composition and typical US MSW composition noted earlier is *without* the yard waste component (“leaves and grass” and “prunings and trimmings”). This suggests that San Bernardino County MSW has a higher fraction of green waste than typical US MSW. Green waste is both more biodegradable and has a lower C:N ratio (due to higher nitrogen content) than does MSW. Typical C:N ratios for grass and tree trimmings are below 20.³

The biodegradable content of the waste should be considered in estimating landfill gas production for the bioreactor landfill. CH2M HILL’s model of landfill gas production separates biodegradable materials into three categories: readily decomposable (food waste), moderately decomposable (paper and green waste), and slowly decomposable (wood). The raw data provided in the Appendix will allow the waste material to be broken down into these categories.

3.1.3 Moisture Content

The most important control parameter for a bioreactor landfill is the moisture content of the wastes. The average moisture content of MSW as delivered to a landfill is considered to be 20 percent to 25 percent by volume.⁴ Optimal decomposition rates and gas production rates occur when the waste moisture is at the field capacity of 35 percent to 45 percent by weight. The intent of the bioreactor operation is to add and recirculate liquids so that the moisture content is maintained at the *field capacity* of the materials. Field capacity is defined as the maximum amount of water a sample of waste will retain against gravity through capillary

³ <http://www.cfe.cornell.edu/compost/OnFarmHandbook/apa.tab1.html>

⁴ Tchobanoglous et. al., Solid Wastes – Engineering Principles and Management Issues, McGraw Hill, 1977, p. 58.

forces.⁵ This is much less than the *saturation* water content, which would fill all voids in the material. However the field capacity is typically a much greater moisture content than the moisture content of the incoming wastes. Typical field capacity for MSW in a landfill is 35 percent to 45 percent by weight, as reported by Reinhart and Townsend.⁵ This means that water comprising 10 percent to 20 percent of the in situ weight of landfill material must be added in order to optimally enhance decomposition of the wastes. Typically from 25 to 50 gallons of *additional* liquids must be added per ton to bring municipal solid waste to field capacity. For the estimated disposal rate at the Mid-Valley Landfill (see below) of at least 400,000 tons per year, this would require addition of 10 to 20 million gallons per year, or 20 to 40 gallons per minute on a continuous basis, in order adequately wet the wastes for bioreactor operation. Only a little of this water would be supplied by incident stormwater, given the arid local climate.

3.2 Quantities of Waste

3.2.1 Current Quantities and Projections

San Bernardino County reports the tons of waste disposed at the Mid-Valley Landfill on a quarterly basis. Table 3-2 shows the tonnage disposed through 3rd quarter 2002, which is the latest data available. The data in Table 3-2 show a significant jump in tonnage disposed starting in 2nd quarter 2002. This reflects changes in disposal practices, i.e. where San Bernardino County waste is disposed. While solid waste generation in the County as a whole can be projected based on population growth and other factors, the amounts that will be disposed at any given site depend on many factors, including how much waste is disposed at *other* in-county and out-of-county sites, how much waste is imported into the county, how much waste is diverted through recycling programs, etc, that depend on decisions that may be made in the future.

TABLE 3-2
San Bernardino County Fontana Mid-Valley Landfill Total Disposed Waste Tonnage by Quarter

YEAR	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Total
1999	53,490	67,314	69,932	63,765	254,501
2000	63,712	72,468	81,942	81,403	299,525
2001	79,685	77,318	77,943	72,571	307,517
2002	73,908	152,483	149,006	0	375,397

The data in Table 3-2 suggest that, for the foreseeable future, at least 400,000 tons per year of material will be disposed of at the Mid-Valley Landfill. County personnel report that current (June 2003) receipts of waste at the landfill scale are on the order of 2,500 tons per day, which if continued could result in over 700,000 tons per year of solid waste disposed at

⁵ Reinhart, Debra R. and Timothy G. Townsend. 1998. *Landfill Bioreactor Design and Operation*. Lewis Publishers, CRC Press LLC. New York, New York, pp. 87-89.

this site. The bioreactor landfill operation will have to be planned to accommodate this range of waste receipts, which is typical of commercial landfill operation.

3.2.2 Physical and Operating Parameters of the Mid-Valley Landfill Unit 3

All waste disposed at the Mid-Valley Landfill is currently disposed in a landfill cell labeled Unit 3. Two other cells have already been filled at the site and the locations of later cells have been defined for the future.

Unit 3 is a 140 feet deep excavation covering approximately 60 acres near the southwest corner of the Mid-Valley Landfill site. The cell has a double composite lining system, meaning that two polyethylene liners, each underlain by geocomposite clay or natural clay, line the excavation to prevent seepage from the landfill into the soil below and surrounding it. A leachate collection and recovery system, consisting of drainage layers (both synthetic and gravel), and perforated pipes, carries leachate generated by the solid wastes to a sump in the southeast corner of the cell. Three 24-inch diameter access pipes into this sump carry smaller discharge pipes from pumps located in the sump, up to two 10,000 gallon leachate storage tanks adjacent to the cell. Several 6-inch access pipes rise up the cell sideslopes from the leachate collection pipe network at other points along the cell sidewall. Landfill gas collection piping has not yet been installed in Unit 3, except for perforated piping installed in the leachate collection drain layer specifically designed to extract gas from this layer on the sideslope.

The total fill volume of the cell volume is more than 10 million cubic yards. As of June 2003, approximately 400,000 tons of waste and cover material filling approximately 945,000 cubic yards of the cell volume have been placed. One to two lifts of waste have been placed over part of the southerly landfill bottom lining. In the northerly part of the cell, no wastes have yet been placed, and the lining system has not yet been constructed.

Landfill gas collection systems have been constructed in Units 1 and 2, with piping leading to an exhaustor and flare system at the south end of the site. Also at the south end of the site is a landfill gas-to-energy system, which became operational in early 2003. The system is operated by a third party energy system developer. It's electrical output capacity is reportedly approximately 2 MW. This facility would need to be expanded to accommodate the landfill gas from Unit 3, if it is sized to use only the gas generated in Units 1 and 2.

Water is available at the site, supplied by the City of Rialto. Water is used on site for dust control. Also, a groundwater extraction and treatment system is in operation south of the site to treat contamination from previous industrial land use. This system reportedly extracts in the range of 150 to 200 gpm, which is currently re-injected back into the aquifer from which it is withdrawn, after treatment. The re-injection of this is reportedly necessary in order to create a groundwater gradient pattern that controls the movement of contaminated groundwater.