WATER RECLAMATION
SOLID WASTE MANAGEMENT

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OF LOS ANGELES COUNTY

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STEPHEN R. MAGUIN
Chief Engineer and General Manager

May 22, 2009

Ms. Mary Nichols
Chair, California Air Resources Board
1001 I Street
Sacramento, California 95814

Dear Chairwoman Nichols:

Comments on the Staff Report: Initial Statement of Reasons for the Proposed Regulation To Reduce Methane Emissions from Municipal Solid Waste Landfills
Appendix D – Evaluation of Landfill Gas Collection Efficiency

Thank you for the opportunity to comment on the Staff Report: "Initial Statement of Reasons for the Proposed Regulation to Reduce Methane Emissions from Municipal Solid Waste Landfills." Specifically, we would like to comment on the Appendix D – "Evaluation of Landfill Gas Collection Efficiency", of this report. Further comments will come under a separate letterhead.

In this "Evaluation of Landfill Gas Collection Efficiency" modeling study, the author utilized the actual landfill surface gas measurement data that the Los Angeles County Sanitation Districts (LACSD) provided to CARB and applied the principles of the LACSD's ISM/ISC methodology, which combines actual integrated surface methane monitoring measurements with air dispersion modeling (e.g., Huitric and Kong, 2006), to evaluate the gas collection efficiency at the LACSD's Palos Verdes Landfill (PVLF). **It is important to note that CARB's evaluation did not follow the exact approach utilized by LACSD, but deviated in a manner that rendered CARB's analysis to more of a screening approach for the published methodology.** Nowhere in Appendix D does CARB provide a detailed discussion of this approach difference. As a result of CARB's deviation, the study produced lower collection efficiency values, 87% vs. 93%, than those estimated by LACSD staff. In fact, CARB took their screening approach one step further by performing an incorrect adjustment of the calculated 87% collection efficiency, reducing it further to under 85%.

As described more fully below, LACSD repeated the landfill gas collection efficiency study for the following year after further enhancements were made to landfill gas collection system at the PVLF. However, this study was accompanied by a field study to directly measure fugitive emissions from the landfill through the use of flux chambers. This study verified the effectiveness of the landfill gas collection system enhancements by increasing the calculated landfill gas collection efficiency to over 99%, but more importantly, the ISM/ISC methodology was field verified using flux chambers. This study was conducted with the oversight of DTSC. With the backing of the field-verified study, LACSD can confidently state that if CARB staff utilized the more exact approach in determining landfill gas collection efficiency, similar results to the LACSD study would have been achieved.

LACSD staff made several attempts to meet with CARB modeling staff to discuss the importance of following the more rigorous approach used in our original study, and to demonstrate the effect of the changes CARB staff made from this original study. Unfortunately, these meetings never occurred and CARB staff followed their screening approach. While we appreciate the efforts taken by the CARB staff to evaluate the approach that LACSD proposed to estimate LFG collection efficiency, it is important to detail some deficiencies in this CARB study that may have resulted in the underestimated collection efficiency values presented in this CARB staff report.

The Meteorological Data Used in the CARB Study Are Not Consistent in Time with the Actual Surface Gas Measurements

The actual surface methane measurement data of PVLF that we provided to CARB for this study were taken according to South Coast Air Quality Management District (SCAQMD) Rule 1150.1 protocol for the monitoring period of July 2001 to June 2002. In the LACSD study detailed in Huitric and Kong (2006), the meteorological data that corresponded to the times of actual surface gas measurements at PVLF, were obtained from an onsite weather station. This time-matched, onsite meteorological data is critical to determining an exact calculation of collection efficiency. However, the CARB study instead used a completely different year (2003) of meteorological data from the Los Angeles International Airport (LAX), which is more than 10 miles north of the PVLF.

In performing their study, we believe that CARB has confused an approach that can be used in a regulatory dispersion modeling exercise vs. what LACSD was trying to achieve in the PVLF study. In a regulatory approach, it is acceptable to not use time-matched meteorological data since the desired output are peak values, and results are typically very conservative. However, in this study a time-critical corresponding uncontrolled surface concentration, derived through the dispersion modeling, must be calculated for each surface measurement. We believe that the full year of 2003 meteorological data used in the CARB study are not representative of meteorological conditions of PVLF from July 2001 to June 2002 when the actual surface gas measurements were taking place. The SCAQMD Rule 1150.1 surface gas monitoring protocol requires that surface gas monitoring be performed at wind speeds below 5 miles per hour (mph), and also prohibits monitoring during storms and for 72 hours afterwards so as to avoid turbulent atmospheric conditions. Hence, the meteorological conditions, especially wind speed and direction, for example at 9:00 a.m., on October 25, 2003 (used in this CARB modeling study) are not necessarily the same, in fact, can be greater in wind speed, which would not match when the original sampling event was conducted two years earlier at 9:00 a.m., on October 25, 2001, rendering this matching invalid. The result of using the air dispersion model at higher wind speeds than during the actual gas measurement event, would be a lower estimated collection efficiency.

Due to the fact that the micro-meteorological conditions are transient and constantly–changing, no two sets of transient weather data are alike. Therefore, if CARB's goal is a precise calculation of gas collection efficiency, it is inappropriate to represent one set of weather data (year 2001/2002) with another set (year 2003). CARB's approach, as presented, should be considered a first-cut screening approach that will yield very conservative results (lower gas collection efficiency).

Air Dispersion Modeling Using USEPA ISCST3 Model

The AERMOD model has been recently approved by the USEPA for regulatory purposes, such as New Source Review and Prevention of Significant Deterioration mandates for Title V Clean Air Act permitting programs. To date, AERMOD is not being fully utilized because of the lack of validated meteorological data used to run the air dispersion model, so ISCST3 continues to be used in air basins, such as the SCAQMD, and in important programs, including the CARB and the Office of Environmental Health Hazard Assessment (OEHHA) HARP (Hazardous Air Pollutant Risk Assessment Program), developed under Assembly Bill 2588, the Air Toxics "Hot Spots" legislation.

The PVLF landfill gas collection system studies required the use of dispersion equation algorithms that were readily available, and approved in ISTST3. The AERMOD dispersion model also uses similar algorithms that do not invalidate the ones used in ISTST3, but instead refine their use. For the purposes of the PVLF study, the use of the ISTST3 equations were quite valid, and continue to be. In fact, the field study conducted in 2007 very convincingly validated their use. It is not clear whether the use of AERMOD will increase or decrease the landfill gas collection efficiency, but it is clear based upon the field verification study that the use of ISTST3 is appropriate. If CARB felt the need to run AERMOD instead of the field validated ISCST3 model, then CARB should have conducted a sensitivity analysis comparing the two while leaving all other factors equal. It is the opinion of LACSD, the greatest difference in results will not be from changing the dispersion models, but by inappropriately using a different meteorological data set, as described above.

Treatment of Methane Concentration Measurements That Are Less Than Background Level

Some of the actually measured surface methane levels in the PVLF study were below the background level, therefore, are considered negative net emissions (e.g., instead of emitting methane into the atmosphere, the landfill cover soil acts as a sink for atmospheric methane). This phenomenon has been widely observed and well documented (e.g., Bogner, *et al.*, 1997, Scheutz, *et al.*, 2004). These below-background surface methane measurements reflect reality and contribute to lower the overall surface methane emissions. Therefore, these below-background surface methane measurements should be included in the analysis. However, the CARB study excludes those surface methane measurements that were less than the background level in the analysis (Table 1, Appendix D). It is suggested that CARB modify Table 1, and omit calculations that exclude below-background surface methane measurements.

Urban versus Rural Modes in Air Dispersion Modeling

In the atmosphere, the air is generally more mixed and dispersive in urban settings, due to enhanced boundary layer turbulence and buoyancy effects, than in rural settings. As a result, the urban mode of the air dispersion modeling (e.g., USEPA, 2009), would result in lower model-predicted surface concentration reductions due to gas collection, which in the PVLF study also results in lower collection efficiency when compared to that of rural mode. It is unclear then, why results presented in Table 1 of Appendix D are contrary (that is collection efficiency for urban mode is actually higher than that of the rural model). This should be corrected or clarified.

Field Verified High Collection Efficiency at PVLF

The LACSD PVLF landfill gas collection efficiency study was performed using the 2001-2002 actual surface gas measurement and onsite meteorological data, and resulted in 93% to 96% collection efficiency, for urban and rural modes, respectively. The LACSD also conducted another study at PVLF in 2007 to validate the ISM/ISC methodology using the same approach proposed in Huitric and Kong (2006), but now with actual field measurements using surface flux chambers (Huitric, *et al.*, 2007). In this updated 2007 study, actual surface methane measurements taken under SCAQMD Rule 1150 protocol with comparable onsite meteorological data from 2006 were used in the estimation of LFG collection efficiency. In parallel track to this theoretical work, surface methane emission fluxes were also measured at the surface of PVLF using surface flux chambers. The ISM/ISC analysis, using year 2006 data, estimated collection efficiencies of +99% under both urban and rural modes, and the collection efficiencies based on the independent surface flux-chamber measurements were calculated to be essentially 100%. The ISM/ISC analysis results were consistent with those from costlier surface flux chamber measurements, thus validating the methodology. These results indicated that LACSD was operating a highly efficient LFG collection system at PVLF.

Conclusion

In summary, results of CARB collection efficiency calculations presented in Table 1 of Appendix D are generally 6%, and +8% after an incorrect adjustment is made, lower than those predicted by the LACSD (Huitric and Kong, 2006). We have pointed out some deficiencies in the CARB analysis, but we strongly believe that the misuse of the year 2003 LAX meteorological data to represent/replace year 2001/2002 onsite meteorological data is the biggest contributor to such result discrepancies. For an accurate assessment of collection efficiency, it is important to employ input data that properly represent the actual field conditions. The study CARB performed represents a screening level analysis that generates very conservative results (lower landfill gas collection efficiency). We therefore requested that the CARB reflect this in Appendix D. We have provided some recommended language as an attachment.

Thank you for your consideration of our comments. Please feel free to call me at (562) 908-4288, extension 2460, should you have any questions.

Very truly yours,

Stephen R. Maguin

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Appendix D

Evaluation of Landfill Gas Collection Efficiency

A. Introduction

This appendix provides a brief overview of the methodology used to provide a conservative estimate of ~~the expected~~ collection efficiency that can be achieved by a well-controlled landfill subject to the proposed regulation to reduce methane emissions from municipal solid waste landfills. As discussed in this staff report, the proposed regulation will provide enhanced control of methane emissions from municipal solid waste landfills by requiring the installation of gas collection and control systems at smaller and other uncontrolled landfills. The control measure also includes requirements for all affected landfills to ensure that gas collection and control systems are operating optimally and that fugitive emissions are minimized.

In order to better understand the proposed regulation's impact on collection efficiency, ARB staff evaluated the collection efficiency values determined for a well-controlled landfill in Palos Verdes, California by performing air dispersion modeling coupled with actual landfill surface gas measurements ~~conducted by District staff~~ required by the SCAQMD under its Rule 1150.1. This landfill is owned and operated by the Los Angeles County Sanitation Districts (Districts). The Districts provided a very rigorous approach to determining gas collection efficiency that culminated in a second year field validated study. ARB staff found the general estimation approach acceptable, but simplified the approach by using meteorological inputs that would be more typical of regulatory modeling rather than the site-specific data employed by the Districts. Thus, the approach outlined here likely results in an estimate of collection efficiency that is conservative (less than would be determined by a more rigorous approach), but very appropriate for the purposes of this document.

The Districts ~~had previously~~ evaluated the gas collection efficiency at this same landfill using actual surface gas measurements and U.S. EPA's air dispersion model – Industrial Source Complex (ISCST3). However, since U.S. EPA phased out the use of the ISCST3 model in 2006, ARB staff conducted the air dispersion modeling using U.S. EPA's new approved replacement model-AERMOD. Despite ARB staff's choice to use the updated model, the Districts approach using ISCST3 is still valid, especially since the approach was field validated. Below is a brief overview of the approach used to determine the landfill collection efficiency using AERMOD modeling and the previously collected landfill gas measurements at the Palos Verdes landfill.

B. Methodology

1. Data Processing

The following data were obtained from the Districts:

- Methane (CH_4) concentration measurements from the Palos Verdes landfill surface in irregular time periods, in parts per million (ppm)
- Landfill gas emission rate (as estimated from the collection system)
- Various modeling parameters (area dimension, emission rates, etc.)

ARB staff evaluated the data sets to ensure there were no outliers. Because the measurements were not taken continuously over a one-hour period, staff used the average of any measurements that occurred within the same hour, date, and month and to represent the entire hour for that specific day.

2. AERMET Modeling

The AERMOD model requires meteorological parameters to characterize air dispersion dynamics in the atmosphere. These parameters are estimated by AERMOD's supporting meteorological processing model, AERMET. The meteorological data used in the model were selected on the basis of representativeness and availability. Representativeness is determined primarily on whether the wind speed/direction distributions and atmospheric stability estimates generated through the use of a particular meteorological station (or set of stations) are expected to mimic those actually occurring at a location where such data are not available. Typically, the key factors for determining representativeness are proximity of the meteorological station and the presence or absence of nearby terrain features that might alter airflow patterns. For this study, 2003 meteorological data from the Los Angeles International Airport (LAX) was used. LAX is about one mile away from the Palos Verdes landfill. For the upper air conditions, San Diego-Miramar and Oakland International Airport are two full-time and reliable stations in California. As the Miramar station is much closer to the landfill, it was used in this study. After running AERMET, the hourly meteorological data for the full year of 2003 were created. The processed meteorological data, including surface and upper air, were filtered to retain only hours corresponding to times of the measurements. The filtered meteorological files were rearranged into a time period with consecutive hours.

3. AERMOD Modeling

The recently U.S. EPA approved air dispersion model-AERMOD, rather than ISCST3 (phased out on November 9, 2006), was used to estimate the CH_4 hourly concentrations within the landfill in the same time series order as the measurements. Key model parameters are as follows:

Model:	AERMOD
Run Mode:	hourly concentrations (in µg/m3)
Model Option:	area source (polygons)
Dispersion Coefficients:	Urban and Rural
Modeling Domain:	800 m x 800 m
Modeling Resolution:	50 m x 50 m for 256 receptors
Receptor Setting:	Placing on center of each area source (1.5 in)
Meteorological Data:	Surface station -LAX (2003),
	Upper Air -San Diego-Miramar (2003)

4. Calculations of CH_4 Gas Collection Efficiency Based on AERMOD

The modeled CH_4 concentration by AERMOD can be regarded as an equivalent concentration reduction in the landfill surface achieved by gas collection (CH_r) where the model estimates the emissions that are captured through the landfill extraction wells. Gas generation is expressed as the sum of the modeled reduction at the surface due to collection and the measured surface CH_4 (CH_m) due to emissions. Gas collection efficiency is then calculated by Equation 1:

$$E = \frac{CH_r}{CH_r + CH_m} \quad (1)$$

5. Conversion of Mass Concentration to Volume Concentration

The outputs from AERMOD are reported as mass concentrations for CH_4 (in µg/m^3), while the measured CH_4 were reported as volume concentrations (in ppm). The conversion of mass concentration into volume concentration can be made by Equation 2 at a standard air pressure of one atm condition for CH_4:

$$C_{mass} = \frac{.195*10^5}{T} \times C_{ppm} \quad (2)$$

where C_{mass} is the CH_4 mass concentration (in µg/m^3), C_{ppm} is the CH_4 volume concentration (in ppm), and T is the atmospheric air temperature (in Kevin). Note that all terms are also a function of time.

C. Results

1. Gas Collection Efficiency Derived from AERMOD Modeling

Table 1 presents the gas collection efficiency determined following Equation 1 and using the AERMOD modeled outputs and CH_4 measurements as inputs to the equation. Any hour with modeled zero concentration was not included in the analysis and the corresponding measurement during that hour was also not included. In addition, because there were hours in which there resulted negative CH_4 concentrations after subtracting the background concentration and being corrected for instrument bias, two sets of collection efficiency values are reported in Table 1 - the "collection efficiency" and the "corrected collection efficiency." "Collection efficiency" represents the results without removing any hours that had negative concentrations of CH_4 and "corrected collection efficiency" represents the results after removing any hours that had negative CH_4 concentrations. As shown in Table 1, the results demonstrate a collection efficiency of about 85 percent for the gas collection system in the Palos Verdes landfill.

Table 1. Gas Collection Efficiency Derived from AERMOD Modeling

	CH4 Conc (ppm)	
	Urban	**Rural**
Measured LF Surface	2.498	2.498
Bias Correction	0.059	0.059
Actual LF Surface	2.557	2.557
Air Background	1.835	1.835
LF Conc (CHm)	0.722	0.722
Corrected LF Conc (CHm)*	**0.879**	**0.879**
Modeled Conc (CHr)**	4.873	4.748
Total Conc (CHr+CHm)	5.595	5.470
Corrected Total Conc (CHr+CHm)	**5.752**	**5.627**
Collection Efficiency	87.10%	86.80%
Corrected Collection Efficiency	**84.72%**	**84.38%**

1. The hours with measurements being less than the background were excluded for the analysis;
2. The hours with modeled zero concentrations were excluded for the analysis.

2. Distribution of Methane Concentrations over the Landfill

Figure 1 shows the spatial distribution of the modeled CH_4 concentrations over the landfill. The concentrations are averaged over the monitoring time period or all monitoring hours. The distribution is nearly uniform except near the landfill boundaries. This implies that the results are not sensitive to the locations of receptors within the landfill, and that the gas collection efficiency approach presented above based on the overall average measurements and average modeled concentrations is reasonable. In fact, a grid-by-grid analysis versus the overall average analysis showed a difference of about 1 percent (analysis not shown).

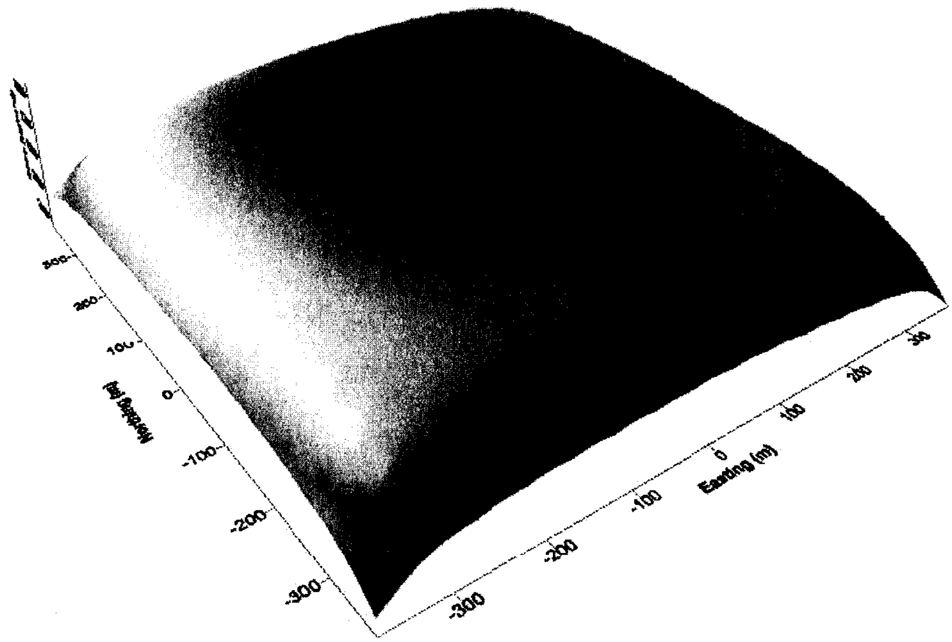

Figure 1. Spatial Distribution of the Modeled CH_4 Concentration over the Landfill Surface

3. <u>Distribution of Methane Concentrations Beyond the Landfill</u>

To investigate how the CH_4 concentrations change with downwind distance outside of the landfill, a modeling run was conducted by placing the receptors along the central line of the domain in the predominate wind direction at distances of 0, 1, 5, 10, and 20 m from the landfill boundary. The modeled CH_4 concentrations are normalized to those that are located on the boundary and on the center of the modeling domain, respectively. The results are summarized in Figure 2. As shown in Figure 2, the CH_4 concentrations decrease with the downwind distance rapidly. At 10 meters, the CH_4 concentrations have decreased by about 40 percent and at 20 meters by about 60 percent compared with those at the boundary.

1.00

0.90

0.80

0.70

0.60

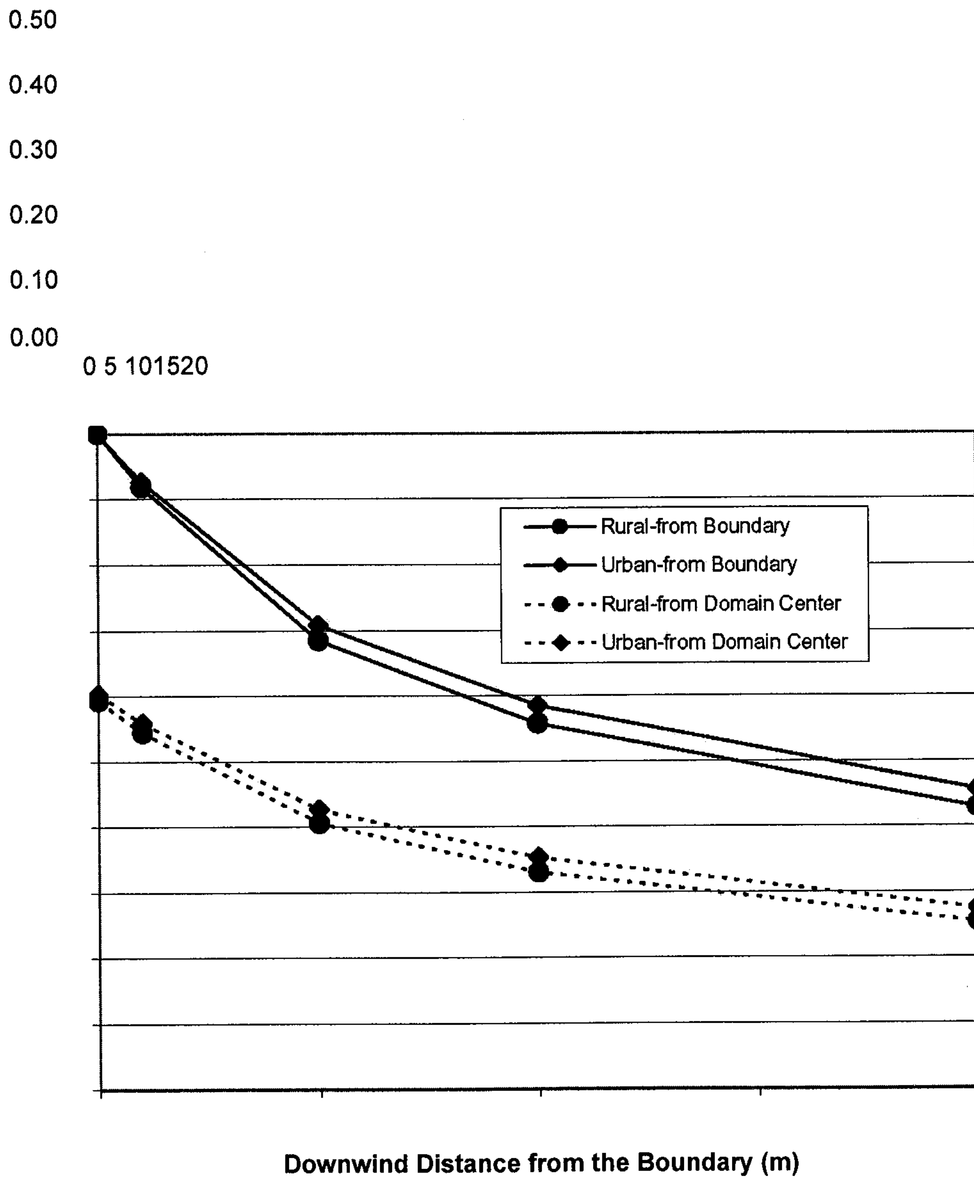

Figure 2. Normalized CH_4 Concentrations vs. Downwind Distances

4. Distribution of Methane Concentrations over Receptor Heights

To see how the modeled CH_4 concentrations change with receptor heights, we conducted a sensitivity study using AERMOD by placing receptors on the center of the modeling domain with different heights – 0, 0.5, 1, 2.5, 5, and 10 meters above the landfill surface. The results are normalized and presented in Figure 3. It is apparent that the setting of receptor heights plays an important role in determining the gas collection efficiency. For this study, the height of all receptors was placed in a height of 1.5 inches, which was identical to the measurement height.

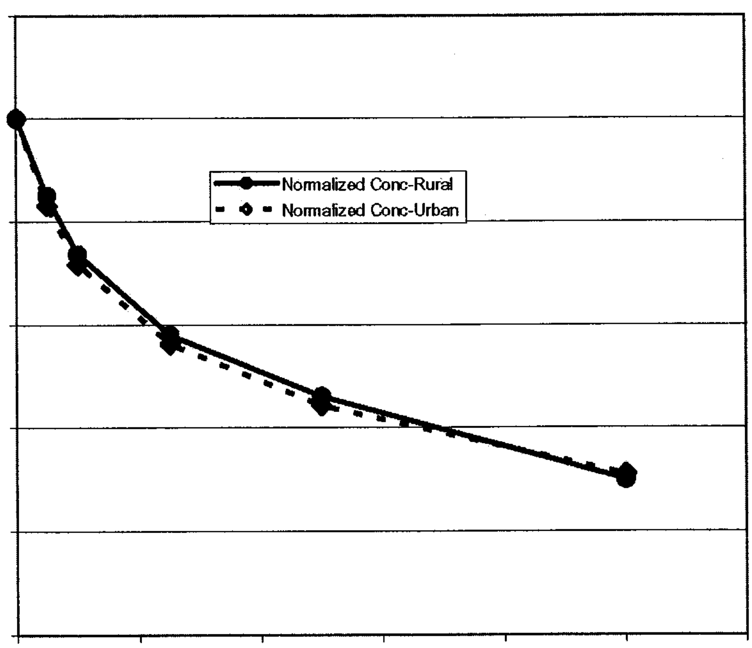

Figure 3. Normalized CH_4 Concentrations vs. Receptor Heights

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