Asbestos Exposure Assessment
and
Risk Evaluation Summary Report

for

South Bay Asbestos
Superfund Site

Alviso, California

August 25, 2010

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List of Acronyms

ABS	activity-based sampling
ATV	all terrain vehicle
ASTM	American Society for Testing Materials
CEFH	Children-specific Exposure Factors Handbook
CT	Central Tendency
ELCR	excess lifetime cancer risk
ED	exposure duration
EF	exposure frequency
EFH	Exposure Factors Handbook
EPA	United States Environmental Protection Agency
EPC	exposure point concentration
ERT	environmental response team
f/cc	fibers (of asbestos) per cubic centimeter (of air)
IUR	inhalation unit risk
ISO	International Organization for Standardization
PCME	phase contrast microscopy equivalent
RME	reasonable maximum exposure
REAC	Response, Engineering, and Analytical Contract
RAGS	Risk Assessment Guidance for Superfund
SBA	South Bay Asbestos Superfund Site
SOP	standard operating procedure
TWF	time weighting factor
y.o.	year(s) old

Executive Summary

This *Exposure Assessment and Risk Evaluation Summary Report* (Summary Report) serves to document an evaluation of potential risks from asbestos exposures performed by the United States Environmental Protection Agency (EPA) at the South Bay Asbestos (SBA) Superfund Site (Site) in the Alviso district of San Jose, California. This evaluation of asbestos risks was conducted as a follow-up to the recommendations contained in the SBA Second Five-Year Review (EPA, 2005). The original remedial action implemented at the Site relied on a one percent asbestos content in soil as the action level to identify soils requiring remediation. Subsequent information and experience on how low asbestos concentrations in soil translate into actual airborne exposures raised questions about whether the original remedial actions continued to be protective. EPA Region IX determined that additional sampling was necessary to address this issue. Consequently, activity-based air samples were taken at various locations throughout the Site. The goal of the additional sampling, exposure assessment, and risk evaluation was to determine if there was the potential for significant risk by exposure to asbestos in public areas of the community and to confirm that the existing Site remedy remains effective in mitigating potential asbestos exposures in the community. The results of this study show that the original remedy continues to be protective of health risks in the community.

Background

The SBA Site is located in the Alviso district of San Jose, California and encompasses the entire 550-acre community where over 2,100 people live (see Figure 1-1). The remedial objective for the SBA Site was to control the release of asbestos fibers into the air from asbestos-contaminated soils and other asbestos-containing material. The remedies selected for the Site included: (1) Removal of what was known as the "ring levee", which contained serpentine, an asbestos-containing rock; (2) Initial paving and eventual excavation and removal of asbestos-containing soil at four truck yards; and (3) Verifying the adequacy of final landfill covers and placing deed restrictions on three landfill areas where asbestos-cement pipe was buried. These remedies provide permanent solutions to meet the remediation objective.

Activity-Based Sampling and Exposure Assessment

Previous EPA studies across the country indicated that the best way to measure exposures to asbestos in air was to perform personal monitoring in the breathing zone during dust-generating activities. The asbestos content of the air samples provides a more representative method of measuring personal exposure to airborne asbestos fibers; this technique is called activity-based sampling (ABS). ABS protocols were used in Alviso to determine if typical activities in the community would expose residents to levels of asbestos that have been associated with a significant risk of developing cancer.

In August 2007, EPA performed activities in the community in order to simulate typical outdoor activities that have the potential to generate dust, including riding all terrain vehicles (ATVs) and bicycles and raking. The areas that were sampled using ABS methods were residential streets, the athletic field and four truck yards (see Figure 3-1). During this assessment, EPA personnel simulating these activities wore

personal air samplers to collect dust from the breathing zone. Stationary air samplers were also set up to collect nearby asbestos samples outside the area of activity. Soil samples were also collected and analyzed in order to determine the concentration of asbestos in representative community soils.

Based on the exposure data from the ABS and stationary sampling, exposure point concentrations (EPCs) were calculated for each of the following five Alviso exposure activities:

- Walking, jogging or riding in a stroller, adjacent to streets in the community.
- Recreational activities ("playing") at the athletic field.
- Bicycling on the streets in the community.
- Driving, or riding in, a motor vehicle on the streets in the community.
- "Quiescent activities" (e.g., eating, reading, watching TV, sleeping).

For the Alviso risk evaluation, a comprehensive exposure scenario was constructed which assumed continual exposure (24 hours per day) integrated across the five activities. The risk characterization considered specific age ranges for each of the exposure activities.

Alviso Risk Characterization

This risk evaluation presents quantitative estimates of excess cancer risk based on the defined exposure scenarios. The scenarios were designed to represent current and future exposures for residents of the Alviso community, focusing on typical outdoor, recreational and quiescent activities. Exposure frequency and duration assumptions were chosen to represent a reasonable maximum exposure (RME) scenario – one that is more likely to overestimate rather than underestimate actual exposures for the majority of Alviso residents. In this respect, the RME 30-Year scenario is expected to result in a conservative, health-protective estimate of exposure and risk. On balance, actual exposures and risks are expected to be lower for most Alviso residents.

All of the Alviso exposure scenarios generated risk estimates that were within a fairly narrow range – risk estimates differed less than 6-fold from one exposure scenario to another. The calculated risks from all of the exposure scenarios, from the least conservative (Central Tendency 9-Year) to most conservative (RME 70-Year), were all well within the Superfund acceptable risk range (target risk range is one in ten-thousand to one in one-million).

Conclusions

Conclusion 1: Based on the exposure assessment and the risk characterization, the estimates of asbestos exposure are below risk-based levels of concern. No further evaluation or remedial action is recommended.

Asbestos exposures from typical activities in the Alviso community pose risks that are low and within the target risk range (i.e., 1.0E-4 (one in ten-thousand) to 1.0E-6 (one in one-million)] for Superfund remedial actions. Exposure scenarios ranging from least conservative to most conservative generated excess lifetime cancer risk estimates ranging 3.4E-6 to 1.9E-5 (3.4 to 19 in one-million).

Conclusion 2: The original remedy for the SBA Site continues to be protective.

Since risks from asbestos exposure in the Alviso community are low and within the Superfund target risk range, the original remedy continues to be protective.

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Section 1
Introduction

This *Exposure Assessment and Risk Evaluation Summary Report* (Summary Report) serves to document an evaluation of potential risks from asbestos exposures performed by the U.S. Environmental Protection Agency (EPA) at the South Bay Asbestos Superfund Site (SBA) in the Alviso district of San Jose, California (see Figure 1-1). This assessment of asbestos risks was conducted as a follow-up to the recommendations contained in the Second Five-Year Review (EPA, 2005) for the SBA. Based on this review, EPA found that cleanup actions at the SBA site are currently protective of human health and the environment because the major sources of asbestos exposure are being controlled (via landfill covers) or have been removed (via truck yards and ring levee). However, because of the new understanding of the potential for the release of asbestos fibers from soil into the air, EPA deferred the final protectiveness statement for this site until the asbestos exposure data could be re-evaluated.

A significant issue raised during the Five Year Review was "…whether or not the one percent asbestos in soil screening level [used to delineate soil areas for remediation] is sufficiently health protective at this site…" (EPA, 2005). As noted in the Second Five-Year Review Report, "A new understanding of how low concentrations of asbestos in soil translate into actual airborne exposures raises the issue of whether the soil screening level used to determine the need for cleanup activities at the site is still protective. EPA plans to re-evaluate the soil asbestos data and re-sample, if necessary." After a review of the existing data on concentrations of asbestos in Alviso soils, EPA Region 9 determined that additional sampling was necessary to address this issue.

Previous EPA studies across the country indicated that the best way to measure exposures to asbestos in air was to perform personal monitoring in the breathing zone during dust-generating activities. The asbestos content of the air samples provides a more representative method of measuring personal exposure to airborne asbestos fibers; this technique is call activity-based sampling (ABS). Based on this experience from multiple sites, ABS was selected as the preferred method at the SBA Site to determine if there is any potential for significant exposure to asbestos and risk to human health during normal dust-generating activities in public areas of the community. The goal of the proposed testing was to confirm that the existing Site remedy remains effective in mitigating potential asbestos exposures in the community. This *Exposure Assessment and Risk Evaluation Summary Report* documents the findings and conclusions from that ABS study.

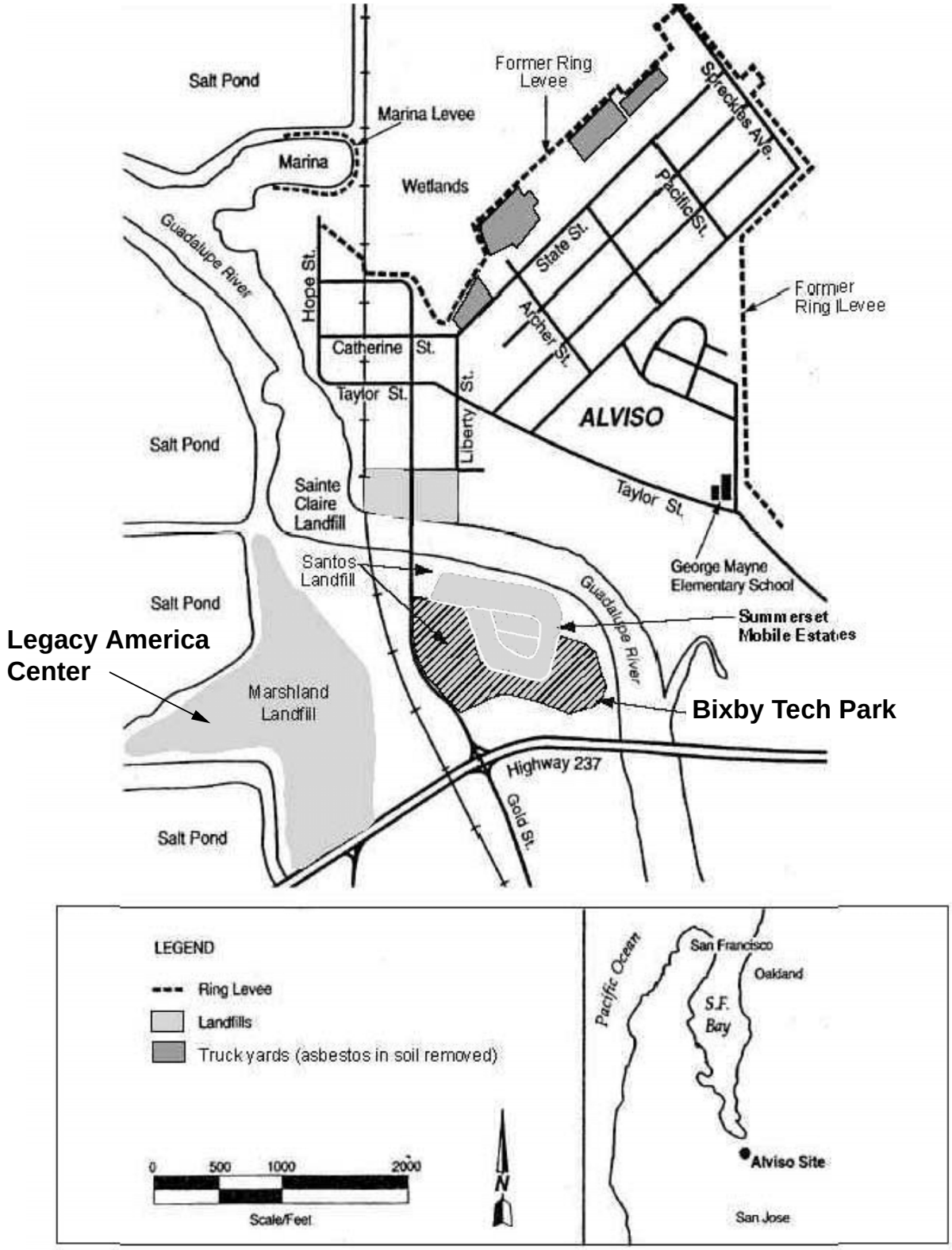


Figure 1-1
Site Location Map
South Bay Asbestos
Asbestos Exposure Assessment Report
Alviso, California

CDM

Section 2
Background

2.1 Site Overview

The SBA is located in the Alviso district of San Jose, California, at the southern edge of San Francisco Bay. The site encompasses the entire 550-acre community of Alviso where over 2,100 people live. The Site was listed on the National Priorities List in October 1984 following discovery of asbestos-containing materials distributed throughout community.

The remedial objective for the SBA Site is to control the release of asbestos fibers into the air from asbestos-contaminated soils and other asbestos-containing material. There were two remedies selected for the Site. The first included the removal of what was known as the "ring levee", constructed by the City of San Jose in 1983 after Alviso flooded. The material used to construct the levee contained serpentine, an asbestos-containing rock. The removal of the asbestos-containing flood control ring levee was completed in 1994. The second remedy addressed the overall Site and included: 1) the initial paving and eventual excavation and removal of asbestos-containing soil at four truck yards; and 2) verifying the adequacy of covers and placing deed restrictions on three landfill areas where asbestos-cement pipe was buried. These remedies provide permanent solutions to meet the remediation objective.

Previous SBA Site investigations for asbestos have been conducted since 1983 and included extensive soil and stationary air sampling. As previously noted, the Site cleanup action level was based on one percent or less asbestos in soil. This assumes that dust-generating activities at soils below this level would not release significant amounts of asbestos into the air. Recent information has shown, however, that soil-based sampling can underestimate the exposure to individuals engaged in activities that disturb asbestos-containing soil materials. Extensive stationary air monitoring was also conducted for the *Remedial Investigation Report* (EPA, 1988) and *Ambient Airborne Asbestos Levels in Alviso* (EPA, 1995). Recent experience has also shown that stationary area samplers underestimate the exposure to an individual engaged in activities that disturb the source material. EPA therefore conducted the additional ABS to address these uncertainties in previous asbestos sampling conducted at the SBA.

2.2 Basis for Taking Action

At the time of remedy selection for the SBA, EPA's standard-of-practice assumed that dust-generating activities on soils containing less than one percent asbestos would not create airborne asbestos exposures of potential health concern (EPA, 2005). A new understanding of how low concentrations of asbestos in soil translates into actual airborne exposures raised the issue of whether the soil screening level used to determine the need for cleanup activities at the Site was still protective (EPA, 2005). The basis for taking action at SBA was to collect data to be used in a risk evaluation to

determine whether community members have experienced significant exposure to airborne asbestos during dust-generating activities (EPA, 2007b).

The exposure assessment and risk evaluation summarized in this document were carried out by EPA Region 9 in support of the Second Five-Year Review (EPA, 2005), which recommended additional sampling and analysis at the SBA using ABS techniques. The goal was to use current asbestos sampling and analytical techniques to assess asbestos exposures and associated excess lifetime cancer risks arising from typical outdoor, recreational and quiescent activities in Alviso. This evaluation was conducted consistent with EPA policy and guidance, including the *Risk Assessment Guidance for Superfund* ([RAGS] EPA, 1989) and the *Framework for Investigating Asbestos Contamination at Superfund Sites* (EPA, 2008a).

Section 3
Study Design and Methods

3.1 Overview

In August 2007, an ABS study was performed to address the potential for asbestos exposures at the SBA. The goal of this study was to determine whether residents of Alviso are at significant risk from asbestos exposures while engaging in typical activities in the community

The ABS program consisted of collecting personal breathing zone air samples for individuals mimicking typical outdoor and recreational activities. All-terrain vehicles (ATV) riding was used as a surrogate for driving or riding in a car, truck or motorcycle and for riding a bicycle on the streets in town. Bicycle riding and raking were used as surrogates for soil-disturbing recreational activities at an athletic field. Roadside ambient air sampling was used as a surrogate for exposure to road dust while walking, or being pushed in a stroller, next to streets in town.

Personal exposure data were compiled for the various individual and recreational activities (summarized in Section 4). The risk characterization involved use of the exposure data to calculate excess lifetime cancer risks for exposure scenarios designed to reflect a spectrum of activities an individual would participate in during a typical lifetime residing in Alviso (summarized in Sections 5 and 6).

In addition to ABS air sample collection, soil samples were collected at and nearby ABS locations for determination of asbestos, particle size, and moisture analysis (Lockheed Martin, 2009). Data on the weather conditions were collected to document conditions at SBA during the ABS.

3.1.1 Activity-Based Sampling/Exposure Assessment

In August 2007, EPA's Environmental Response Team (ERT) and its Response, Engineering, and Analytical Contract (REAC) conducted ABS at the SBA. Daily asbestos exposures were developed based on measured asbestos levels in air associated with various typical activities for Alviso residents. The objective of this work was to evaluate whether community members have experienced significant exposure to airborne asbestos during dust-generating activities (EPA, 2007b). The tasks required to achieve this objective were to:

- Collect personal air monitoring samples during simulated activities including riding ATVs on the streets of Alviso, bicycle riding and raking on grassy and natural dirt areas of the athletic field.
- Collect roadside air samples to simulate walking on the sidewalk during ATV riding.
- Collect stationary air monitoring samples upwind and downwind of each activity location.

- Analyze filters by Transmission Electron Microscopy.
- Collect soil moisture and meteorological data during the ABS activities.

3.1.2 Risk Characterization

The objective of the risk characterization was to assess asbestos exposures and associated excess lifetime cancer risks arising from typical outdoor, recreational and quiescent activities in Alviso. Estimates were developed of the excess lifetime cancer risk associated with the exposures measured during the exposure assessment activities.

3.2 Implementation of Activity-Based Sampling

Provided below is a description of the elements of the ABS program, including field team, health and safety considerations, ABS scenarios, soil sampling activities, laboratory analytical methods, and quality assurance/quality control.

3.2.1 Field Team

The sampling team and individuals performing activities were from the EPA's ERT and REAC personnel.

3.2.2 Health and Safety

ABS sampling was performed by adult EPA contractors, all of whom had hazardous materials training and wore personal protective equipment.

3.2.3 Activity-Based Sampling Scenarios

For all ABS events, asbestos was collected onto filters in asbestos sampling cassettes. These cassettes were connected to a portable pump which drew air from the breathing zone of the person performing the surrogate activity. ABS sampling was performed over a 5-day period during the dry season (August 2007). The ABS locations are presented in Figure 3-1 and ABS photographs are shown in Appendix B.

Personal breathing zone air samples were collected from individuals mimicking typical outdoor and recreational activities in Alviso. These activities included:

- Riding ATVs on streets in four areas of the Alviso community: State Street, the streets around the intersection of Elizabeth and Hope, streets in an older residential area, and streets in a newer residential area. ATV riding was performed as a surrogate for driving, or riding in, a motor vehicle and bicycling.

- Roadside exposures were determined using stationary samplers during ATV riding to measure asbestos exposures for someone on the sidewalk or by the side of the street while traffic was moving.

- Athletic field exposure was determined while conducting two activities at the athletic field: bicycle riding and raking. Both activities were performed on grassy and natural dirt areas. Raking was performed as a generic soil-disturbing activity that was expected to produce maximal or near-maximal inhalation exposures to fugitive dust. Stationary samplers were located roughly up-wind and down-wind during the raking activity. In addition, bicycle riding was performed on the playground area located behind the George Mayne Elementary School.

- Sampling of four truck yard areas (i.e. Archer St. Truck, Catherine St., Wemco and Mervyn Salt Landscape) was conducted using two activities: ATV riding and raking.

- Sampling of ambient air was performed at the 4 reference stations for approximately 8 hours/day during all five ABS days. The four reference stations included the Post Office, Marina, Wastewater Treatment Plant, and Mallard Slough Trail.

The reference ambient air samples were intended to provide information on background asbestos concentrations in community air and as a measure of personal exposures during quiescent, non-soil disturbing activities. Reference samples were collected by stationary monitors and the sampling was performed simultaneously with ABS although at sites chosen so as to not be impacted by ABS events.

More detailed information on ABS sampling is contained in the environmental response team standard operating procedure (SOP) for ABS (EPA, 2007a).

3.2.4 Soil Sampling Activities

Composite and discrete soil samples were collected at and nearby ABS locations for determination of asbestos, particle size, and moisture analysis. Soil samples were collected from a depth of up to two inches below ground surface. A total of 87 soil samples were collected from 55 locations within the SBA. The soil sample locations are presented in Figure 3-2. Soil collection methods are further described in the *Asbestos Exposure Assessment using ABS* (Lockheed Martin, 2009).

3.2.5 Analytical Methods

Asbestos collection filters from both ABS breathing zone and stationary monitors were analyzed using transmission electron microscopy methodology based on the International Organization for Standardization (ISO) Method 10312 (ISO, 1995). Analysis of the filters was performed according to Annex E of ISO 10312 for counting a size classification known as Phase Contrast Microscopy Equivalent (PCME) fibers with the following specifications: (1) width 0.25 to 3 microns, (2) aspect ratio 3:1 or greater, and (3) length greater than 5 microns.

Soil samples were analyzed for:

- Asbestos in soil using California Air Resources Board Method 435 for PLM.
- Particle size using American Society for Testing Materials Method (ASTM) D422-63.
- Soil moisture content using ASTM Method D2216-05.

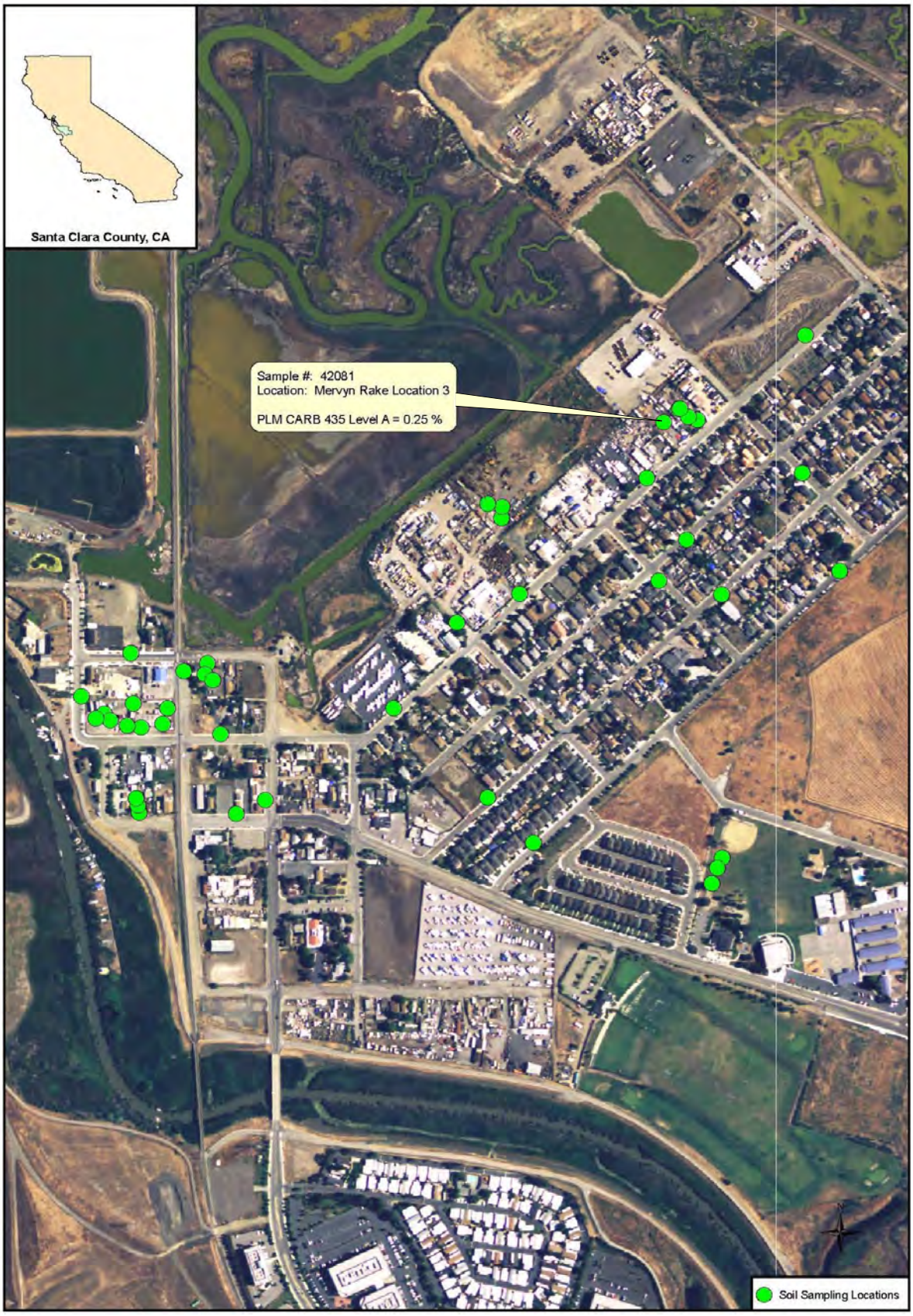
3.2.6 Quality Assurance and Quality Control

Quality Assurance and Quality Control (QA/QC) procedures were followed during asbestos field sampling and laboratory analyses. A Field Sampling and Quality Assurance Project Plan (Lockheed Martin, 2007) was prepared and implemented during the ABS at the Site. This included data quality objectives, sampling plan design, and analytical methods. For example, during the ABS activities, a high and low volume sample area was collected in order to increase the likelihood that at least one sample could be analyzed by the direct preparation method (ISO 10312). The high and low volume samples were co-located and collected over the same sampling period in order to obtain estimates of the same exposure scenario (Lockheed Martin, 2009). When the high volume sample was overloaded with extraneous particulate, the corresponding low volume sample was analyzed and the high volume sample was archived. This approach facilitated comparability between samples (Lockheed Martin, 2009). Regarding laboratory analyses, the SOPs for asbestos were followed and data validation reports were prepared for air and soil sample results (Lockheed Martin, 2009).

0 0.25 0.5 Kilometers
Approximate Scale

CDM

Figure 3-1
ABS Air Sampling Locations
Asbestos Exposure Assessment Report
Alviso, California



0 50 100 200 300 400 Meters

Approximate Scale

CDM

Figure 3-2
ABS Soil Sampling Locations
Asbestos Exposure Assessment Report
Alviso, California

Section 4
ABS Sampling Results

This section summarizes the results of the activity-sampling and the soil sampling that occurred in 2007. A full presentation of all results can be found in *Asbestos Exposure Assessment using ABS* (Lockheed Martin, 2009).

4.1 Air

A total of 83 air samples were analyzed for asbestos. The type of asbestos detected was predominantly chrysotile fibers. EPA analyzed for the presence of what are known as PCME fibers in the exposure assessment and risk evaluation. PCME fibers are the type of fibers found in and the basis for most health studies related to cancers in humans caused by asbestos exposure. Tables 4-1 through 4-3 present data on asbestos concentrations measured during the various outdoor and recreational activities during the ABS sampling. Exposure data are expressed as PCME fiber concentrations per cubic centimeter of air (f/cc). Mean exposure concentrations were calculated from breathing zone or stationary monitors (with non-detect = zero f/cc).

4.1.1 ATV Riding

Asbestos PCME fibers were detected in 4 of the 15 ABS samples collected during ATV riding. The data in Table 4-1 represent the mean fiber concentrations for 3 to 5 ATV riders in each study area.

Table 4-1. Personal Exposure Data - ATV Riding on Alviso Streets

Study Area	PCME (f/cc)
State Street Personal Exposure Mean (n=5)	0.00020
Elizabeth and Hope Personal Exposure Mean (n=3)	0.00129
Older Residential Personal Exposure Mean (n=4)	0.00000
Newer Residential Personal Exposure Mean (n=3)	0.00033

4.1.2 Roadside Exposures

The data in Table 4-2 represent the mean fiber concentrations for 3 to 8 roadside samplers in each study area.

Table 4-2. Roadside Exposure Data from ATV Riding on Alviso Streets

Study Area	PCME (f/cc)
State Street Roadside Exposure Mean (n=4)	0.00124
Elizabeth and Hope Roadside Exposure Mean (n=4)	0.00000
Older Residential Roadside Exposure Mean (n=8)	0.00000
Newer Residential Roadside Exposure Mean (n=3)	0.00000

4.1.3 Athletic Field Exposures

Table 4-3 presents the data for personal asbestos exposure levels and the up-wind and down-wind raking sampling. The average concentration of all of these measurements was used to estimate exposure concentrations during recreational activities at the athletic field.

Table 4-3. Exposure Data from Recreational Activities at the Athletic Field

Sample Type	**PCME** (f/cc)
Athletic Field Rake - Upwind	0.00099
Athletic Field Rake - Downwind	0.00000
Athletic Field Rake - Personal	0.00000
Athletic Field Bike – Personal (n=3)	0.00032
Athletic Field Activities Mean	**0.00033**

4.1.4 Ambient Exposures

Airborne PCME asbestos fibers were detected only 3 times and at only 2 of the 4 reference station locations. All 3 detections were at relatively low concentrations, ranging from 0.00016 to 0.00033 f/cc. For purposes of the exposure assessment and risk evaluation, the overall mean concentration of all of the reference station results was 0.00003 f/cc. This was assumed to represent the long-term ambient air asbestos concentration and exposure level during quiescent activities.

4.2 Soil

A total of 55 soil samples were analyzed for asbestos. All but one were non-detect for asbestos in soil at the analytical sensitivity of 0.25% (Lockheed Martin, 2009). Figure 3-2 illustrates all soil sampling locations and indicates the location of the single positive sample.

The data for the soil particle size and soil moisture content are further described in the *Asbestos Exposure Assessment using ABS* (Lockheed Martin, 2009).

Section 5
Exposure Assessment

The Framework specifies that estimates of asbestos risk depend on the specific age range over which each exposure activity occurs. This is because the asbestos inhalation unit risk varies as a function of time since onset for any activity creating an exposure. In a community where there are many activities creating potential exposures, an exposure scenario must be constructed specifying the age range (in addition to frequency and duration) for each activity. For the Alviso risk evaluation, a comprehensive exposure scenario was constructed which assumed continual exposure (24 hours/day) integrated across five activities:

- Walking, jogging or riding in a stroller, adjacent to streets in the community.
- Recreational activities ("playing") at the athletic field.
- Bicycling on the streets in the community.
- Driving, or riding in, a motor vehicle on the streets in the community.
- "Quiescent activities" (e.g., eating, reading, watching TV, sleeping).

This integrated exposure scenario used a combination of average and high end asbestos concentrations and exposure frequency and duration assumptions in order to represent a reasonable maximum exposure (RME).

5.1 Exposure Point Concentrations

Exposure data from the ABS and stationary sampling were used to calculate exposure point concentrations (EPCs) for each of the 5 Alviso exposure activities as follows.

5.1.1 Walking/Jogging/Stroller Riding

Asbestos exposure levels while walking, jogging or riding in a stroller (early-life exposures) were estimated using the data collected from roadside monitors during the ATV activities (Table 4-2). A community-wide roadside EPC was calculated by pro-rating the roadside exposure data according to the total length of roadway in each of the four study areas. Thus, an individual's exposure, averaged over the entire community, is assumed to be proportional to the length of roadway in each study area. State Street represented 15% of the total roadway length; the Elizabeth and Hope Streets area, 19%; the older residential area, 50% and the newer residential area, 15%. The community-wide roadside EPC calculation is detailed in Table 5-1.

Table 5-1. Calculation of a Community-Wide Roadside EPC Assuming the Relative Contribution of Each Study Area is Proportional to Its Total Roadway Length

Study Area	Study Area EPC	% EPC Contribution	EPC Contribution
State Street ATV - Roadside	0.00124	15%	0.00019
Elizabeth/Hope ATV - Roadside	0.00000	19%	0.00000
Older Res ATV - Roadside	0.00000	50%	0.00000
Newer Res ATV - Roadside	0.00000	15%	0.00000
Mean Walking/Jogging/Stroller EPC for Alviso:			**0.00005**

5.1.2 Modification for Early-Life Exposures

To ensure that a conservative, health-protective approach was incorporated into the RME for early-life risks, the EPC for walking/riding in a stroller during ages 0 to 6 years old was assumed to be the mean roadside asbestos concentration measured along State Street. This was the highest mean concentration for any of the study areas (0.00124 f/cc). This approach was taken because early-life exposures make a disproportionately large contribution to overall risks from asbestos.

The community-wide value (0.00005 f/cc) was the EPC for all other age ranges.

5.1.3 Playing at the Athletic Field

The asbestos EPC used in the risk evaluation for play and other recreational activities at the athletic field was the mean value from the bicycling and raking activities detailed in Table 4-3 (0.00033 f/cc).

5.1.4 Bicycling in Town

The bicycling EPC was derived from personal exposure data during the ATV riding events. Since an ATV weighs more and generates more force, it is assumed the EPC based on ATV riding is a conservative, health-protective assumption likely to overestimate actual bicycling exposures. Similar to the situation for the walking/ jogging /stroller activity, a community-wide bicycling EPC was pro-rated based on the proportional roadway length in each area (Table 5-2 presents the details).

Table 5-2. Calculation of a Community-Wide Bicycling EPC Assuming the Relative Contribution of Each Study Area is Proportional to its Total Roadway Length

Study Area	Study Area EPC	% EPC Contribution	EPC Contribution
State Street ATV - Personal	0.000198	15%	0.00003
Elizabeth/Hope ATV - Personal	0.001293	19%	0.00025
Older Res ATV - Personal	0.000000	50%	0.00000
Newer Res ATV - Personal	0.000326	15%	0.00005
Mean Bicycling EPC for Alviso:			**0.00008**

5.1.5 Driving/Riding in a Motor Vehicle

The community-wide EPC for asbestos exposures while driving or riding in a motor vehicle was also derived from the personal exposure data generated during the ATV-riding events. Since an ATV is more open to air, it is assumed that the ATV-related EPC is a conservative, health-protective assumption that is likely to overestimate actual exposures while driving or riding in a motor vehicle.

As with the bicycling and walking / jogging /stroller exposures, calculations of the community-wide EPC for motor vehicle exposures were also pro-rated using the proportional roadway length sampled in each area (Table 5-3).

Table 5-3. Calculation of a Community-Wide Motor Vehicle EPC Assuming the Relative Contribution of Each Study Area is Proportional to its Total Roadway Length

Study Area	Study Area EPC	% EPC Contribution	EPC Contribution
State Street ATV - Personal	0.000198	15%	0.00003
Elizabeth/Hope ATV - Personal	0.001293	19%	0.00025
Older Res ATV - Personal	0.000000	50%	0.00000
Newer Res ATV - Personal	0.000326	15%	0.00005
Mean Motor Vehicle EPC for Alviso:			**0.00008**

Since ATV-riding personal exposure data were used to develop both the bicycling and motor vehicle community-wide EPCs, the EPCs are the same for both scenarios.

5.1.6 Quiescent Activities

Quiescent activities - such as eating, reading, watching TV and sleeping - are not expected to generate asbestos exposures significantly greater than those provided by background ambient air. Therefore, the EPC for quiescent activities was assumed to be the mean of all of the reference station data (0.00003 f/cc), which were taken to represent a general background level of exposure to asbestos in ambient air in Alviso.

5.2 Exposure Frequency and Duration Assumptions

Exposure duration (ED) and exposure frequency (EF) assumptions for each exposure activity were taken from the Exposure Factors Handbook ([EFH] EPA, 1997) for adults or the Child-Specific Exposure Factors Handbook ([CEFH] EPA, 2008b). The primary sources were the "Activity Factors" chapters in each (Chapter 16 in the CEFH and Chapter 15 in the EFH). An RME scenario was developed, generally based on 90th percentile exposure activity pattern data.

In Superfund risk assessment, an RME scenario is typically based on 95th percentile exposure frequency and duration values; 90th percentile values were chosen in this risk evaluation for two reasons: (1) The CEFH notes that "…95th percentile [child activity frequency and duration] values may be misleading for estimating chronic exposures [because they are based on short-term survey data]". (2) Using only 95th percentile values produced unrealistic exposure

scenarios (e.g., 16 to 25 y.o. [year old] people who are recreating for almost 8 h/d, 365 d/yr); use of 90th percentile values produced exposure scenarios that were still reasonably high end, but were also more believable.

Many CEFH tables contain data for both Whole Populations (includes data from people who did not engage in the specific activity) and Doers Only (which includes only data from people who perform the activity). Because early-life exposures convey a disproportionately higher risk, child exposure data from the CEFH that focused on Doers Only was used preferentially. Because adult age ranges in the EFH tables did not match exactly the age ranges in the risk evaluation, exposure frequency and duration assumptions for ages 16 to 70 y.o. typically represented values for ages 18 to 64 y.o. in the EFH tables. These RME frequency and duration assumptions represent fairly vigorous activity patterns, thus they are likely to overestimate actual exposures and risks for the typical resident.

Most of the activity data in the CEFH and EFH tables are normalized on a "per day" basis, so only exposure duration values are presented in minutes per day (min/day); exposure frequency has effectively been factored into the exposure duration variable.

5.2.1 Walking/Jogging/Stroller Riding

Exposure duration data on walking, jogging or riding in a stroller (for early-life exposures) were obtained from CEFH Table 16-16 and EFH Table 15-126 and are summarized in Table 5-4.

Table 5-4. Exposure Duration Values for Walking, Jogging, or Riding in a Stroller

	RME - 90th percentile	
Age Range	(min/day)	(hours/day)
Birth to 1 y.o.	9.2	0.15
1 to 2 y.o.	2	0.03
2 to 3 y.o.	51	0.85
3 to 6 y.o.	56	0.93
6 to 11 y.o.	40	0.67
11 to 16 y.o.	60	1.00
16 to 21 y.o.	70	1.17
21 to 25 y.o.	70	1.17
25 to 50 y.o.	70	1.17
50 to 70 y.o.	70	1.17

5.2.2 Playing at the Athletic Field

Data on exposure frequency and duration for children playing at the athletic field was obtained from Table 16-13, "Time Spent in Selected Outdoor Locations", of the CEFH; data for adults came from Table 15-108, "Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds and Playgrounds" of the EFH. Table 5-5 summarizes the RME exposure duration values used in the risk evaluation.

Table 5-5. Exposure Duration Values for Athletic Field Play

	RME - 90th percentile	
Age Range	(min/day)	(hours/day)
Birth to 1 y.o.	0	0.00
1 to 2 y.o.	0	0.00
2 to 3 y.o.	0	0.00
3 to 6 y.o.	150	2.50
6 to 11 y.o.	169	2.82
11 to 16 y.o.	149	2.48
16 to 21 y.o.	240	4.00
21 to 25 y.o.	240	4.00
25 to 50 y.o.	240	4.00
50 to 70 y.o.	240	4.00

5.2.3 Bicyling in Town

Activity pattern data for biking were found in Table 15-127, "Statistics for 24-Hour Cumulative Number of Minutes Spent Traveling on a Bicycle, Skateboard or Rollerskate" in the EFH. These data were for "doers" only and the age ranges did not exactly match the exposure scenario. RME exposure duration assumptions for bicycling were taken from the 90th percentile data and age ranges were matched as closely as possible. The values used in the risk evaluation are presented in Table 5-6.

Table 5-6. Exposure Duration Values for Bicycling

	RME - 90th percentile	
Age Range	(min/day)	(hours/day)
Birth to 1 y.o.	20	0.33
1 to 2 y.o.	30	0.50
2 to 3 y.o.	30	0.50
3 to 6 y.o.	30	0.50
6 to 11 y.o.	151	2.52
11 to 16 y.o.	65	1.08
16 to 21 y.o.	105	1.75
21 to 25 y.o.	105	1.75
25 to 50 y.o.	105	1.75
50 to 70 y.o.	105	1.75

5.2.4 Driving/Riding in Town

Exposure duration assumptions for children riding in a motor vehicle in town were taken from CEFH Table 16-15, "Time Spent in All Vehicles" and for adults (16 years old and older), driving or riding in a motor vehicle, exposure duration data came from EFH Table 15-133, "Statistics for 24-Hour Cumulative Minutes Spent Traveling Inside a Vehicle". Mean exposure duration values were used in the RME risk calculations; the 90th percentile values were not used because it was felt that those longer durations (113 to 180 min/day) would only be applicable to vehicle trips

outside of town. The exposure duration values used for driving and riding in a vehicle in town are presented in Table 5-7.

Table 5-7. Exposure Duration Values for Driving and Riding in a Motor Vehicle

	RME – Mean	
Age Range	(min/day)	(hours/day)
Birth to 1 y.o.	39	0.65
1 to 2 y.o.	44	0.73
2 to 3 y.o.	50	0.83
3 to 6 y.o.	50	0.83
6 to 11 y.o.	57	0.95
11 to 16 y.o.	67	1.12
16 to 21 y.o.	104	1.73
21 to 25 y.o.	104	1.73
25 to 50 y.o.	104	1.73
50 to 70 y.o.	104	1.73

5.3 Time Weighting Factors

Consistent with the Framework, EF and ED assumptions were used to calculate a time weighting factor (TWF) for each activity in the risk evaluation. TWFs were calculated according to the equation:

$$\text{TWF} = \frac{\text{ED hours/day}}{\text{24 hours/day}} \times \frac{\text{EF days/year}}{\text{365 days/year}}$$

Since all of the exposure duration data are normalized to hours/day for a 365-day year, the EF variable is set to 365 days/year for all of the TWFs. Years (per lifetime) over which each activity occurs are not included in the TWF calculation because this factor is used to select the appropriate unit risk value reflecting the each age range during each exposure activity.

TWFs used in the risk evaluation are presented for each activity and age range in the risk calculation tables in Section 6.

Section 6
Risk Characterization and Evaluations

This section discusses the evaluations performed to characterize the potential risk to the community of exposure to asbestos.

6.1 Asbestos Risk Calculation Equations

Cancer risk from asbestos is a function of exposure concentration, frequency and duration of exposure, and age range during which exposure occurs. Section 5.0 of the Framework presents the equation for estimating the excess lifetime cancer risk due to inhalation of asbestos fibers as a consequence of a specific exposure activity:

$$ELCR = EPC \times TWF \times IUR$$

where:

ELCR	=	excess lifetime cancer risk (unit less),
EPC	=	exposure point concentration, the PCME fiber concentration (f/cc),
TWF	=	time weighting factor (unit less),
IUR	=	inhalation unit risk $(f/cc)^{-1}$, a measure of the carcinogenic potency based on the age range during which exposure occurs

Table E-4 of the Framework presents IUR values assigned to various different age ranges and Section 5.4, "Selection of Less-than-Lifetime IURs" details how to identify the appropriate IUR value for a specific less-than-lifetime exposure activity.

As discussed in Section 5.5 of the Framework, risks can be integrated across many different exposures when there are multiple activities capable of producing asbestos fiber exposures. The risk from each individual activity is estimated using the above ELCR equation; risks are then summed to generate an overall estimate of ELCR from all of the exposures:

$$ELCR_C = \sum EPC_i \times TWF_i \times IUR_{LTLi}$$

where:

$ELCR_C$	=	cumulative excess lifetime cancer risk (unitless) from all exposures,
EPC_i	=	exposure point concentration for each activity
TWF_i	=	time weighting factor (unitless), for each activity, and
IUR_{LTLi}	=	less-than-lifetime inhalation unit risk $(f/cc)^{-1}$ for each activity

6.2 Alviso Risk Calculations

Risks for Alviso residents can be calculated for an RME exposure scenario using the ELCR equation with the EPC data presented in Tables 4-3 and 5-1 to 5-3; the exposure frequency assumptions presented Tables 5-4 to 5-7 and IURs from Table E-4 of the Framework.

Example – Risks for 6 to 11 y.o.: This ELCR calculation is illustrated for the 6 to 11 y.o. age range. There are five exposure activities included in the risk calculations during these years: walking in town, playing at the athletic field, biking in town, riding in a motor vehicle in town and quiescent activities.

The EPCs for each activity are:

- Walking in town: 0.00005 f/cc (integrated mean, Table 5-1).
- Playing at the athletic field: 0.00033 f/cc (mean, Table 4-3).
- Bicycling in town: 0.00008 f/cc (integrated mean, Table 5-2).
- Riding in a motor vehicle: 0.00008 f/cc (integrated mean, Table 5-3).
- Quiescent activities: 0.00003 f/cc (mean, reference ambient monitors)

The TWFs for each activity are:

- Walking in town: 0.67 hr/day (Table 5-4) x 365 days/yr = 0.028 TWF
- Playing, athletic field: 2.82 hr/day (Table 5-5) x 365 days/yr = 0.118 TWF
- Bicycling in town: 2.52 hr/day (Table 5-6) x 365 days/yr = 0.105 TWF
- Riding, motor vehicle: 0.95 hr/day (Table 5-7) x 365 days/yr = 0.040 TWF
- Quiescent activities: remainder of the day = 0.710 TWF

The IUR for asbestos fiber exposures during the 6 to 11 y.o. age range is found in Table E-4 of the Framework as the IUR for a 5-year exposure starting at age 6 y.o. This IUR value is 3.7E-2 $(f/cc)^{-1}$, which can also be expressed as 0.037 $(f/cc)^{-1}$.

Substituting these EPC, TWF, and IUR values into the ELCR equation above yields the following table (Table 6-1) of activity-specific ELCRs.

Table 6-1. Example Risk Calculations for Activities During Ages 6 to 11 y.o.

Activity	EPC (f/cc)	TWF	IUR $(f/cc)^{-1}$	ELCR *
Walking in Town	0.00005	0.028	3.7E-2	4.8E-8
Playing at Athletic Field	0.00033	0.118	3.7E-2	1.4E-6
Biking in Town	0.00008	0.105	3.7E-2	3.2E-7
Driving/Riding in Town	0.00008	0.040	3.7E-2	1.2E-7
Quiescent activities at home and in town	0.00003	0.710	3.7E-2	7.9E-7
Total ELCR summed over all age 6 to 11 y.o. activities:				**2.7E-6**

* ELCR = EPC x TWF x IUR

6.2.1 Reasonable Maximum Exposure 30-Year Risk Evaluation

To complete the risk estimation, the process illustrated above is repeated for all of the other age ranges in the RME scenario. The risk estimates for each age range are then summed to generate an ELCR estimate for the entire 30-year exposure period.

The high end nature of this RME scenario can be appreciated by considering some of the assumptions about time spent in outdoor recreational activities. The scenario assumes that children between ages 3 and 11 y.o. spend 3.75 hours to over 5 hours recreating outside (playing at the athletic field and bicycling) every day. Similarly, adolescents and young adults (ages 16 to 27 y.o.) are assumed to spend 5.75 hours at these activities every day. It is likely that most residents spend significantly less time engaged in these activities. This is especially significant for actual risks because the EPC for playing at the athletic field is the highest of any of the activities in the evaluation. Playing at the athletic field therefore contributes the most, on a minute-by-minute basis, to the overall risk estimates. Any residents who engage in less daily activity there will experience proportionately less risk.

Another RME assumption is noteworthy. This scenario assumes continuous exposure in the community 24 hours/day, 365 days/year for 30 years. Anyone spending less time (i.e., fewer hours/day, days/year and total years) in the community will be experience proportionately less exposure and hence less risk.

These features of the RME 30-Year scenario make it more likely to overestimate, rather that underestimate, actual risks experienced by most community residents.

Table 6-2 presents the calculations for the entire 30-Year RME scenario.

Table 6-2 Risk Calculations for the 30-Year RME Scenario

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
0 to 1 y.o.	Stroller along State St.	0.00124	0.15	365	0.006	1.0E-2	7.7E-8
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	1.0E-2	0.0E+0
	Biking in town	0.00008	0.33	365	0.014	1.0E-2	1.1E-8
	Motor vehicle in town	0.00008	0.65	365	0.027	1.0E-2	2.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.953	1.0E-2	2.9E-7
1 to 2 y.o.	Stroller along State St.	0.00124	0.03	365	0.001	9.9E-3	1.5E-8
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.9E-3	0.0E+0
	Biking in town	0.00008	0.50	365	0.021	9.9E-3	1.7E-8
	Motor vehicle in town	0.00008	0.73	365	0.030	9.9E-3	2.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.948	9.9E-3	2.8E-7
2 to 3 y.o.	Walk/jog along State St.	0.00124	0.85	365	0.035	9.6E-3	4.2E-7
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.6E-3	0.0E+0
	Biking in town	0.00008	0.50	365	0.021	9.6E-3	1.6E-8
	Motor vehicle in town	0.00008	0.83	365	0.035	9.6E-3	2.7E-8
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.909	9.6E-3	2.6E-7

Table 6-2 (con't)

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
3 to 6 y.o. (3 years)	Walk/jog along State St.	0.00124	0.93	365	0.039	2.6E-2	1.2E-6
	Play at athletic field	0.00033	2.50	365	0.104	2.6E-2	8.9E-7
	Biking in town	0.00008	1.25	365	0.052	2.6E-2	1.1E-7
	Motor vehicle in town	0.00008	0.83	365	0.035	2.6E-2	7.3E-8
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.770	2.6E-2	6.0E-7
6 to 11 y.o. (5 years)	Walk/jog in town	0.00005	0.67	365	0.028	3.7E-2	4.8E-8
	Play at athletic field	0.00033	2.82	365	0.118	3.7E-2	1.4E-6
	Biking in town	0.00008	2.52	365	0.105	3.7E-2	3.2E-7
	Motor vehicle in town	0.00008	0.95	365	0.040	3.7E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.710	3.7E-2	7.9E-7
11 to 16 y.o. (5 years)	Walk/jog in town	0.00005	1.00	365	0.042	3.1E-2	6.0E-8
	Play at athletic field	0.00033	2.48	365	0.103	3.1E-2	1.1E-6
	Biking in town	0.00008	1.08	365	0.045	3.1E-2	1.1E-7
	Motor vehicle in town	0.00008	1.12	365	0.047	3.1E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.763	3.1E-2	7.1E-7
16 to 21 y.o. (5 years)	Walk/jog in town	0.00005	1.17	365	0.049	2.6E-2	5.9E-8
	Play at athletic field	0.00033	4.00	365	0.167	2.6E-2	1.4E-6
	Biking in town	0.00008	1.75	365	0.073	2.6E-2	1.5E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	2.6E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.640	2.6E-2	5.0E-7
21 to 27 y.o. (6 years)	Walk/jog in town	0.00005	1.17	365	0.049	2.5E-2	5.7E-8
	Play at athletic field	0.00033	4.00	365	0.167	2.5E-2	1.4E-6
	Biking in town	0.00008	1.75	365	0.073	2.5E-2	1.5E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	2.5E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.640	2.5E-2	4.8E-7
27 to 30 y.o. (3 years)	Walk/jog in town	0.00005	1.17	365	0.049	1.1E-2	2.5E-8
	Play at athletic field	0.00033	4.00	365	0.167	1.1E-2	6.1E-7
	Biking in town	0.00008	1.75	365	0.073	1.1E-2	6.5E-8
	Motor vehicle in town	0.00008	1.73	365	0.072	1.1E-2	6.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day	365	0.640	1.1E-2	2.1E-7
		Total ELCR for the RME 30-Year Scenario:					**1.4E-5**

6.2.2 Other Exposure and Risk Scenarios

Risk-based decision-making for Superfund sites typically focuses on risks estimated for the RME 30-Year exposure scenario. Since the RME 30-Year scenario is so conservative in its assumptions about exposure for the activities in Alvis, potential risks were also evaluated for three Central Tendency (CT) exposure scenarios: 9-Year, 30-Year and 70-Year CT exposures). A scenario even more conservative than the RME 30-Year, an RME 70-Year scenario, was also evaluated. Details of the exposure scenarios and risk calculations for these additional scenarios are presented and discussed in the Appendix. A side-by-side comparison of the ELCRs estimated by all

of the scenarios allows consideration of how different exposure assumptions affect the overall risk estimates (Table 6-3).

Table 6-3. Risk Calculations for Five Exposure Scenarios

Scenario	Risk	Key Assumptions
CT 9-Year	3.4E-6	• 9-year total exposure duration during the most sensitive period of life* (ages 0 to 9 y.o.) • Average exposure frequency and duration assumptions. • Typical Superfund Central Tendency exposure scenario.
CT 30-Year	9.4E-6	• 30-year total exposure duration (ages 0 to 30 y.o.) including early-life, the most sensitive period of life*. • Average exposure frequency and duration assumptions. • Mixed Superfund Central Tendency / Reasonable Maximum Exposure scenario.
CT 70-Year	1.2E-5	• 70-year total exposure duration (ages 0 to 70 y.o.), representing an entire lifetime of exposure in Alviso. • Average exposure frequency and duration assumptions Lifetime exposure scenario with average assumptions.
RME 30-Year	1.4E-5	• 30-year total exposure duration (ages 0 to 30 y.o.) including early-life, the most sensitive period of life*. • 90th percentile exposure frequency and duration assumptions. • Typical Superfund Reasonable Maximum Exposure scenario. • Includes high-end roadside exposures during ages 0 to 6 y.o.
RME 70-Year	1.9E-5	• 70-year total exposure duration (ages 0 to 70 y.o.), representing an entire lifetime of exposure in Alviso. • 90th percentile exposure frequency and duration assumptions. • Lifetime exposure scenario with high end assumptions. • Includes high-end roadside exposures during ages 0 to 6 y.o.

*Early-life exposures convey proportionately greater risk with asbestos – hence the hence the importance of exposures during ages 0 to16 y.o.

6.3 Alviso ABS Risks in Relation to the Superfund Acceptable Risk Range

As Table 6-3 illustrates, all of the Alviso exposure scenarios generated risk estimates that were within a fairly narrow range – risk estimates differed less than 6-fold from one exposure scenario to another. Table 6-3 also illustrates that the calculated risks from all of the exposure scenarios, from less conservative (CT 9-Year) to most conservative (RME 70-Year), were all well within the Superfund acceptable risk range.

> ***Acceptable Risk Range.*** The U.S. EPA Superfund program defines an acceptable risk range for determining whether exposure to a carcinogen (e.g., asbestos) entails an unacceptable health risk. This acceptable risk range is 10^{-4} (approximately 100 in one million) to 10^{-6} (approximately 1 in one million) ELCR (Code of Federal Regulations). 40 CFR Part 300 section 430(e)(2)(i)(A)(2) says "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response...". Exposures which pose a risk greater than 10^{-4} are generally considered to be of concern and may require action to reduce the exposure and risk.

As Table 6-3 illustrates the ELCR for the RME 30-Year scenario is 1.4E-5, which is well within the acceptable risk range.

6.4 Risk Evaluation

This risk evaluation presents quantitative estimates of excess cancer risk based on the defined exposure scenarios. The scenarios were designed to represent current and future exposures for residents of the Alviso community, focusing on typical outdoor, recreational and quiescent activities. Exposure frequency and duration assumptions were chosen to represent a reasonable maximum exposure scenario – one that is more likely to overestimate rather than underestimate actual exposures for the majority of Alviso residents. In this respect the RME 30-Year scenario is expected to result in a conservative, health-protective estimate of exposure and risk. On balance, actual exposures and risks are expected to be lower for most Alviso residents.

Section 7
Risk Uncertainties

Evaluation of potential risks to human health caused by any chemical involves determining both the extent of exposure to that chemical and the toxicity or dose-response of the organism to the chemical. All risk evaluations have some level of uncertainty associated with them. EPA strives to conduct risk evaluations that neither underestimate nor grossly overestimate risk. However, because EPA's mission is to protect public health and the environment, the Agency tries to ensure that the public is protected by incorporating risk assessment principles and assumptions that are more likely to overestimate, rather than underestimate, actual risks where uncertainty exists.

7.1 ABS Activities

The assessment of asbestos exposures during outdoor and recreational relied on personal exposure data generated by surrogate activities (e.g., ATV riding as a surrogate for driving, riding in a motor vehicle and bicycle riding), so there is uncertainty about whether they produced greater or lesser asbestos exposures than the activities they were intended to simulate. Surrogate activities were chosen with the intent of creating equivalent or greater exposures than actual. For example it is expected that personal exposures measured during ATV riding are likely to be greater than actual exposures while driving or riding in a motor vehicle (except a motorcycle) and while riding a bicycle. This is because an ATV is an open vehicle – the rider sits directly within the vehicle's dust cloud - and produces a more energetic disturbance of dust and soil than would a bicycle.

7.2 Exposure Time and Frequency

The exposure assessment relied on published data on children's activity patterns for exposure frequency and duration assumptions. There is uncertainty about whether these frequency and duration assumptions overestimate or underestimate actual activity patterns within the community; exposure overestimates would likely lead to overestimates of risk and vice versa. The intent of using 90th percentile exposure frequency and duration assumptions, where applicable in the RME scenario, was to make it more likely that exposures would be overestimated, rather than underestimated, for most children and other individuals in Alviso.

7.3 Integrated Street Exposure Point Concentrations

Asbestos exposure levels while on Alviso streets (e.g., motor vehicle or bicycling) or adjacent to streets (e.g., walking, jogging or riding in a stroller) are estimated as an integrated, community-wide EPC by pro-rating exposure data according to the total length of roadway in each of the four study areas. Thus, an individual's exposure, averaged over the entire community, is assumed to be proportional to the length of roadway in each study area. Individuals whose street/street-side activities do not match this model will experience lesser or greater exposure depending on their

specific activity patterns relating to driving or riding in a motor vehicle, bicycling or walking, jogging or riding in a stroller.

7.4 Risks from Episodic Exposures

The IUR toxicity values used in the risk calculations were derived from studies on cancers in occupational environments (EPA, 1986) where asbestos exposures were to relatively high concentrations over relatively extended periods (e.g., 8-hour work days, 5 days/week, for weeks to years). There is uncertainty in using dose-response data derived from these high concentration, extended exposure occupational environments to predict risks for outdoor and recreational exposure scenarios, which are generally associated with lower concentration exposures and are less frequent. Because there is no clear mode of action for asbestos-induced disease, using a direct time-weighted extrapolation from the occupational exposures to shorter-term, episodic exposures may underestimate or overestimate the risk. Actual risks from short-term episodic exposures could be much lower because they may be too infrequent or the total retained fiber burden too low to initiate the asbestos disease process.

7.5 Representativeness of the Season

The ABS sampling in Alviso was conducted during August, which is the dry season for the region. There is uncertainty about whether the asbestos exposures during the dry season are representative of exposures throughout the entire year. The sampling was scheduled for late summer with the expectation it would be more likely to overestimate, rather than underestimate, year-round exposures because of the very dry nature of dust and soils during that season.

7.6 Alternative Exposure-Risk Metrics

The current standard-of-practice within EPA and most other health agencies is to assess risks from asbestos using exposure data expressed as PCME fiber concentrations. PCME fibers are those fibers counted under the electron microscope that are equivalent in size to fibers that can be observed using the less powerful phase contrast microscope (hence, “Phase Contrast Microscope Equivalent” fibers). PCME fiber concentrations are used because the toxicity values for asbestos risk assessment are expressed in terms of PCM fiber concentrations. This is because the current asbestos risk models are derived from studies of disease incidence in workplaces where asbestos exposures were monitored only with the phase contrast microscope, or other methods even less discerning. PCME fibers typically do not represent all of the fibers present in any asbestos environment; notably there are often many asbestos fibers present which are too short to be included in the PCME classification. It is possible that alternative exposure metrics (e.g., total fiber concentration) would better correlate to the risk of developing asbestos-related disease than does PCME concentration. Therefore, reliance on a PCME exposure metric may underestimate or overestimate actual risks; additional research on asbestos exposure-disease

relationships is needed in order to identify the magnitude and direction of the uncertainties of relying on PCME for risk assessment.

7.7 Non-Cancer Risk

There is currently no asbestos toxicity value available for non-cancer effects; therefore, non-cancer risks were not addressed in this risk evaluation. Recent epidemiological studies and observation of disease incidence in Libby, Montana indicate that non-cancer health effects from exposure to asbestos (e.g., respiratory and pleural disease) can be significant and, in some studies, exceed the cancer risks – at least for an amphibole form of asbestos (Rohs et al., 2008).

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Section 8
Conclusions

ABS protocols were used in Alviso to determine if typical activities in the community would expose residents to levels of asbestos that have been associated with a significant risk of developing cancer. This sampling and analysis was conducted as a follow-up to a Five Year Review of the protectiveness of various remedial actions performed by EPA and other stakeholders under the authority of the Superfund program (EPA, 2005). These Superfund remedial actions were taken in response to finding significant, uncontrolled releases into community air from asbestos present in truck yards, landfills, and a flood control ring levee in the community.

The original remediation relied on a one percent asbestos content screening threshold to identify soils requiring remediation. Subsequent information and experience on how low asbestos concentrations in soil translate into actual airborne exposures raised questions about whether the original remediation continued to be protective. The goal of the ABS, exposure assessment, and risk evaluation was to determine if there was the potential for significant risk by exposure to asbestos in public areas of the community.

Conclusion 1: The estimates of asbestos exposure are below risk-based levels of concern. No further evaluation or remedial action is recommended.

Asbestos exposures from typical activities in the Alviso community pose risks that are low and within the target risk range [i.e., 1.0E-4 (one in ten-thousand) to 1.0E-6 (one in one-million)] for Superfund remedial actions. A risk evaluation of the Reasonable Maximum Exposure scenario, which estimated risks associated with upper bound exposures to asbestos during 30 years of continuous, typical activities in Alviso, indicated that the excess lifetime cancer risk is 1.4E-5 (14 in one-million). Four other exposure scenarios (Central Tendency exposures for 9 years, 30 years, and 70 years and a Reasonable Maximum Exposure for 70 years) generated excess lifetime cancer risk estimates ranging 3.4E-6 to 1.9E-5 (3.4 to 19 in one-million).

Conclusion 2: The original remedy for the SBA Site continues to be protective.

Since risks from asbestos exposure in the Alviso community are low and within the Superfund target risk range, the original remedy continues to be protective.

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Section 9
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Appendix A
Risk Calculations for CT 9-Year, CT 30-Year, CT 70-Year and RME 70-Year Scenarios

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Appendix A
Risk Calculations for CT 9-Year, CT 30-Year, CT 70-Year and RME 70-Year Scenarios

Other Exposure & Risk Scenarios

A total of 5 exposure scenarios were developed for evaluation of potential risks related to residential and recreational activities in the Alviso community. As discussed in the body of the report, risk-based decision making in the Superfund program typically focuses on an RME 30-Year exposure scenario, details of which are discussed in Sections 5 and 6. This appendix presents the details on the other 4 scenarios: CT 9-Year, CT 30-Year, CT 70-Year and RME 70-Year. The intent of including these other scenarios in the evaluation is to provide an indication of how the risk varies, based on differing exposure assumptions.

Frequency and duration assumptions for each activity in all of the exposure scenarios were taken mainly from data presented in either the U.S. EPA's Exposure Factors Handbook (hereafter EFH, EPA, 1997) or Child-Specific Exposure Factors Handbook (hereafter CEFH, EPA, 2008b). The primary source of information on children's exposure patterns was Chapter 16, "Activity Factors", of the CEFH. The tables in CEFH, Chapter 16 present data from numerous studies on how much time children spend in various activities and microenvironments at various different ages. For adults, the primary sources were activity pattern data tables in Chapter 15, "Activity Factors" of the EFH.

In accordance with risk assessment guidance in RAGS (EPA, 1989), exposure and risk calculations were developed for three Central Tendency (CT) exposure scenarios (9-Year, 30-Year and 70-Year) and for two Reasonable Maximum Exposure (RME) scenarios (30-Year and 70-Year). The RME scenarios are included to assess exposures and estimate risks for those residents whose more extreme activity patterns expose them to near maximal risks, while the CT scenarios represent exposure and risk estimates that are more applicable for average residents of the community.

The RME scenario was generally developed using 90th percentile exposure activity pattern data. For a Superfund risk assessment, an RME scenario is typically based on 95th percentile values, where available, for exposure frequency and duration. For the present risk assessment, 90th percentile values were chosen for two reasons: (1) The CEFH notes that "…95th percentile [child activity frequency and duration] values may be misleading for estimating chronic exposures" because they are based on short-term survey data. (2) Also, using only 95th percentile values produced unrealistic exposure scenarios (e.g., 16 to 25 y.o. people who are recreating – playing at the athletic field and riding bikes – for almost 8 hours per day, every day of the year). Use of 90th percentile values produced exposure scenarios that were still reasonably high end, but were also more believable.

CT exposure scenarios were developed using mean activity frequency and duration values for all specific activities.

Many of the CEFH tables contain data for both Whole Populations (which includes data from people who did not engage in the specific activity, who thus spend zero hours/day at that activity) and Doers Only (which includes only data from people who perform the activity). Because early-life exposures convey a disproportionately higher risk than those from similar activities later in life, child exposure data from the CEFH that focused on Doers Only was preferentially used where available. Thus it is expected that these exposure assessments are more likely to overestimate, rather than underestimate, actual exposures experienced by most residents.

- ***Ages birth to 16 y.o.:*** Exposure frequency and duration data for activities for these age ranges generally came from the CEFH.

- ***Age ranges 16 to 70 y.o.***: The EFH was the source of most of the activity data in these age ranges. Because the age ranges in the EFH tables did not match exactly the age ranges in the exposure assessment and risk evaluation, data for ages 16 to 70 y.o. typically represented reported values for ages 18 to 64 y.o. in the EFH tables.

Because these assumptions represent fairly vigorous activity patterns, especially for the RME scenarios, it is expected that these assumptions are more likely to overestimate, rather than underestimate, actual exposures and risks for the typical resident.

Walking. Exposure duration data on walking, jogging or riding in a stroller (for early-life exposures) were obtained from 2 tables. Child-specific data came from CEFH Table 16-16, "Time Spent in Selected Activities, Whole Population and Doers-Only" and adult data were derived from EFH Table 15-126, "Statistics for 24-Hour Cumulative Number of Minutes Spent Walking" (also doers only). For ages birth to 16 y.o., mean values from CEFH Table 16-16 were used in the CT scenario, with values for birth to 2 y.o. coming from the Whole Population section and values for the rest of life coming from the Doer's Only section. For ages above 16 y.o., the mean value for ages 18 to 64 y.o. from Table 15-126 of the EFH was used for the CT scenario. RME exposure duration data were taken primarily from the 90th percentile values in the 2 tables, except for ages birth to 2 y.o., which came from the Whole Population section of CEFH Table 16-16 as there were no entries under Doer's Only. Both tables normalized the data on a "per day" basis so there are only exposure duration values (minutes per day); exposure frequency has effectively been factored into the exposure duration variable. The use of Doer's Only data is expected to more likely overestimate - rather than underestimate - exposures to asbestos for the average resident in the CT scenarios.

Table A1 presents the CT and RME exposure duration values chosen for the walking/stroller activity in the exposure assessment and risk evaluation for the Alviso community.

Table A1. Exposure Duration Values for Walking, Jogging or Riding in a Stroller

	CT - mean		RME - 90th %tile	
Age Range	(min/day)	(hours/day)	(min/day)	(hours/day)
Birth to 1 y.o.	6	0.10	9.2	0.15
1 to 2 y.o.	2	0.03	2	0.03
2 to 3 y.o.	19	0.32	51	0.85
3 to 6 y.o.	20	0.33	56	0.93
6 to 11 y.o.	18	0.30	40	0.67
11 to 16 y.o.	25	0.42	60	1.00
16 to 21 y.o.	31	0.52	70	1.17
21 to 25 y.o.	31	0.52	70	1.17
25 to 50 y.o.	31	0.52	70	1.17
50 to 70 y.o.	31	0.52	70	1.17

Playing at the Athletic Field. Data on exposure frequency and duration for children playing at the athletic field was obtained from Table 16-13, "Time Spent in Selected Outdoor Locations", of the CEFH; data for adults 16 y.o. and older came from Table 15-108, "Statistics for 24-Hour Cumulative Number of Minutes Spent Outdoors on School Grounds & Playgrounds" of the EFH (which compiled data for doers only).

These tables both contained exposure duration data (normalized on a "per day" basis so that exposure frequency is effectively factored in) on time spent at school grounds & playgrounds. As with the walking activity above, for ages birth to 16 y.o., mean values from CEFH Table 16-13 were used in the CT scenario; values for birth to 2 y.o. were Whole Population and values for the rest of life were Doer's Only. For ages above 16 y.o., the mean value - ages 18 to 64 y.o. - from Table 15-108 of the EFH was used for the CT scenario. RME activity duration data came from the 90th percentile values in the 2 tables, again except for ages birth to 2 y.o., which came from the Whole Population section of CEFH Table 16-13 as there were no entries under Doer's Only

Table A2 presents the CT and RME exposure duration values chosen for playing at the athletic field used in the exposure assessment and risk evaluation.

Table A2. Exposure Duration Values for Athletic Field Play

	CT - mean		RME - 90th %tile	
Age Range	(min/day)	(hours/day)	(min/day)	(hours/day)
Birth to 1 y.o.	2	0.03	0	0.00
1 to 2 y.o.	0	0.00	0	0.00
2 to 3 y.o.	4	0.07	0	0.00
3 to 6 y.o.	138	2.30	150	2.50
6 to 11 y.o.	80	1.33	169	2.82
11 to 16 y.o.	72	1.20	149	2.48
16 to 21 y.o.	119	1.98	240	4.00
21 to 25 y.o.	119	1.98	240	4.00
25 to 50 y.o.	119	1.98	240	4.00
50 to 70 y.o.	119	1.98	240	4.00

Biking in Town. Activity pattern data for biking were found in Table 15-127, "Statistics for 24-Hour Cumulative Number of Minutes Spend Traveling on a Bicycle/Skateboard / Rollerskate" in the EFH. These data were for doer's only and the age ranges (birth-1, 1-4, 5-11, 12-17 and 18-64 y.o.) did not exactly match exposure scenarios in the current assessment. For the CT scenario, mean data were used and the age ranges matched as closely as possible. Since these data are the means of doer's only, they are more likely to overestimate, rather than underestimate, true averages across the entire community for time spent bicycling. Exposure duration assumptions for bicycling in the RME scenario were taken from the 90th percentile data of Table 15-127; again age ranges were matched as closely as possible. As with other data from the CEFH or EFH, the exposure duration data in Table 15-127 were normalized on a per day basis so no exposure frequency assumptions need to be included in the exposure assessment.

The values bicycling (or skateboarding, rollerskating) exposure durations used in the exposure assessment and risk evaluation are presented in Table A3.

Table A3. Exposure Duration Values for Bicycling

	CT - mean		RME - 90th %tile	
Age Range	(min/day)	(hours/day)	(min/day)	(hours/day)
Birth to 1 y.o.	15	0.25	20	0.33
1 to 2 y.o.	20	0.33	30	0.50
2 to 3 y.o.	20	0.33	30	0.50
3 to 6 y.o.	20	0.33	30	0.50
6 to 11 y.o.	40	0.67	151	2.52
11 to 16 y.o.	32	0.53	65	1.08
16 to 21 y.o.	53	0.89	105	1.75
21 to 25 y.o.	53	0.89	105	1.75
25 to 50 y.o.	53	0.89	105	1.75
50 to 70 y.o.	53	0.89	105	1.75

Driving/riding in Town: Exposure duration assumptions for children to age 16 y.o., riding in a motor vehicle in town were taken from Table 16-15, "Time Spent in All Vehicles" of the CEFH. For adults, 16 y.o. and older, driving or riding in a motor vehicle, exposure duration data came from Table 15-133, "Statistics for 24-Hour Cumulative Minutes Spent Traveling Inside a Vehicle" of the EFH. For both the CT and RME scenarios, the mean time spent values for each age range were used in the risk calculations. The 90th percentile value was not used for the RME scenario because it was felt that those longer durations (113 to 180 minutes per day) would only be applicable to vehicle trips outside of town. As with other data from CEFH or EFH tables, these exposure duration data were normalized on a per day basis so no exposure frequency assumptions are included..

Exposure duration values used for driving and riding in a vehicle in town in the exposure assessments and risk evaluations are presented in Table A4.

Table A4. Exposure Duration Values for Driving & Riding in a Motor Vehicle

	CT		RME (same as CT)	
Age Range	(min/day)	(hours/day)	(min/day)	(hours/day)
Birth to 1 y.o.	39	0.65	39	0.65
1 to 2 y.o.	44	0.73	44	0.73
2 to 3 y.o.	50	0.83	50	0.83
3 to 6 y.o.	50	0.83	50	0.83
6 to 11 y.o.	57	0.95	57	0.95
11 to 16 y.o.	67	1.12	67	1.12
16 to 21 y.o.	104	1.73	104	1.73
21 to 25 y.o.	104	1.73	104	1.73
25 to 50 y.o.	104	1.73	104	1.73
50 to 70 y.o.	104	1.73	104	1.73

The tables (A6 through A9) on the following pages present the detailed EF, ED, TWF and risk calculations for the CT 9-Year, CT 30-Year, CT 70-Year and RME-70 Year exposure and risk scenarios. Table A5 (a duplicate of Table 6-13 in the body of the report) summarizes the exposure assumptions and estimated risks for all scenarios.

Table A5. Risk Calculations for Five Exposure Scenarios

Scenario	Risk	Key Assumptions
CT 9-Year	3.4E-6	• 9-year total exposure duration during the most sensitive period of life* (ages 0 to 9 y.o.) • Average exposure frequency and duration assumptions. • Typical Superfund Central Tendency exposure scenario.
CT 30-Year	9.4E-6	• 30-year total exposure duration (ages 0 to 30 y.o.) including early-life, the most sensitive period of life*. • Average exposure frequency and duration assumptions. • Mixed Superfund Central Tendency / Reasonable Maximum Exposure scenario.
CT 70-Year	1.2E-5	• 70-year total exposure duration (ages 0 to 70 y.o.), representing an entire lifetime of exposure in Alviso. • Average exposure frequency and duration assumptions Lifetime exposure scenario with average assumptions.
RME 30-Year	1.4E-5	• 30-year total exposure duration (ages 0 to 30 y.o.) including early-life, the most sensitive period of life*. • 90th percentile exposure frequency and duration assumptions. • Typical Superfund Reasonable Maximum Exposure scenario. • Includes high-end roadside exposures during ages 0 to 6 y.o.
RME 70-Year	1.9E-5	• 70-year total exposure duration (ages 0 to 70 y.o.), representing an entire lifetime of exposure in Alviso. • 90th percentile exposure frequency and duration assumptions. • Lifetime exposure scenario with high end assumptions. • Includes high-end roadside exposures during ages 0 to 6 y.o.

*Early-life exposures convey proportionately greater risk with asbestos – hence the hence the importance of exposures during ages 0 to16 y.o.

Table A6. Risk Calculations for the CT 9-Year Scenario

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
0 to 1 y.o.	Stroller in Town	0.000046	0.10	365	0.004	1.0E-2	1.9E-9
(1 year)	Play at Athletic Field	0.000124	0.03	365	0.001	1.0E-2	1.5E-9
	Driving/Riding in Town	8.11E-05	0.65	365	0.027	1.0E-2	2.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.968	1.0E-2	2.9E-7
1 to 2 y.o.	Stroller in Town	0.000046	0.03	365	0.001	9.9E-3	5.7E-10
(1 year)	Play at Athletic Field	0.000124	0.00	365	0.000	9.9E-3	0.0E+0
	Driving/Riding in Town	8.11E-05	0.73	365	0.030	9.9E-3	2.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.968	9.9E-3	2.9E-7
2 to 3 y.o.	Walking in Town	0.000046	0.32	365	0.013	9.6E-3	5.9E-9
(1 year)	Play at Athletic Field	0.00033	0.07	365	0.003	9.6E-3	9.2E-9
	Driving/Riding in Town	8.11E-05	0.83	365	0.035	9.6E-3	2.7E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.949	9.6E-3	2.7E-7
3 to 6 y.o.	Walking in Town	0.000046	0.33	365	0.014	2.6E-2	1.7E-8
(3 years)	Play at Athletic Field	0.00033	2.30	365	0.096	2.6E-2	8.2E-7
	Biking in Town	8.11E-05	1.15	365	0.048	2.6E-2	1.0E-7
	Driving/Riding in Town	8.11E-05	0.83	365	0.035	2.6E-2	7.3E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.808	2.6E-2	6.3E-7
6 to 9 y.o.	Walking in Town	0.000046	0.30	365	0.013	2.3E-2	1.3E-8
(3 years)	Play at Athletic Field	0.00033	1.33	365	0.055	2.3E-2	4.2E-7
	Biking in Town	8.11E-05	0.67	365	0.028	2.3E-2	5.2E-8
	Driving/Riding in Town	8.11E-05	0.95	365	0.040	2.3E-2	7.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.865	2.3E-2	6.0E-7
						Total ELCR for the CT 9-Year Scenario:	**3.4E-6**

Table A7. Risk Calculations for the CT 30-Year Scenario

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
0 to 1 y.o.	Stroller in town	0.00005	0.10	365	0.004	1.0E-2	1.9E-9
(1 year)	Play at athletic field	0.00033	0.03	365	0.001	1.0E-2	4.1E-9
	Biking in town	0.00008	0.25	365	0.010	1.0E-2	8.4E-9
	Motor vehicle in Town	0.00008	0.65	365	0.027	1.0E-2	2.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.957	1.0E-2	2.9E-7
1 to 2 y.o.	Stroller in town	0.00005	0.03	365	0.001	9.9E-3	5.7E-10
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.9E-3	0.0E+0
	Biking in town	0.00008	0.33	365	0.014	9.9E-3	1.1E-8
	Motor vehicle in Town	0.00008	0.73	365	0.030	9.9E-3	2.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.955	9.9E-3	2.8E-7
2 to 3 y.o.	Walk/jog in town	0.00005	0.32	365	0.013	9.6E-3	5.9E-9
(1 year)	Play at athletic field	0.00033	0.07	365	0.003	9.6E-3	9.2E-9
	Biking in town	0.00008	0.33	365	0.014	9.6E-3	1.1E-8
	Motor vehicle in Town	0.00008	0.83	365	0.035	9.6E-3	2.7E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.935	9.6E-3	2.7E-7
3 to 6 y.o.	Walk/jog in town	0.00005	0.33	365	0.014	2.6E-2	1.7E-8
(3 years)	Play at athletic field	0.00033	2.30	365	0.096	2.6E-2	8.2E-7
	Biking in town	0.00008	0.33	365	0.014	2.6E-2	2.9E-8
	Motor vehicle in Town	0.00008	0.83	365	0.035	2.6E-2	7.3E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.842	2.6E-2	6.6E-7
6 to 11 y.o.	Walk/jog in town	0.00005	0.30	365	0.013	3.7E-2	2.1E-8
(5 years)	Play at athletic field	0.00033	1.33	365	0.055	3.7E-2	6.8E-7
	Biking in town	0.00008	0.67	365	0.028	3.7E-2	8.4E-8
	Motor vehicle in Town	0.00008	0.95	365	0.040	3.7E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.865	3.7E-2	9.6E-7
11 to 16 y.o.	Walk/jog in town	0.00005	0.42	365	0.018	3.1E-2	2.5E-8
(5 years)	Play at athletic field	0.00033	1.20	365	0.050	3.1E-2	5.1E-7
	Biking in town	0.00008	0.53	365	0.022	3.1E-2	5.6E-8
	Motor vehicle in Town	0.00008	1.12	365	0.047	3.1E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.864	3.1E-2	8.0E-7
16 to 21 y.o.	Walk/jog in town	0.00005	0.52	365	0.022	2.6E-2	2.6E-8
(5 years)	Play at athletic field	0.00033	1.98	365	0.083	2.6E-2	7.1E-7
	Biking in town	0.00008	0.89	365	0.037	2.6E-2	7.8E-8
	Motor vehicle in Town	0.00008	1.73	365	0.072	2.6E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	2.6E-2	6.1E-7

Table A7. Risk Calculations for the CT 30-Year Scenario (continued)

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
21 to 27 y.o. (6 years)	Walk/jog in town	0.00005	0.52	365	0.022	2.5E-2	2.5E-8
	Play at athletic field	0.00033	1.98	365	0.083	2.5E-2	6.8E-7
	Biking in town	0.00008	0.89	365	0.037	2.5E-2	7.5E-8
	Motor vehicle in Town	0.00008	1.73	365	0.072	2.5E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	2.5E-2	5.9E-7
27 to 30 y.o. (3 years)	Walk/jog in town	0.00005	0.52	365	0.022	1.1E-2	1.1E-8
	Play at athletic field	0.00033	1.98	365	0.083	1.1E-2	3.0E-7
	Biking in town	0.00008	0.89	365	0.037	1.1E-2	3.3E-8
	Motor vehicle in Town	0.00008	1.73	365	0.072	1.1E-2	6.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	1.1E-2	2.6E-7

Total ELCR for the CT 30-Year Scenario: 9.4E-6

Table A8. Risk Calculations for the CT 70-Year Scenario

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
0 to 1 y.o.	Stroller in town	0.00005	0.10	365	0.004	1.0E-2	1.9E-9
(1 year)	Play at athletic field	0.00033	0.03	365	0.001	1.0E-2	4.1E-9
	Biking in town	0.00008	0.25	365	0.010	1.0E-2	8.4E-9
	Motor vehicle in town	0.00008	0.65	365	0.027	1.0E-2	2.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.957	1.0E-2	2.9E-7
1 to 2 y.o.	Stroller in town	0.00005	0.03	365	0.001	9.9E-3	5.7E-10
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.9E-3	0.0E+0
	Biking in town	0.00008	0.33	365	0.014	9.9E-3	1.1E-8
	Motor vehicle in town	0.00008	0.73	365	0.030	9.9E-3	2.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.955	9.9E-3	2.8E-7
2 to 3 y.o.	Walk/jog in town	0.00005	0.32	365	0.013	9.6E-3	5.9E-9
(1 year)	Play at athletic field	0.00033	0.07	365	0.003	9.6E-3	9.2E-9
	Biking in town	0.00008	0.33	365	0.014	9.6E-3	1.1E-8
	Motor vehicle in town	0.00008	0.83	365	0.035	9.6E-3	2.7E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.935	9.6E-3	2.7E-7
3 to 6 y.o.	Walk/jog in town	0.00005	0.33	365	0.014	2.6E-2	1.7E-8
(3 years)	Play at athletic field	0.00033	2.30	365	0.096	2.6E-2	8.2E-7
	Biking in town	0.00008	0.33	365	0.014	2.6E-2	2.9E-8
	Motor vehicle in town	0.00008	0.83	365	0.035	2.6E-2	7.3E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.842	2.6E-2	6.6E-7
6 to 11 y.o.	Walk/jog in town	0.00005	0.30	365	0.013	3.7E-2	2.1E-8
(5 years)	Play at athletic field	0.00033	1.33	365	0.055	3.7E-2	6.8E-7
	Biking in town	0.00008	0.67	365	0.028	3.7E-2	8.4E-8
	Motor vehicle in town	0.00008	0.95	365	0.040	3.7E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.865	3.7E-2	9.6E-7
11 to 16 y.o.	Walk/jog in town	0.00005	0.42	365	0.018	3.1E-2	2.5E-8
(5 years)	Play at athletic field	0.00033	1.20	365	0.050	3.1E-2	5.1E-7
	Biking in town	0.00008	0.53	365	0.022	3.1E-2	5.6E-8
	Motor vehicle in town	0.00008	1.12	365	0.047	3.1E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.864	3.1E-2	8.0E-7
16 to 21 y.o.	Walk/jog in town	0.00005	0.52	365	0.022	2.6E-2	2.6E-8
(5 years)	Play at athletic field	0.00033	1.98	365	0.083	2.6E-2	7.1E-7
	Biking in town	0.00008	0.89	365	0.037	2.6E-2	7.8E-8
	Motor vehicle in town	0.00008	1.73	365	0.072	2.6E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	2.6E-2	6.1E-7

Table A8. Risk Calculations for the CT 70-Year Scenario (continued)

Age Range	Activity	EPC (f/cc)	Hours per day	Days per year	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
21 to 25 y.o. (4 years)	Walk/jog in town	0.00005	0.52	365	0.022	1.7E-2	1.7E-8
	Play at athletic field	0.00033	1.98	365	0.083	1.7E-2	4.6E-7
	Biking in town	0.00008	0.89	365	0.037	1.7E-2	5.1E-8
	Motor vehicle in town	0.00008	1.73	365	0.072	1.7E-2	9.9E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	1.7E-2	4.0E-7
25 to 50 y.o. (25 years)	Walk/jog in town	0.00005	0.52	365	0.022	5.6E-2	5.6E-8
	Play at athletic field	0.00033	1.98	365	0.083	5.6E-2	1.5E-6
	Biking in town	0.00008	0.89	365	0.037	5.6E-2	1.7E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	5.6E-2	3.3E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	5.6E-2	1.3E-6
50 to 70 y.o. (20 years)	Walk/jog in town	0.00005	0.52	365	0.022	1.4E-2	1.4E-8
	Play at athletic field	0.00033	1.98	365	0.083	1.4E-2	3.8E-7
	Biking in town	0.00008	0.89	365	0.037	1.4E-2	4.2E-8
	Motor vehicle in town	0.00008	1.73	365	0.072	1.4E-2	8.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.787	1.4E-2	3.3E-7
						Total ELCR for the CT 70-Year Scenario:	**1.2E-5**

Table A9. Risk Calculations for the RME 70-Year Scenario

Age Range	Activity	EPC (f/cc)	Hours/day	Days/yr	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
0 to 1 y.o.	Stroller along State St.	0.00124	0.15	365	0.006	1.0E-2	7.7E-8
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	1.0E-2	0.0E+0
	Biking in town	0.00008	0.33	365	0.014	1.0E-2	1.1E-8
	Motor vehicle in town	0.00008	0.65	365	0.027	1.0E-2	2.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.953	1.0E-2	2.9E-7
1 to 2 y.o.	Stroller along State St.	0.00124	0.03	365	0.001	9.9E-3	1.5E-8
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.9E-3	0.0E+0
	Biking in town	0.00008	0.50	365	0.021	9.9E-3	1.7E-8
	Motor vehicle in town	0.00008	0.73	365	0.030	9.9E-3	2.4E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.948	9.9E-3	2.8E-7
2 to 3 y.o.	Walk/jog along State St.	0.00124	0.85	365	0.035	9.6E-3	4.2E-7
(1 year)	Play at athletic field	0.00033	0.00	365	0.000	9.6E-3	0.0E+0
	Biking in town	0.00008	0.50	365	0.021	9.6E-3	1.6E-8
	Motor vehicle in town	0.00008	0.83	365	0.035	9.6E-3	2.7E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.909	9.6E-3	2.6E-7
3 to 6 y.o.	Walk/jog along State St.	0.00124	0.93	365	0.039	2.6E-2	1.2E-6
(3 years)	Play at athletic field	0.00033	2.50	365	0.104	2.6E-2	8.9E-7
	Biking in town	0.00008	0.50	365	0.021	2.6E-2	4.4E-8
	Motor vehicle in town	0.00008	0.83	365	0.035	2.6E-2	7.3E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.802	2.6E-2	6.3E-7
6 to 11 y.o.	Walk/jog in town	0.00005	0.67	365	0.028	3.7E-2	4.8E-8
(5 years)	Play at athletic field	0.00033	2.82	365	0.118	3.7E-2	1.4E-6
	Biking in town	0.00008	2.52	365	0.105	3.7E-2	3.2E-7
	Motor vehicle in town	0.00008	0.95	365	0.040	3.7E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.710	3.7E-2	7.9E-7
11 to 16 y.o.	Walk/jog in town	0.00005	1.00	365	0.042	3.1E-2	6.0E-8
(5 years)	Play at athletic field	0.00033	2.48	365	0.103	3.1E-2	1.1E-6
	Biking in town	0.00008	1.08	365	0.045	3.1E-2	1.1E-7
	Motor vehicle in town	0.00008	1.12	365	0.047	3.1E-2	1.2E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.763	3.1E-2	7.1E-7
16 to 21 y.o.	Walk/jog in town	0.00005	1.17	365	0.049	2.6E-2	5.9E-8
(5 years)	Play at athletic field	0.00033	4.00	365	0.167	2.6E-2	1.4E-6
	Biking in town	0.00008	1.75	365	0.073	2.6E-2	1.5E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	2.6E-2	1.5E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.640	2.6E-2	5.0E-7
21 to 25 y.o.	Walk/jog in town	0.00005	1.17	365	0.049	1.7E-2	3.8E-8
(4 years)	Play at athletic field	0.00033	4.00	365	0.167	1.7E-2	9.4E-7
	Biking in town	0.00008	1.75	365	0.073	1.7E-2	1.0E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	1.7E-2	9.9E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.640	1.7E-2	3.3E-7

Table A9. Risk Calculations for the RME 70-Year Scenario (cont.)

Age Range	Activity	EPC (f/cc)	Hours/day	Days/yr	TWF	IUR $(f/cc)^{-1}$	ELCR by Activity
25 to 50 y.o. (25 years)	Walk/jog in town	0.00005	1.17	365	0.049	5.6E-2	1.3E-7
	Play at athletic field	0.00033	4.00	365	0.167	5.6E-2	3.1E-6
	Biking in town	0.00008	1.75	365	0.073	5.6E-2	3.3E-7
	Motor vehicle in town	0.00008	1.73	365	0.072	5.6E-2	3.3E-7
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.640	5.6E-2	1.1E-6
50 to 70 y.o. (20 years)	Walk/jog in town	0.00005	1.17	365	0.049	1.4E-2	3.2E-8
	Play at athletic field	0.00033	4.00	365	0.167	1.4E-2	7.7E-7
	Biking in town	0.00008	0.88	365	0.036	1.4E-2	4.1E-8
	Motor vehicle in town	0.00008	1.73	365	0.072	1.4E-2	8.2E-8
	Quiescent activities at home and in town	0.00003	Remainder of day.	365	0.676	1.4E-2	2.8E-7
						Total ELCR for the RME 70-Year Scenario:	**1.9E-5**

Appendix B
Activity-Based Sampling Photographs

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Photograph 1: Close-up stationary air monitor showing air pump and filter.

Photograph 2: Reference air monitor located on Spreckles Avenue near the wastewater treatment plant.

Photograph 3: Raking of athletic field showing worker wearing personal protective equipment and air sampling pack with filter.

Photograph 4: Biking on athletic field (playground) behind George Mayne Elementary School.

Photograph 5: Biking on athletic field (baseball infield area).

Photograph 6: All-terrain vehicle (ATV) sampling in new residential area showing worker wearing personal protective equipment and air sampling pack with filter.

Photograph 7: Roadside stationary monitor in older residential area at the corner of Michigan Avenue and Archer Street showing air pump and filter.

Photograph 8: ATV sampling on State Street showing worker wearing personal protective equipment and air sampling pack with filter.

Photograph 9: Raking of Catherine Street truck yard showing upwind and downwind air monitors and worker wearing personal protective equipment and air sampling pack with filter.

Photograph 10: ATV sampling at the Wemco truck yard.