APPENDIX F

AIR QUALITY HEALTH RISK ASSESSMENT

DRAFT

Health Risk Assessment for the Proposed Greenbriar Farms Development

October 4, 2005

Summary

The California Air Resource Board's (CARB's) guidance document entitled "Air Quality and Land Use Handbook: A Community Health Perspective[1]," recommends, among other things, that new residences should not be sited within 500 feet of a freeway. This recommendation was based on analyses suggesting that health risks were increased within 300 feet of a freeway, and that a 70% reduction in ambient particulate levels is seen at 500 feet from the source. As a consequence, a site-specific health risk assessment was performed for the Greenbriar Farms development project, which entails the proposed construction of residences within about 200 feet of Interstate 5 (I-5) and State Route 99 (SR-99) where the two freeways intersect in northern Sacramento.

The analysis of the potential health risks associated with the impact of freeway emissions on the proposed Greenbriar Farms development was prepared based on CARB and U.S. Environmental Protection Agency (EPA) emission factors, EPA dispersion models, and traffic data provided by the Sacramento Area Council of Governments (SACOG). This analysis indicates that risks from nearby I-5, SR-99, and the freeway interchange on proposed residences in the Greenbriar Farms development are lower than those suggested in CARB's land use guidance document. For the residences nearest the freeways, the acute and chronic non-cancer health risks are below all established regulatory significance levels, and the 70-year average increased cancer risk is less than 6% of recent background risk levels attributable to toxic air pollutants in the Sacramento area.

The lower risks identified for this project, in comparison with the values presented in the CARB Land Use Guidance document, are the result of a number of site-specific factors, including vehicle traffic volumes, the relative orientation of the freeway vis-à-vis the proposed development, local meteorology, and the expected decline in vehicle emissions over time. Notwithstanding the fact that these impacts are substantially lower than those upon which CARB's siting recommendations are based, if additional mitigation measures are desired, the following measures should be considered:

- Use of sound walls to enhance the dispersion of emissions from freeways; and
- Use of tiered tree planting to enhance the dispersion of emissions from freeways.

[1] Published in April 2005.

These two measures are intended to enhance the dispersion of emissions, and hence reduce concentrations of pollutants at residences that are closest to the freeway. Unfortunately, there are no tools available at the present time to quantify the potential benefits of these measures.

Introduction

In April 2005, the California Air Resource Board (CARB) published a guidance document entitled "Air Quality and Land Use Handbook: A Community Health Perspective," which recommended, among other things, that new residences should not be sited within 500 feet of a freeway. This recommendation was based on analyses suggesting that additional health risks were strongest within 300 feet of a freeway and that a 70% reduction in ambient particulate levels is seen at 500 feet from the source. The CARB recommendation directly affects the proposed Greenbriar Farms development, which entails the proposed construction of residences within about 200 feet of the freeway edges. Figure 1 shows a map of the proposed development site adjacent to the intersection of Interstate 5 (I-5) and State Route 99 (SR-99), along with the typical wind patterns in the area based on historical meteorology. As shown in the wind rose plot, the winds are strongest from the south and southwest. This would effectively minimize the exposure of the proposed site to emissions from SR-99 and the interchange; however, emissions from I-5 would be directed towards the proposed development under prevailing wind conditions. A site-specific health risk assessment was performed in order to quantify the risk associated with the combination of meteorology and traffic volumes from the adjacent freeways, including I-5, SR-99, and the interchange.

To assess the risk associated with exposure to mobile source air toxics (MSATs) emitted from vehicles on the freeways adjacent to the development, vehicle emissions on the freeways segments were quantified and the cancer and non-cancer risks due to exposure were estimated at various distances from I-5, SR-99, and the interchange using dispersion modeling. The MSATs included in the study are the 21 toxic air pollutants identified by the U.S. Environmental Protection Agency (EPA)[2] and listed in Table 1. The analysis was performed for calendar year 2007 and every five years thereafter until 2037 using projected emission rates and traffic activity on the given stretch of freeway. This report summarizes the traffic data and methodology used and the results of the assessment.

[2] "List of Mobile Source Air Toxics (MSATs)," U.S. Environmental Protection Agency, Mobile Source Air Toxics Website, http://www.epa.gov/otaq/toxics.htm, Accessed July 26, 2005.

Figure 1
Greenbriar Farms Development Site Map And Wind Direction

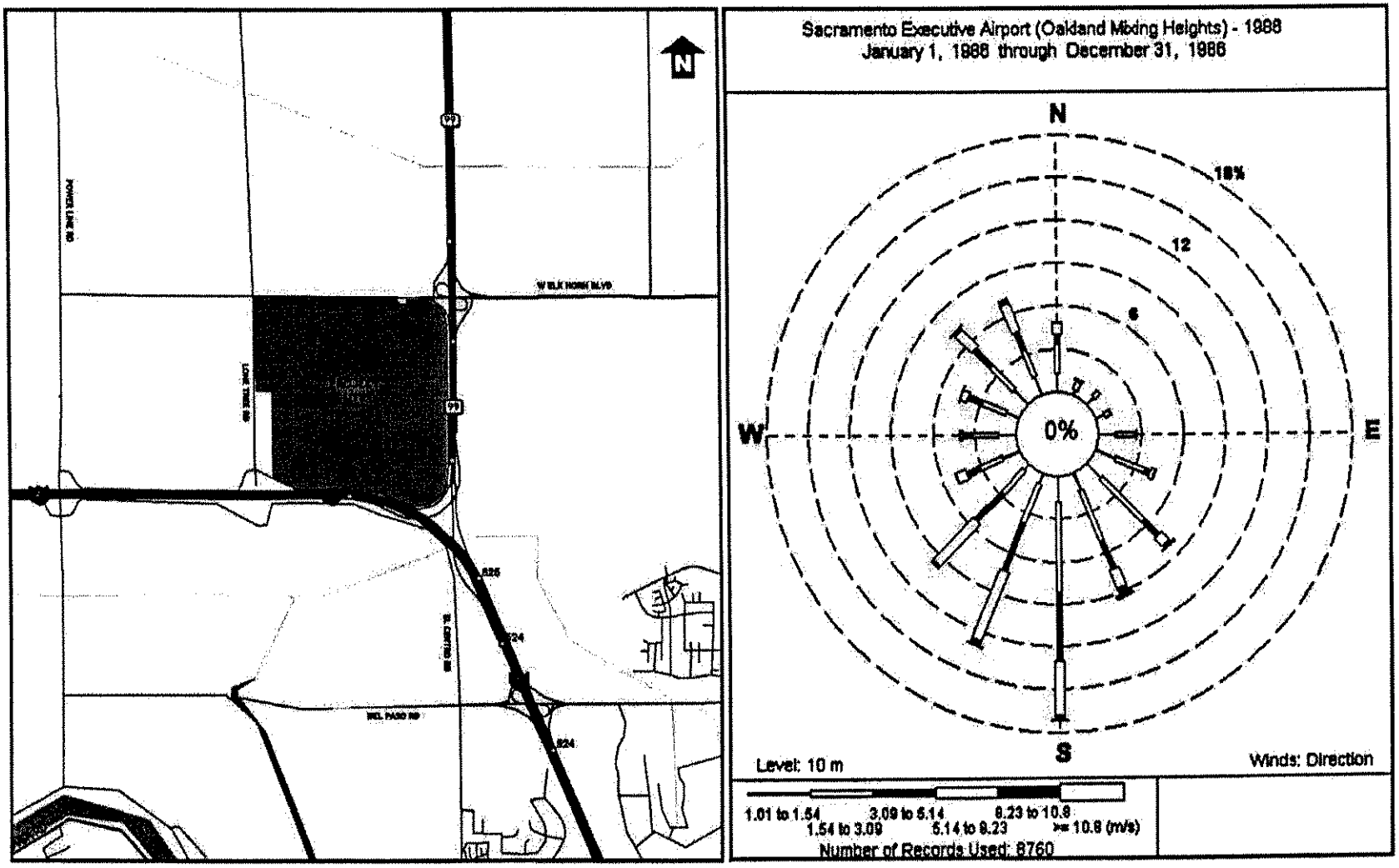

Table 1 21 Mobile Source Air Toxic Pollutants Identified by EPA		
Acetaldehyde	Diesel Particulate Matter (PM) and Diesel Exhaust Organic Gases	MTBE
Acrolein		Naphthalene
Arsenic Compounds		Nickel Compounds
Benzene	Formaldehyde	Polycyclic Organic Matter (POM)
1,3-Butadiene	n-Hexane	
Chromium Compounds	Lead Compounds	Styrene
Dioxins/Furans	Manganese Compounds	Toluene
Ethylbenzene	Mercury Compounds	Xylene

Estimating MSAT Emission Levels

To be consistent with the development timeline, the analysis years were chosen to begin in 2007, and were projected as far into the future as the emissions modeling would permit at five-year increments to 2037. CARB's most current version of the EMFAC emissions inventory model[3] was used as the basis for the analysis; this model projects emissions through calendar year 2040. The EMFAC model has the capability to estimate emissions of hydrocarbons (in the form of total organic gases [TOG] and reactive organic gases [ROG], among others) and particulate matter greater than 10 microns in diameter (PM_{10}) from gasoline and Diesel vehicles specifically for Sacramento County.

EMFAC runs were developed to generate average TOG, ROG, and PM_{10} emission factors in grams per mile for Sacramento County for each of the 13 vehicle classes in the model, by technology group (non-catalyst, catalyst, and Diesel), for a total of 39 combinations. Because the EMFAC model does not estimate MSAT emissions, the emission factors generated from the model runs were multiplied by air toxic pollutant emission ratios (expressed as MSAT/TOG, MSAT/volatile organic compounds (VOC), and MSAT/PM_{10}) from EPA. For example,

MSAT (g/mi) = TOG (g/mi) * MSAT/TOG.

The most current version of EPA's MOBILE model[4] provides ratios to estimate emissions for benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, and MTBE from TOG emissions and average fuel properties. The fuel used in Sacramento County for 2007 through 2037 was assumed to fall within the requirements of the California Phase 3 Reformulated Gasoline flat limits, and the winter fuel Reid vapor pressure (RVP) was estimated to be 13 psi based on historical winter gasoline in the area.

[3] EMFAC2002 dated April 21, 2003.
[4] MOBILE6.2 dated September 24, 2003.

In addition to the six MSATs explicitly modeled in MOBILE, emissions for dioxins, naphthalene, ethylbenzene, n-hexane, styrene, toluene, xylene, a representative group of POMs,[5] chromium (Cr^{6+} and Cr^{3+}), manganese, nickel, mercury, and arsenic were estimated using ratios and emissions factors developed by EPA for use in creating the 2002 National Emissions Inventory (NEI). The ratios for naphthalene, ethylbenzene, n-hexane, styrene, toluene, and xylene from the NEI were based on VOC emissions, the POM ratios were based on the PM_{10} emissions, and emission factors in milligrams per mile were obtained for the metals and dioxins[6]. Because the EMFAC model does not generate hydrocarbon emissions as VOC, the model emissions for ROG were used with the VOC-based ratios.[7]

After MSAT emission factors were developed for each vehicle class from the combination of the TOG, ROG, or PM_{10} emissions from EMFAC, and ratios and emission factors from EPA, separate Diesel and gasoline fleet-average MSAT emission factors were estimated using the fraction of vehicle miles traveled (VMT) by vehicle class in EMFAC for Sacramento County for each analysis year. The average gasoline and Diesel MSAT emission factors were then combined with the estimated average annual and peak period total VMT for each fuel type for the adjacent freeways for the study years using the following equation:

MSAT (g/mi) * VMT (mi/s) = MSAT (g/s)

The VMT (the product of roadway length and traffic volume) for vehicles traveling on I-5, SR-99, and the interchange were estimated from local traffic volume data derived from the Sacramento Regional Travel Demand Model (SACMET) and obtained from the Sacramento Area Council of Governments (SACOG)[8] and freeway segment lengths estimated to affect the proposed Greenbriar Farms development. The SACOG traffic volume data included the annual average and 3-hour AM peak-period traffic volumes for the north (west) and southbound (eastbound) portions of I-5, the north and southbound portions of SR-99, and the interchange[9] for 2005, along with the volume projections for 2027. The freeway segment lengths selected were based on the length of the freeway adjacent to the proposed development plus an additional 1,000 feet in all directions[10] in order to ensure that all emissions with potential to result in near-field impacts to the development were captured. This resulted in about two miles of I-5, one mile of SR-99,

[5] A group of seven polynuclear aromatic hydrocarbons (7-PAH)—benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenz(ah)anthracene, and indeno(1,2,3-cd)pyrene)—was used as a surrogate for the larger group of POM compounds.
[6] No health risk factors were available for furans; therefore, emission factors for furans were not sought beyond the EPA sources referenced.
[7] The differences between VOC and ROG are believed to be insignificant in the context of this analysis.
[8] Robert McCrary, SACOG. Personal communication. September 2005.
[9] 2005 and projected 2027 traffic volumes were obtained from SACOG for the northbound SR-99 freeway ramps from I-5 and for the southbound I-5 freeway ramps from SR-99. Traffic volumes for the other interchanges (northbound SR-99 freeway ramps from I-5) and interchange through traffic (vehicles continuing down I-5 north and southbound past the SR-99 interchange) were estimated from a traffic volume balance over the entire interchange system since all traffic is conserved within the two freeways.
[10] The freeway segments adjacent to the development were extended by 1,000 feet west and 1,000 feet southeast for I-5 and 1,000 feet north for SR-99.

and more than three miles of interchange connectors being included in the freeway system analyzed. The resulting VMT for I-5, SR-99 and the interchange were combined to result in the total VMT for the freeway system for each data year (2005 and 2027). The data were interpolated to develop VMT estimates for 2007, 2012, 2017, and 2022 and extrapolated for travel estimates for 2032 and 2037. The total VMT estimates for the entire freeway system are shown in Table 2.

Table 2
Annual Average and Peak VMT on Freeway System (I-5, SR-99 and Interchange) Adjacent to the Greenbriar Farms Development

	Annual Average		Peak Period	
Calendar Year	VMT/Hour	VMT/Sec	VMT/Hour	VMT/Sec
2007	9,466	2.63	17,338	4.82
2012	10,087	2.80	18,300	5.08
2017	10,707	2.97	19,261	5.35
2022	11,328	3.15	20,222	5.62
2027	11,949	3.32	21,183	5.88
2032	12,570	3.49	22,144	6.15
2037	13,190	3.66	23,105	6.42

To generate fuel-specific VMT, the total yearly VMT shown in Table 2 were multiplied by the VMT fraction for gasoline and Diesel vehicles derived from the EMFAC model. The fuel-specific VMT were used along with the gasoline and Diesel average MSAT emission factors in the equation shown above to result in MSAT emissions by fuel type in grams per second. The resulting gram-per-second MSAT emission levels were then combined with the cancer and non-cancer risk factors (in per microgram/meter^3 or $\mu g/m^3$) to generate emissions-weighted risk per 1 $\mu g/m^3$ per gram/second.

Cancer risk factors and acute and chronic risk health hazard indices (HHIs) were generated using CARB's Hotspots Analysis and Reporting Program (HARP).[11] Risk factors for the MSATs from gasoline-powered vehicles were weighted separately by multiplying the pollutant emission level by the cancer risk factors and HHIs for each individual MSAT. The cancer risk factors and chronic risk HHIs were weighted using the pollutant emission levels generated from the annual average traffic volumes on the freeway system, whereas the acute risk HHIs were weighted using the emission levels during the peak traffic hour. The resulting products were then summed for all MSATs to result in the total risk for gasoline vehicles. For Diesel-powered vehicles, the Diesel PM risk factor in HARP includes all of the MSATs from Diesel exhaust, so only the Diesel PM emission rate and the Diesel PM cancer risk factor were used to account for all of the toxic risk from Diesel exhaust. As with gasoline vehicles, the Diesel cancer risk factor

[11] HARP version 1.0 with update 230221 and update to the health and pollutant tables dated September 21, 2004.

and chronic risk HHI were weighted using the annual average traffic emission levels. No acute non-cancer risk HHI is available for Diesel vehicles from HARP.

Dispersion Modeling

The dispersion model used in the analysis is EPA's CAL3QHCR model,[12] which is designed to predict pollutant concentrations near roadways. Unit impacts (assuming a total of 1 gram per second is emitted by all the freeway segments) were generated by the model runs for each calendar year at different distances from the freeway. These unit impacts were then combined with the emissions-weighted risk values generated above to estimate the overall impacts of the freeway traffic emissions. The modeling procedure is described in more detail below.

Fifty freeway segments were modeled, all associated with the I-5/Highway 99 interchange. The emission factor for each segment was adjusted, reflecting changing traffic volumes with time, so that the total emission rate from the I-5, SR-99 and the interchange equaled 1.0 gram per second for each scenario year. The number of lanes modeled was derived from SACOG link attributes where available, and supplemented by aerial photos of the interchange. Each lane was assumed to be a standard 12 feet in width. The traffic volumes for the runs were based on the volumes on each freeway segment obtained from SACOG.[13] Freeway dimensions were taken from the DeLorme Road Atlas software and imported into the TOPO! software map to generate UTM coordinates (NAD27). The two segment sources were modeled following CAL3QHCR's standard line source/mixing zone approach. Meteorological data collected in 1986 at Sacramento Executive Airport were used for the dispersion modeling. Meteorological differences between the Airport and the project site are not likely to significantly affect the reported results.

Three rows of 33 receptors each were modeled (for a total of 99 receptors), with each row extending 300 meters into the housing development. Receptor rows were modeled perpendicular to I-5, SR-99, and the interchange roadway segments, from midway along each segment. The location of the receptors relative to the freeway segments and the Greenbriar Farms developments is shown in Figure 2. In general, the receptors were spaced at 10-meter intervals, starting with the first receptor at the edge of the mixing zone (the boundary of which is defined as 10 feet past the edge of the freeway/traveled way). Two additional receptors were placed in each receptor row at the distances where the edges of the project development and the nearest residential property are estimated to be. The distances between the nearest residential property and I-5, SR-99, and the interchange were estimated using the tentative subdivision map for Greenbriar Farms and aerial photos of the site. The receptor flagpole height was set at the standard 1.8 meters (breathing height) for all CAL3QHCR runs.

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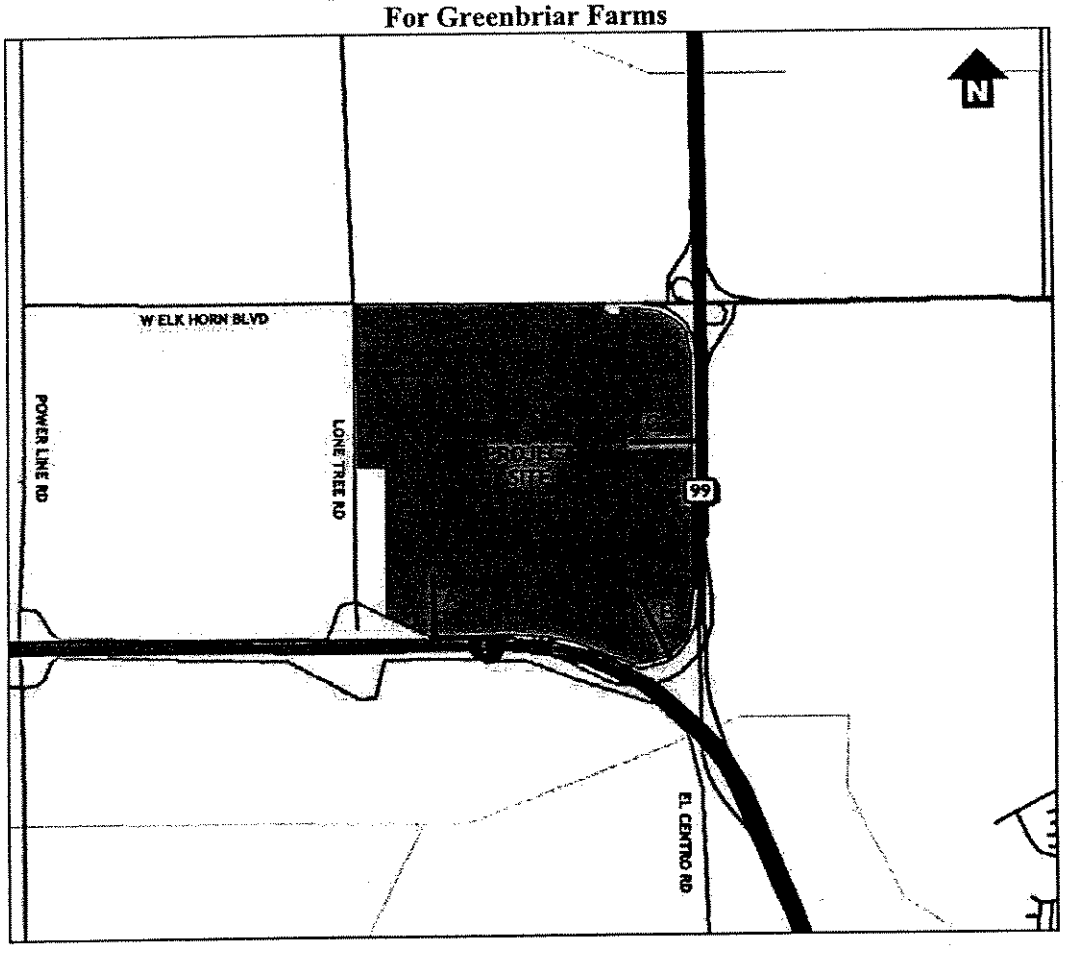
[12] CAL3QHCR version dated September 7, 2004

[13] Traffic volumes on each segment (north and southbound I-5, north and southbound SR-99 and interchange connectors) are inputs to the model to account for the emissions dispersion attributable to moving vehicles on the roadway.

Figure 2
Location of Dispersion Modeling Receptors (Rows A, B and C)
For Greenbriar Farms



Health Risk Assessment Results

The cancer and non-cancer risks associated with freeway emissions were estimated for the range of distances from 0 to 300 meters from the edge of the mixing zone (i.e., from 10 to 994 feet from edge of freeway traveled way) of each freeway segment extending into the development, as shown in the receptor map in Figure 2, for each analysis year. In addition, the 70-year average impacts were estimated by assuming that the results for 2007 through 2032 represent the average for the given year and the subsequent four years, and that the results for 2037 represent the average for that year and the next 40 years. This represents a very conservative assumption for the 70-year average, since the cancer and non-cancer risks from vehicle sources tend to decrease with time.

Both the chronic and acute non-cancer risk indices were below the significance level of 1.0 at all distances from the freeway segments and for all years analyzed. The highest acute and chronic non-cancer indices of 0.63 and 0.26 per million, respectively, occur for 2007 at the edge of the I-5 mixing zone (10 feet from the freeway edge). The non-cancer risks at the edge of the SR-99 and interchange mixing zones in 2007 are less at 0.54 and 0.37 per million for acute risk, respectively, and 0.18 and 0.17 per million for chronic risk, respectively. The risk decreases with time and distance from all the freeway segments.

Figure 3, 4, and 5 show the average cancer risk estimated by distance from I-5, SR-99, and the interchange mixing zones, respectively, for 2007, 2037, and the 70-year average. As shown, the estimated average cancer risk is well below the range of relative cancer risk estimated by CARB in its land use handbook. The handbook, which recommends not siting residences within 500 feet of a freeway, estimates a range of relative cancer risk of 300-1,700 chances in a million. The risk values estimated for the proposed Greenbriar Farms development at the nearest residential property line are about 5 to 8 times lower than the low-end of CARB's range in 2007 and 13 to 15 times lower than the low end of the range in 2037.

In Table 3, the 2007, 2037, and 70-year average cancer risks for the project are presented as a percentage of the 2000 total average cancer risk estimated by CARB for the Sacramento Valley Air Basin. CARB estimated the average basin cancer risk due to air toxics to be 520 per million as part of "The California Almanac of Emissions and Air Quality - 2005 Edition."[14] The estimated basin risk takes into account emissions of 10 select toxic air contaminants[15] (those that pose the greatest health risk in California based primarily on ambient air quality data) from all sources. Therefore, the actual total average basin risk would be higher when all air toxic pollutants are accounted for, and the percentages shown in the table would be lower. These data indicate that, at the property line for the residences that are nearest to the freeways, the 70-year average incremental cancer risk for the project is less than 6% of recent background levels.

[14] http://www.arb.ca.gov/aqd/almanac/almanac05/almanac05.htm

[15] The selected 10 toxic air contaminants are acetaldehyde, benzene, 1,3-butadiene, carbon tetrachloride, hexavalent chromium, para-dichlorobenzene, formaldehyde, methylene chloride, perchloroethylene, and Diesel particulate matter.

Figure 3
Average Cancer Risk By Distance From I-5 Mixing Zone Edge

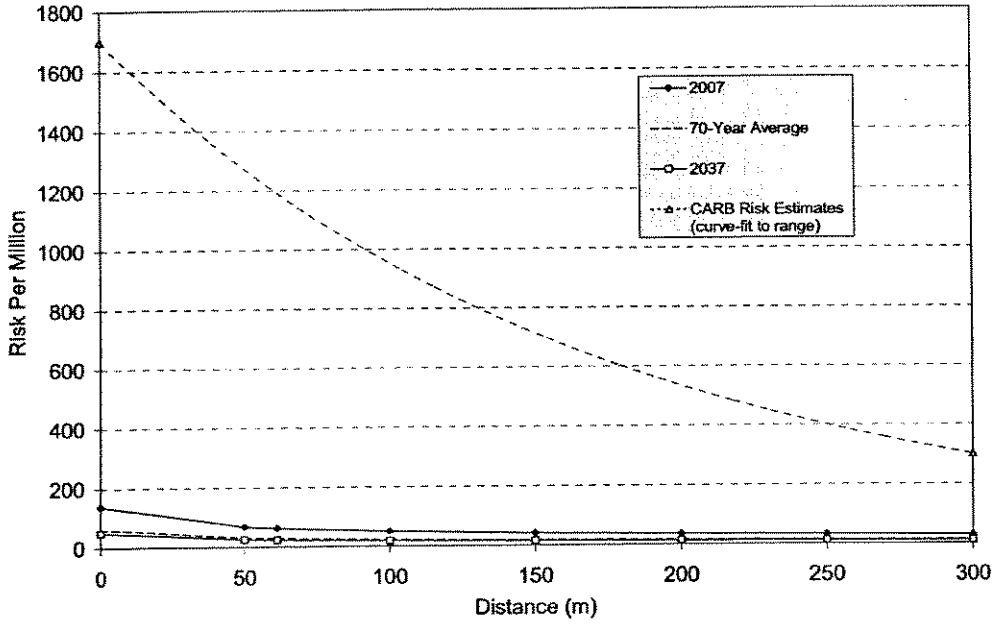


Figure 4
Average Cancer Risk By Distance From SR-99 Mixing Zone Edge

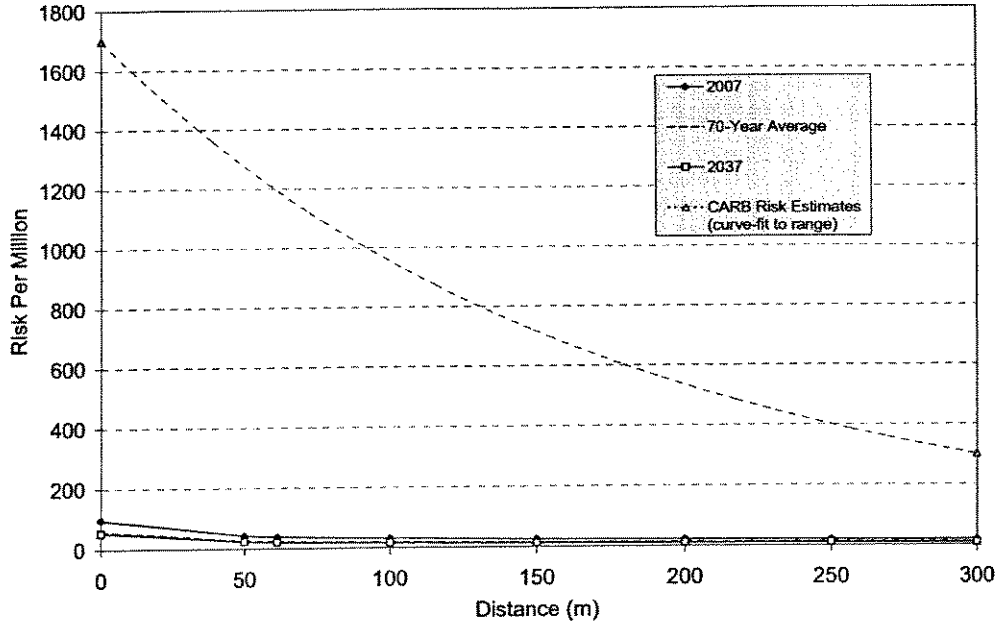


Figure 5
Average Cancer Risk By Distance From I-5/SR-99 Interchange Mixing Zone Edge

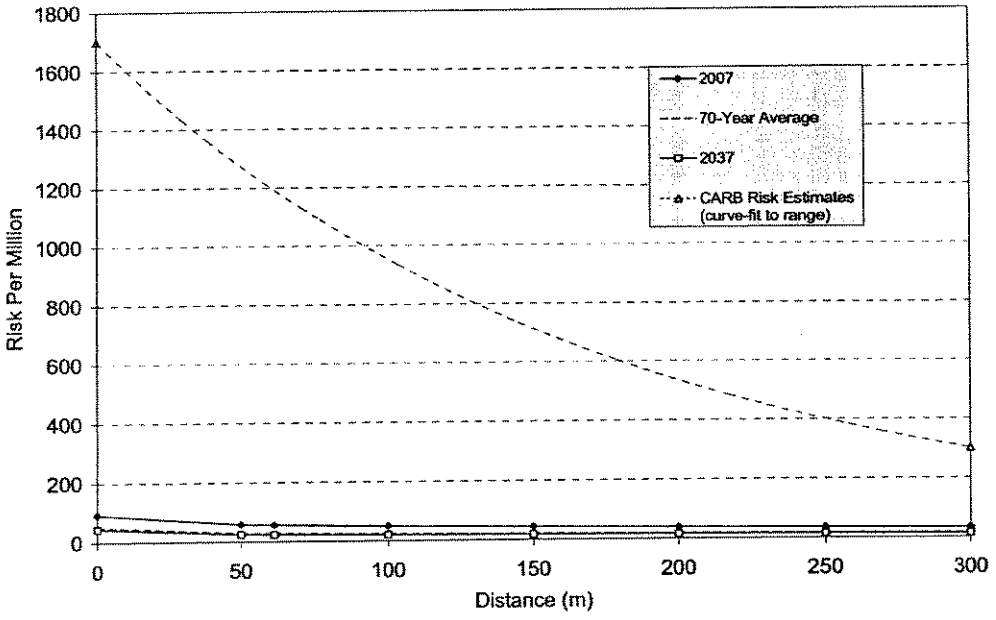


Table 3
Cancer Risk As % of 2000 Total Average Risk for the Sacramento Valley Air Basin

Meters from I-5 Mixing Zone Edge	% Of Basin Background Risk by Distance/Calendar Year		
	2007	2037	70-Yr Average
0	26.6%	9.6%	12.0%
50	13.2%	4.8%	6.0%
61.4*	12.2%*	4.4%*	5.5%*
100	9.8%	3.6%	4.5%
150	8.0%	2.9%	3.7%
200	7.0%	2.6%	3.2%
250	6.2%	2.3%	2.9%
300	5.6%	2.1%	2.6%
Meters from SR-99 Mixing Zone Edge	2007	2037	70-Yr Average
0	18.5%	10.3%	11.3%
50	8.2%	4.4%	4.9%
63.8*	7.4%*	3.9%*	4.4%*
100	6.0%	3.1%	3.5%
150	4.9%	2.5%	2.8%
200	4.3%	2.1%	2.4%
250	3.9%	1.9%	2.1%
300	3.6%	1.7%	1.9%
Meters from Interchange Mixing Zone Edge	2007	2037	70-Yr Average
0	17.7%	8.6%	9.8%
50	11.2%	4.6%	5.5%
59.3*	10.8%*	4.4%*	5.3%*
100	9.6%	3.9%	4.7%
150	8.4%	3.4%	4.1%
200	7.6%	3.0%	3.7%
250	6.9%	2.8%	3.4%
300	6.4%	2.6%	3.1%

* Location of property line for residences nearest to freeway segment

Conclusions and Recommendations

A site-specific analysis of the potential health risks associated with the impact of freeway emissions on the proposed Greenbriar Farms development indicates that risks are lower than those suggested in CARB's land use guidance document. This is the result of a number of factors, including vehicle traffic volumes, the relative orientation of the freeway vis-à-vis the proposed development, local meteorology, and the expected decline in vehicle emissions over time. Notwithstanding the fact that these impacts are substantially lower than those upon which CARB's siting recommendations are based, if additional mitigation measures are desired the following measures should be considered:

- Use of sound walls to enhance the dispersion of emissions from freeways; and
- Use of tiered tree-planting to enhance the dispersion of emissions from freeways.

These two measures are intended to enhance the dispersion of emissions, and hence reduce concentrations of pollutants at residences that are closest to the freeway. Unfortunately, there are no tools available at the present time to quantify the potential benefits of these measures.