Allan C. Lloyd, Ph.D.
Agency Secretary
Cal/EPA

Department of Toxic Substances Control

B. B. Blevins, Director
8800 Cal Center Drive
Sacramento, California 95826-3200

Arnold Schwarzenegger
Governor

STUDY OF AIRBORNE ASBESTOS FROM A SERPENTINE ROAD IN GARDEN VALLEY, CALIFORNIA

April 2005

Printed on Recycled Paper

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1.0 EXECUTIVE SUMMARY

In response to concerns about Naturally Occurring Asbestos (NOA) concentrations in the air in the community of Garden Valley, DTSC has conducted surface soil and air studies to identify potential sources of NOA emissions in the community. DTSC concluded that roads surfaced with serpentine aggregate were the primary source of airborne NOA in the Garden Valley community. Based on elevated NOA concentrations, the report recommended that a NOA emission study be conducted on a typical road in Garden Valley.

In 2002 and 2003, DTSC conducted a study to measure airborne NOA emissions from a serpentine aggregate covered road. As part of the study the road was resurfaced and the NOA emissions study was repeated. The study was intended to evaluate the effectiveness in reducing NOA emissions by sealing the road. This report summarizes the design, results, conclusions and recommendations from the studies. Technical details of the studies are included in appendices to this report.

An airborne asbestos emission study was conducted on Slodusty Road. Bulk samples of the road surfacing materials and soil were collected to measure the NOA content. Stationary monitors were set up adjacent to the road ranging from 5 to 190 feet from the road edge. Two vehicles were driven back and forth on the road in two traffic patterns. In the first pattern, vehicles were driven at 10 miles per hour (mph) at a rate of 10 vehicles per hour (vph). This condition simulated the posted speed and number of vehicles reasonably expected to use this road. In the second pattern, vehicles were driven at 25 mph at a rate of 30 vph to simulate the maximum safe speed and number of vehicles using the road. After the initial emission study, the road was resurfaced with a chipseal and limestone aggregate cover. The emission study was then repeated.

The study concluded that there was an average of approximately two percent NOA in the surfacing materials and soils. Both traffic study patterns yielded significant concentrations of NOA at distances up to the maximum distance measured of 190 feet. NOA concentrations in air decreased with distance from the road. Fibers were detected at greater distances than visible dust was observed. NOA emissions were reduced by an average of 98% after resurfacing the road.

Potential human health risk associated with exposure to emissions from the serpentine surfaced roads was estimated for three hypothetical exposure durations: 9, 30 and 70 years (adjusted to reflect more realistic exposure conditions of 16-hours per day and 306 days per year). For a “lifetime” (70 year) exposure to the 10 vph/10 mph traffic pattern, the time adjusted estimated risk decreased from 3 additional potential cancer occurrences in one thousand (3×10^{-3}) to 3 additional potential cancer occurrences in 100,000 (3×10^{-5}) as the distance from the road increased from 5 to 190 feet. For the 30 vph/25mph traffic pattern, the airborne asbestos concentrations and associated estimated risk was approximately 10 times higher. These cancer risk estimates likely have substantial uncertainty associated with the exposure estimates.

The study recommends that property owners and agencies responsible for maintaining serpentine roads resurface their roads with non-NOA-containing materials. Until resurfacing is completed, vehicles should be driven slowly over these roads to lessen NOA emissions. The study also made technical recommendations to improve on the design for any future emission studies. Additional Information about measures to reduce exposure to NOA can be found at:
http://www.arb.ca.gov/toxics/Asbestos/general.htm.

2.0 INTRODUCTION

This report describes a NOA emission study conducted by the California Environmental Protection Agency (EPA), Department of Toxic Substances Control (DTSC) on a serpentine covered road located in the community of Garden Valley, California. The purpose of the study was to first measure concentrations of asbestos in the air at selected distances from the road during modeled traffic patterns and to evaluate the effectiveness of resurfacing the road in reducing the concentrations of asbestos in the air near the road. This report describes this study, and includes findings and recommendations for property owners and the public to reduce potential exposure to asbestos from roads that are surfaced with materials that may contain NOA. For the purposes of this document, NOA refers to all mineral forms of asbestos that have been or potentially could be disturbed through human or natural activities. NOA does not include manufactured building or other manufactured products that may contain asbestos. Unless specified, the term “soil” will refer to a heterogeneous mixture of dirt, rock, and/or crushed aggregate.

3.0 BACKGROUND

Garden Valley is located in the foothills of the Sierra Nevada Mountains in El Dorado County, California (Figure 1). The geographic coordinates are approximately 38^{o}51' 15" N latitude and 120^o 51'30" W longitude (Township12N, Range10E, Section 5). The average elevation is approximately 2,000 feet above mean sea level. DTSC chose the boundary of the Garden Valley Site Discovery Area (GVSDA) area as approximately a two-mile radius around the Golden Sierra High School (Figure 2). The community of Garden Valley is located between two north-south trending serpentine deposits. These deposits contain one active serpentine aggregate quarry (Bear Creek Quarry) and one inactive serpentine quarry (Garden Valley Aggregates). NOA is associated with serpentine and other altered ultramafic rocks. Furthermore, serpentine aggregate has been used in many surfacing applications throughout the community, particularly for surfacing private roads and driveways.

In November 1998 and September 1999, the California Air Resources Board (CARB) collected ambient air samples in the Garden Valley community and found NOA concentrations that might pose a risk to human health. Visual observation by DTSC indicated that there were numerous potential sources of NOA within the community that may have been responsible for the measured NOA emissions. NOA in this area is associated with serpentine rock, which is a form of ultramafic rock.

To begin identifying potential NOA sources, DTSC collected soil samples within the sixteen square mile area around the Garden Valley community in the summer of 2000. Figure 2 shows the study area location. The soil samples were collected as part of a site discovery project funded by a Superfund grant from the U.S. EPA. The soil sampling project was the initial step in collecting information to identify potential sources of NOA that might be released to the air within the GVSDA. Potential NOA sources identified in the GVSDA include:

- Two serpentine rock quarries (one active and one inactive);
- Numerous unpaved roads and driveways;
- Road cuts;
- Road shoulders; and
- School bus stops

DTSC collected soil samples in August and September of 2000. Private road samples were collected with property owner’s consent. Inspection warrants were obtained to gain access and collect samples at the Bear Creek Quarry and Garden Valley Aggregates. DTSC collected a total of 137 samples within the GVSDA. Samples were analyzed by Polarized Light Microscopy (PLM) using the CARB 435 Method and by Transmission Electron Microscopy (TEM) according to the U. S. EPA’s “Method for the Determination of Asbestos in Bulk Building Materials” (EPA 600/R-93-116).

The mean concentration of samples from all potential sources listed above analyzed by PLM was 1.1% (number of structures identified). Chrysotile was the only NOA type found during the PLM analysis. The TEM analysis results showed a mean concentration of 2.1% (by weight) NOA. The majority of the NOA detected was chrysotile, although trace amounts of actinolite, tremolite, and anthophyllite were detected in several samples. This data indicates that the serpentine found throughout the GVSDA contains low levels of NOA.

Based upon results of this study and air sampling conducted by DTSC and the ARB, DTSC concluded that the serpentine covered roads in the GVSDA are the primary source of NOA found in ambient air samples. DTSC recommended that the highest priority for further studies should be assessing emissions from the unpaved serpentine roads. Information on the Garden Valley Discovery project can be found in DTSC's "Report on Surface Soil Sampling for Naturally Occurring Asbestos, Garden Valley, California, October 2002".

4.0 HEALTH CONCERNS

There are six minerals whose fibrous forms are defined as asbestos and that are currently regulated. The six regulated forms of asbestos fibers are one from the serpentine family of minerals: chrysotile, and five from the amphibole family: actinolite asbestos, fibrous grunerite (amosite), anthophyllite, fibrous reibeckite (crocidolite), and tremolite. Asbestos minerals may be created from ultramafic rocks. Ultramafic rocks contain two asbestos bearing groups: serpentine asbestos and amphibole asbestos. Serpentine asbestos, which includes the mineral chrysotile, is a magnesium silicate mineral, possessing flexible crystalline fibers that are capable of being woven. Serpentine minerals are usually formed from peridotite by hydrothermal metamorphic processes. Amphibole asbestos, which includes the mineral series tremolite-actinolite, forms crystalline fibers that are substantially more brittle than chrysotile asbestos. Amphiboles, such as the tremolite-actinolite series, are formed principally from metamorphic processes involving ultramafic deposits and are often associated with faulting. While the chrysotile asbestos is often associated with serpentine rock outcrops, amphibole asbestos can also be found in some serpentine formations.

All asbestos minerals are hazardous and when inhaled may cause lung disease and cancer. Health risks are dependent upon human exposure to asbestos fiber. The longer a person is exposed to asbestos and the greater the intensity of exposure, the greater the chances for a health problem. Asbestos-related disease, such as lung cancer, asbestosis, and mesothelioma, may not occur for decades after breathing asbestiform fibers. For mesothelioma cancer, age and time of asbestiform exposure are also factors in increasing risk. For example a ten-year-old child exposed to a certain dose of asbestos for a period of 20 years is at higher risk than a 30 year old with the same exposure. Risk assessment for asbestos is based on fiber concentrations in air. No safe level of asbestos has been established for soil. More information on health effects from asbestos exposure can be found in the fact sheet prepared by the California Office of Environmental Health Hazard Assessment (OEHHA) contained in Appendix A "Asbestos Fact Sheet" and the Agency for Toxic Substances and Disease Registry (ATSDR) "Toxicological Profile for Asbestos", dated September 2001 and published by the Atlanta, Georgia office of the United States Department of Health and Human Services, Public Health Service.

5.0 OTHER NOA ROAD STUDIES IN CALIFORNIA

Roads surfaced with serpentine aggregate have been previously studied in California. The following sections summarize the protocols used in these studies:

5.1 Garden Valley Ranch Estates, California

In July 1986, a resident of the Garden Valley Ranch Estates collected a soil sample from a road within the Garden Valley Ranch Estates subdivision and submitted the material to Thermal Analytical/EAL laboratory. The laboratory analyzed the sample by phase-contrast microscopy. Results indicated the presence of chrysotile NOA ranging in concentration from ten to twenty percent. The resident then contacted the U.S. EPA Emergency Response Program to inform them of the results. U.S. EPA used the National Emissions Standards for Hazardous Air Pollutants (NESHAP) maximum level of one percent asbestos to re-use mine tailings as their action level. USEPA dispatched a Technical Assistance Team (TAT) to the area to collect further samples.

The TAT collected composite soil samples at various locations along the unpaved roads. Sample results showed chrysotile NOA concentrations ranging from two to twenty-five percent. This data along with other factors (e.g., roads located in a residential area) provided U.S. EPA with the rationale to chipseal the serpentine aggregate roads. No emission studies were conducted.

5.2 Knoxville, California

This road study was conducted in 1988 as part of an environmental review evaluation for a United States Department of the Interior Bureau of Land Management (BLM) proposal to construct an off road vehicle park. Roads in the proposed area were covered with serpentine aggregate. Three test runs of one hour each were conducted over three different roads in the vicinity of Knoxville, California. Each test run consisted of driving a Ramcharger four wheel drive vehicle at approximately 16 miles per hour (mph). Polycarbonate sample cassettes where mounted on the right side mirror of a Suburban four wheel drive that followed the Ramcharger during the test runs. Samples were analyzed using TEM. Results ranged from 10.7 to 17.8 NOA structures per cubic centimeter (s/cc) of air.

5.3 Jackson, California

In 1988 U. S. EPA conducted a road study near the City of Jackson, Amador County, California. A 100 foot road segment was selected in an area with relatively flat terrain and open spaces on either side of the road. Three bulk samples were collected across each end and the middle of the road segment being tested. The three samples from each portion of the road were then composited into one sample resulting in one sample each for the middle and ends of the road segment. A fourth bulk sample was collected from the dust that had settled on the rear bumper of the test vehicle at the conclusion of the testing. Ten bulk samples had been collected in September 1987 to confirm the presence of NOA in the road surfacing material. Air sampling stations were established at the midpoint of the road segment and distributed perpendicular to the road with one station placed upwind at 10 feet from the road and five placed downwind of the road at 10, 25, 50,100 and 300 feet. Air samples were collected at one and eight hour intervals over a six day period. Meteorological data was also collected. A compact size vehicle traveled the road segment every 15 minutes at 30 mph. Bulk samples were analyzed using PLM and TEM analysis methods. Bulk sample results ranged from 0 to 7.8% NOA by weight (TEM). Air samples were analyzed using both PCM and TEM. Air sample results for NOA assessed using the TEM method ranged from non-detect at the 100 foot downwind station to 8.996 s/cc at the 10 foot downwind station for the one hour test runs. The eight hour test results for NOA using the TEM method ranged from non-detect to a maximum of 1.068 s/cc, at the 50 foot downwind station.

5.4 Oakdale, California

In August 1991, The CARB conducted a road study in the vicinity of Oakdale. Four road sites surfaced with serpentine aggregate were selected for testing. At each site, a network of four to five NOA monitoring stations was established at distances of 25, 50, 75 and 250 feet from the road in the downwind direction, and 50 feet from the road in the upwind direction. Meteorological stations measured wind speed, wind direction, temperature and humidity. Five to eight tests of one hour each were conducted at each site. Traffic was simulated over a 500 foot section of the road by repeated van trips while air samples were taken and meteorological conditions were monitored. Vehicle speeds were 0, 10, and 25 mph with frequencies of 0, 15, and 45 vehicles per test run. Bulk samples of the road material were also collected and analyzed by PLM using CARB Method 435. The NOA content of the bulk material ranged from 14 to 18.3 % by PLM count. Air samples were analyzed for NOA using both optical and electron microscopes. Measurable levels of NOA were detected at down wind distances up to 250 feet. TEM results for all NOA structures ranged from 0.01 to 10.04 NOA s/cc of air. Results for structures greater than 5 microns ranged from 0.00 to 1.57 NOA s/cc of which chrysotile was the predominant NOA fiber type detected. Some amphiboles were detected.

5.5 Diamond XX, Copperopolis, California

In September 1993, U. S. EPA conducted a serpentine road study in the Diamond XX residential development near Copperopolis, California. Two roads were chosen that had segments that were relatively straight for at least 300 feet, were clear of obstructions for several hundred feet on either side of the road, and ran approximately perpendicular to the prevailing winds. Tests were conducted for three days with two three-hour test runs each day. The test vehicle drove back and forth at 30 mph at 0, 5, and 15 vehicles per hour. Air sampling stations were set up perpendicular to the midpoint of the road segment at distances from the road of 150 feet upwind and 25, 75 and 150 feet downwind. Each station had a high volume sampler to collect samples of total dust and a low volume sampler to collect samples suitable for NOA analysis. NOA air sample filters with heavy loading were analyzed using an indirect preparation method (Chatfield and Berman 1990). A conversion factor was developed to equate the indirect counts to equivalent direct counts. The ISO 10312 method using TEM was used to quantify NOA concentrations on the air filters. Results ranged from 1.04×10^{-4}

to 1.55 s/cc Phase Contrast Microscopy Equivalent (PCME). Bulk soil samples were collected and analyzed using the Berman and Kolk, 1994 Elutriator Method. Average results were 5 X 10^7 structures/gram. The Diamond XX study also calculated risk to various potential receptors and concluded that the level of risk potentially experienced by children riding bicycles along these roads was of particular concern.

6.0 SERPENTINE AGGREGATE ROAD STUDY DESIGN

The serpentine aggregate road study is based upon the recommendation outlined in DTSC's October 2002 Garden Valley Study Area report to conduct emissions studies from a typical road surfaced with serpentine aggregate in the Garden Valley area. The goal is to begin understanding the contribution to air concentrations of NOA from roads. The specific objectives of the Slodusty Road study were to:

- Measure NOA concentrations in the road surfacing materials to identify potential source concentrations
- Using stationary samplers, measure concentrations of NOA in the air at prescribed distances from the road under controlled traffic conditions,
- Examine the use of hand held particulate meters as an indicator of NOA concentrations
- Evaluate the effectiveness of resurfacing the road in reducing the concentrations of NOA in the air near the road.
- Estimate the potential risk from NOA emissions and the risk reduction from resurfacing the road

The focused objectives, methodologies, results, conclusions and recommendations from this study are summarized in this report. The full study is described in appendices to this report.

The following criteria were used to select a study road within the Garden Valley area:

- Must be surfaced with serpentine aggregate;
- Must contain typical concentrations of NOA,
- Must be a fairly straight road for at least 100 feet;
- Must be located where native soils are not serpentine (the only source of NOA would be the serpentine gravel on the road);
- Should have little to no tree cover that would interfere with wind movement;
- Should have fairly flat topography to collect up-wind and down-wind samples; and,
- Permission can be obtained from property owners to do the study, including resurfacing the road.

Slodusty Road met all of these criteria. See Figure 2 for location of Slodusty Road in the Garden Valley Study Area. Slodusty Road was surfaced with serpentine aggregate. The NOA concentrations from bulk samples collected from Slodusty Road during the previous discovery project showed concentrations that were typical for the Garden Valley area. The road is straight to slightly curving for approximately 175 linear feet. The native soils in the immediate vicinity of the road did not originate from serpentine minerals. Open fields with only a few trees are located on both sides of the road for approximately 200 feet, and the property owners provided consent to do the study.

7.0 NOA CONCENTRATIONS IN THE ROAD SURFACING MATERIAL

7.1 Study Objectives and Design

The objective of sampling the road surface was to obtain representative bulk concentrations of NOA by collecting bulk samples at several locations across and over the length of the road segment being studied. The results would represent the source concentrations that could potentially be emitted to the air. Fine and coarse size fractions were evaluated to look at the NOA concentration that could be immediately released (fine fraction) and the NOA concentrations that could be released over time (coarse fraction). In addition samples were analyzed by two different methods: a method commonly used to determine asbestos in bulk building material (Bulk Method), and a modified Superfund method designed to measure releasable asbestos in soils (Elutriator Method).

Currently, risk from asbestos exposures, including NOA, is assessed by measuring concentrations in air. These studies are costly and time consuming. A long term goal is to find an inexpensive way to measure NOA concentrations in bulk materials so that the results can be used for making decisions about when actions are needed to mitigate exposures. To do so, a method is needed that can link bulk material concentrations with air concentrations of NOA. The Elutriator Method is one such method developed in an attempt to bridge this gap. A second method is currently being reviewed by USEPA, called the “glove box” method. Both methods take bulk soil samples and mechanically disturb the sample to generate dust that is collected on a filter that is analyzed using standard air analysis methods. As part of the road sampling study, DTSC looked at the fine fraction of bulk material to see if there is a correlation between this measurement and the Elutriator Method. If a correlation exists, measuring NOA concentrations in the fine fraction of bulk material may be the least expensive approach to evaluate NOA exposure conditions.

The DTSC October 2002 report showed concentrations of NOA in bulk samples ranging from 1.20 to 2.80% by weight from the four samples collected on Slodusty Road**.** Chrysotile was the primary type of asbestos detected. These NOA concentrations were within the typical range of NOA found in bulk samples collected from roads in the Garden Valley Discovery Project.

As part of the Initial Study, DTSC collected bulk samples from the road segment being tested for NOA analysis. Details of the bulk sample collection and analysis procedure are contained in Appendix B to this report and are summarized in the following discussion.

The Elutriator Method and the Bulk Method are very different methods. The Elutriator Method attempts to mimic soil disturbance that would be expected to occur from activities such as driving on aggregate surfaced roads. The Elutriator Method is considered a direct method. A bulk sample is agitated creating dust which is passed into the elutriator and collected directly onto a filter. The Bulk Method is considered an indirect method. The bulk sample is processed by milling (grinding) to a size that will pass through a #200 mesh sieve. A small sub-sample is placed in a known volume of water and sonicated to disperse the particles evenly throughout the water. The water sample is then filtered through a millipore filter to collect the dispersed particles evenly over the filter surface. The indirect method may result in more of the asbestos clusters being broken into fibers. The direct method may result in retaining more of the bundle, cluster and other matrix structures found in the original sample. Once the sample is deposited on the filter from either method, the sample preparation for TEM analysis is essentially identical.

As shown in the Figure 3, five transects crossing the road perpendicular to the direction of traffic flow were evenly spaced along the length of the road segment being tested. Five discrete samples were collected from each transect as follows: each of the tire paths (two samples) the center of the road (one sample), and each edge (two samples). Twenty-five discrete samples were collected. The transects were spaced 30 feet apart covering a total road distance of 120 feet.

Each of the twenty-five samples was divided into two portions using a riffle splitter. One portion from each of the five samples from each transect was composited into one sample to represent each transect yielding a total of five samples. Each of the composited samples was analyzed using the Elutriator Method.

Each of the remaining portions of the discrete samples was further divided into a coarse and a fine fraction by sieving with a #200 mesh (75 micron) sieve. Each of the coarse and fine fractions was separately analyzed for a total of 50 samples. These samples were analyzed using the Bulk Method.

There are some differences in the asbestos fiber counting rules which are primarily important for the Elutriator Method because of all the complex structures that appear on the filter. The two methods report asbestos content differently. The Elutriator Method reports total and long structures by type of asbestos according to a protocol. To be counted a fiber must be longer than 5um (micrometer or micron) and less than 0.5 um diameter. Long structures are greater than 10 um and less than 0.5 um in diameter. All other structures are excluded. For this road study, all structures greater than 0.5 um with a 3:1 aspect ratio were also reported by the lab. The results are reported in units of the number of structures per gram of PM_{10} dust particles and structures per gram of total sample weight. The PM_{10} particles represent the fraction of particles that measure less than 10 um in length. Scientists believe that the PM_{10} fraction is the critical particle size capable of penetrating deep into the lungs.

The Bulk Method reports asbestos concentration by percent weight of asbestos to the sample weight. To determine the weight of asbestos, the volume of each type of asbestos structure is calculated and multiplied by the density of the type of asbestos identified. The weights of each type of asbestos in the sample are then summed to obtain the total asbestos weight.

7.2 Bulk Sample Results

Table 1 "NOA Bulk Data Results" summarizes the results of these analyses. This table compares the NOA concentrations measured by the Bulk Method for both the less than 200 mesh and greater than 200 mesh fractions with the results from the Elutriator Method. Results are shown for each discrete sample, the average content for each transect and the single sample results for each transect using the Elutriator Method. It is important to note that the results are reported in different units. The Bulk Method results are reported as percent by weight and the elutriator results are reported in structures counted per gram of solid material or per gram PM_{10} particulate matter in the total sample.

The study results show that the average bulk concentration ranged from 0.2% to 7.8% in the discrete samples. Average concentrations among the transects range from 1.14% to 2.82%. These NOA concentrations are typical for serpentine aggregate surfaced roads within the Garden Valley area. These concentrations were generally lower than bulk concentrations measured in the road studies conducted in other areas of California as described earlier in this report. The NOA concentrations are less than the 5.0 % allowed in road surfacing materials under CARBs' 1990 ATCM. The ATCM was revised in November 2001. Currently, new road surfacing materials must contain less than 0.25 % NOA as measured by CARB method 435 using a 400 point count procedure. The ATCM only addresses NOA content in new materials. NOA content in existing roads are not addressed in the ATCM.

As described in Appendix B and shown in Figure 4, there appears to be a correlation between the less than 200 mesh fraction analyzed by the Bulk Method and the Elutriator Method results. Due to the limited number of samples, additional studies are needed to evaluate the potential correlation with greater certainty.

A linear regression is a mathematical method of comparing data sets to see if there may be a relationship or correlation. Regressions were run comparing the results of the Bulk Method to the Elutriator Method. Because the samples for the Elutriator Method were sector composites, the average results for each sector of the Bulk Method were used for the comparison. The regression comparing the less than 200 mesh fraction (by Bulk Method) shows good correlation with the PM_{10} fraction results produced by the Elutriator Method (R^2=0.945). While the correlation was good, only five data point pairs were involved which is insufficient to draw any conclusion. The data suggests that there may be a strong correlation. However, to confirm these findings, further studies are needed. Such a correlation could allow the use of the Bulk Method results from the fine fraction to assess risk to the same extent as the Elutriator Method results.

High variability in NOA concentrations was noted for the greater than 200 mesh fraction analyzed using the Bulk Method. The reasons for this variability could be due to the following factors:

- Environmental variability
- Use of a second lab to mill the samples
- The process of milling the larger particles

8.0 NOA EMISSION STUDY

8.1 Study Objectives and Design:

The objectives of the emission study were to measure NOA concentrations at prescribed distances on each side of the road segment under two traffic patterns. The first pattern represents typical driving speeds and frequency used by the residents along the road and the second represents the safe maximum velocity and vehicle frequency on the road. The tests were run before and after resurfacing the road in order to evaluate the reduction in NOA emissions from resurfacing the road.

In 2002, DTSC established an Interagency Agreement with the U.S. Department of Transportation's, John A. Volpe National Transportation Systems Center (Volpe). The agreement was established to assist DTSC in addressing concerns regarding potential exposure to airborne NOA fibers resulting from vehicular traffic along unpaved roadways known to contain NOA within the Garden Valley community. Volpe support included providing DTSC with a variety of technical and scientific services related to assessing NOA emissions from unpaved roads.

In July 2002, Volpe and DTSC conducted the Initial Study phase, as described below and in Appendix C. In early August 2003, DTSC resurfaced Slodusty Road with chipseal and limestone aggregate surfacing materials that did not contain NOA. These materials were presumed to provide an effective seal to prevent releases of NOA from the underlying materials. Approximately four inches of ¾ inch aggregate was added to the road and the road surface was compacted. The road was then covered with a chipseal solution to seal and cement the aggregate. A top surface of fine limestone aggregate was subsequently applied. Approximately one week later, Volpe returned with DTSC to resample NOA air emissions along the roadway.

Both the Initial Study and the Post-Resurfacing Study sampling events involved monitoring levels of airborne NOA on a selected section of the road. The sampling was completed at discrete distances on either side the road. Figure 5 shows the location of stationary samplers in relation to the road. Two traffic patterns were tested using the same two test vehicles, a four wheel drive truck and a compact sedan. A 25 miles per hour (mph)/30 vehicles per hour (vph) traffic pattern was chosen to represent a worst case traffic condition for Slodusty Road and a 10 mph/10 vph traffic pattern was chosen to represent typical speed and traffic conditions expected on Slodusty Road. Residents have informally posted 10 mph as the speed limit for the road. Local traffic frequencies observed during both sampling events confirmed the 10 mph/10 vph traffic pattern to be representative of typical driving conditions. Each traffic pattern was tested for two hours. Stationary sample cassettes where collected for analysis at the end of each run. Details of the sampler flow rates, volumes of air drawn through individual cartridges, and specific sample results are described in Appendix C.

The stationary air samplers were located at similar distances on both (east and west) sides of the road, along a transect approximately perpendicular to the road. Samplers were stationed at 5, 10, 30, 50, 80, 100, 160, and 190 feet from the road. In order to directly compare sampling results collected during the Initial Study and Post-Resurfacing Study, the air samplers were positioned at the same locations, with two exceptions. During the post resurfacing study, an additional air station was established at a further distance (300 ft) on the west side of the road. A similar station was not established on the east side due to physical barriers. Another air station was established at a residence on Bayleaf Drive approximately 1.5 miles from the site to serve as an ambient background location.

Ambient air samples were collected by drawing a measured volume of air through a 25 mm diameter mixed cellulose ester membrane filter of pore size 0.45 um by means of a battery powered pump. The stationary sampler cartridges were collected for analysis after each run. Flow rates were calibrated before and after each run. All analyses were performed by laboratories that are fully accredited under the National Voluntary Laboratory Accreditation Program (NVLAP).

During each emission air sampling event meteorological data, particulate data, and personal air samples were also collected. Information about these studies is described in sections following the Stationary Air Sampling sections.

8.2 Stationary Air Sampling

Stationary air samples were collected to represent both tested traffic patterns. Stationary air samples were analyzed using the ISO 10312 TEM (ISO) Method. The ISO Method was selected in order to be able to gain a better understanding of the fiber distribution within the samples. Some laboratory difficulties were encountered during this study. The laboratory problems were primarily based on the analyst's interpretation of scrolled lizardite vs. chrysotile. Many of the structures were observed to have splayed ends ("weathered") and some of them also were observed to have a tubular appearance. Based on these observations the two laboratories used in the study had differences in analyzing the samples. One of the laboratories classified many of the chrysotile structures as "scrolled lizardite". However, based on further evaluation of micrographs, and numerous discussions among several experienced microscopists, it was determined that these structures should be classified as chrysotile structures. The AHERA method was also used for analysis of the stationary samples. A stopping rule of ten grid openings was established in order to assure analytical efficiencies of resources, time, production and cost.

The AHERA Method requires that a minimum of 580 liters (L) of air be collected for each sample and that the analytical sensitivity be no greater than 0.005 s/cc. One of the purposes of the Initial Study was to maximize the flow rate for each sample location during each traffic pattern in order to collect the largest volume possible without overloading the sample with particulates. Due to the experimental nature of the Initial Study, twelve samples were collected with volumes less than the 580 L required. All twelve samples were collected within 10 ft of the road during 25 mph (30 vph) traffic patterns, which were observed to generate greater amounts of particulate requiring reduced flow rates within immediate proximity to the road. Based on the Initial Study samples the flow rates were adjusted during the Post Resurfacing sampling and consequently only four of the 96 samples were collected with volumes less than the

AHERA 580 L requirement. All four samples were collected within 5 ft of the road during 25 mph (30 vph) traffic patterns with volumes ranging from 462 L to 494 L and sensitivities ranging from 0.0069 s/cc to 0.0074 s/cc. In the case of each of the four samples the asbestos concentration exceeded the analytical sensitivity. A maximum of ten grid openings are analyzed for an AHERA analysis, regardless of sample volume and as a result in some instances the specified analytical sensitivity of 0.005 s/cc was not reached.

The Initial Study results indicated the presence of NOA at all distances. The NOA concentrations of the air samples varied with proximity to the road and the traffic pattern. Tables 2 and 3 compare the results of the Initial Study and the Post-Resurfacing Study for the 10mph/10 vph and 25mph/30vph traffic patterns respectively. Initial Study results ranged from 0.0093 s /cc at the farthest station during the 10mph/10 vph pattern to 9.5 s/cc at 5 feet from the road during the 25mph/30 vph pattern. At 190 ft, which was the furthest sample collected during the Initial Study, the average concentration was still a significant 0.1870 s/cc for the 25 mph/30 vph traffic pattern. Figures 6, 7 and 8 show plots of the Initial Study results averaged for the same distances on both sides of the road. The full data set showing discrete concentrations for each side of the road is contained in Appendix C and estimated risk associated with each location is contained in Appendix D. The figures show that the NOA concentrations were significantly higher 5 feet from the roadway, with the concentration at 10 feet being 64% to 70% lower for both traffic pattern runs. As the distance from the roadway increases beyond 10 feet, the concentration reduction was much more gradual, dropping by approximately 40% every 20 feet. In addition to distance, traffic conditions appear to significantly affect the levels of NOA that were emitted from the road. The concentrations at all distances were approximately an order of magnitude higher for the 25 mph/30 vph pattern compared to the 10 mph/10 vph pattern.

Following completion of the resurfacing activities, the stationary sampling was repeated during the summer of 2003 (Post- Resurfacing Study) following the same protocols used for the initial study. None of the sample filters were overloaded so all the samples were analyzed using a direct sample preparation procedure. The NOA concentrations of these samples also varied with proximity and traffic pattern, ranging from less than 0.0043 s/cc to 0.0654 s/cc. The sample result from the background station shows a NOA concentration of 0.0047 s/cc. As shown in Table 5 and Figure 9, unlike the Initial Study, there is no apparent trend to the NOA concentrations based on distance from the road for the 10 mph/10 vph pattern. For the 25 mph/30 vph pattern, sample results measured at 5 feet from the road show elevated results compared to sampling stations further from the roadway. Post -Resurfacing sample results show up to a 100 fold reduction in NOA concentrations in air adjacent to the road as compared to the Initial Study results. The lowest NOA concentrations measured were similar to background levels in the community. The 10 mph/10 vph NOA concentration results were generally lower than those measured during the 25 mph/35 vph pattern. The results from both traffic patterns tended to be slightly higher than the results from the no traffic pattern and the background sample. It should be noted that these observed reductions are based on Post Resurfacing sampling that was performed one week following the completion of the road resurfacing activities and that there was no precipitation during the week.

The Post Resurfacing Study sample results show that NOA concentrations generally decline with distance from the road. NOA fibers were primarily complex chrysotile structures less than 5 microns in length, with a few free scattered chrysotile fibers. Approximately 90% of the NOA structures observed are less than 5.0 microns in length. Table 5 shows post resurfacing results. Figure 9 shows a comparison of post resurfacing average concentrations for all scenarios.

8.3 Meteorological Sampling:

Meteorological data was collected to measure wind speed and direction, as well as temperature and humidity. Details of the monitoring are described in Appendix C. Ideally, meteorological conditions should be similar for the Initial Study and the Post Resurfacing Study in order to have higher confidence in comparing the results and estimating the reduction of NOA emissions due to resurfacing the road. The measured meteorological conditions were very similar during both the Initial Study and Post-Resurfacing Study sampling events. Wind conditions were on average very consistent between the two studies, with little fluctuation during the day. The winds were predominantly out of the west and northwest direction and were generally less than 8 mph. The average morning temperature readings ranged from 82.4 to 88.6 degrees Fahrenheit, with temperatures increasing in the afternoon ranging from 89.8 to 90.0 degrees Fahrenheit. The afternoon relative humidity readings were also similar, ranging from 23.3% to 26.0%. However, the average morning relative humidity readings were higher during the Initial Study than they were during the Post-Resurfacing Study (49.5% compared to 27.6%).

8.4 Particulate Sampling:

Dust meters that provide instantaneous (real time) readings were used to collect measurements at different times near several of the stationary samplers. The objective was to examine the viability of using dust meters as indicators of NOA concentrations in the air. Particulate measurements were collected by DTSC during both the Initial Study and Post-Resurfacing Study emissions sampling events as field screening indicators for assessing dust generation. During the Initial Study, spot measurements were taken west of the roadway at various distances (5, 10, 30, 50, 80, and 100 ft) during the two different traffic pattern tests. The particulate measurements ranged from 0.02 to 3.48 milligram per cubic meter (mg/m^3) of air, depending on proximity to the roadway. Post - Resurfacing Study measurements were taken only within immediate proximity to the road. Comparison of measurements between the two studies shows a dramatic decrease in dust generated from the road. Measurements ranged from 0.005 to 0.015 mg/m^3 for the Post-Resurfacing Study compared to Initial Study readings of 1.01 to 2.54 mg/m^3 at the same distances.

Based on a limited set of particulate readings it appears the resurfacing activities reduced particulate emissions by more than 99% near Slodusty Road. No direct correlation between particulate meter readings and NOA concentrations was found. Qualitatively, visible dust is an indicator that NOA may be released. However, airborne NOA may be present at significant levels even when dust is not visibly observed, as was indicated by the Initial Study results that showed significant NOA concentrations at 190 feet from the road despite the lack of visible dust at that distance.

8.5 Personal Air Sampling:

Air samples were collected using personal air pumps worn by workers to monitor NOA concentrations during the Initial Study, the road resurfacing, and the Post-Resurfacing Study. The objective of the personal air monitoring was to monitor staff to protect their health and safety and to comply with OSHA worker health and safety requirements. The Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) is based on PCM analytical results. The OSHA 8-hour time-weighted-average (TWA) PEL is 0.1 f/cc.

As a precautionary measure, DTSC staff working in areas with highly visible dust wore full face respirators equipped with air purifying cartridges to trap dust and NOA fibers. Staff activities included driving vehicles, controlling traffic, setting up and maintaining stationary monitors, and observing resurfacing operations. No attempt was made to link specific activities to specific staff. As a result, the data cannot be used to evaluate airborne NOA exposure for specific field activities.

Air samples were collected on 25 mm diameter, 0.8 um pore cellulose ester membranes in conductive cowl cassettes. Air volumes drawn through the samplers ranged from 140 liters to 752 liters of air. All personal samples were analyzed via both Phase Contrast Microscopy (PCM) and Transmission Electron Microscopy (AHERA TEM analysis). A limitation of PCM technology is that it is unable to distinguish between NOA fibers and non-NOA fibers. Due to this known limitation the personal samples were also analyzed via TEM-AHERA, in order to identify asbestos fibers.

Results of these analyses are included in Table 4 . Initial Study PCM TWA results ranged from less than 0.0033 f/cc to 0.0158 f/cc. TEM TWA results ranged from 0.056 s/cc to 1.6875 s/cc. All of the Post-Resurfacing Study personal PCM TWA concentrations were significantly below the OSHA PCM PEL of 0.1 f/cc. Results ranged from less than 0.0045 f/cc to 0.0158 f/cc. TEM TWA results ranged from less than 0.0044 s/cc to 0.3825 s/cc.

All of the Initial Study and Post-Resurfacing Study PCM TWA concentrations are significantly below the OSHA PCM PEL. The TEM results were not used to make decisions for compliance with Cal OSHA requirements. A comparison of the Initial Study PCM and TEM results indicated no apparent trend between the results other than the TEM results were higher in concentration because TEM is able to detect smaller and thinner structures than PCM.

A personal air monitor was also placed in a test vehicle for four hours to assess NOA air concentrations inside the vehicle. TWA results using PCM analysis were 0.0130 f/cc and 0.2844 s/cc using TEM analysis. The test vehicle was driven with windows up and the air condition venting system was on recirculation. As such these conditions do not represent typical driving conditions where the vehicle ventilation system is open or windows are down. Also, because the vehicles were driven for a brief time on a few isolated days, the measured NOA concentrations inside the vehicle do not represent long term exposures from riding in vehicles being driven over the road. Other studies conducted by USEPA in Libby, Montana and at the Clear Creek Recreational Area have shown that NOA concentrations inside vehicles can be much higher than measured in this study.

8.6 Resurfacing Measures

Between the Initial Study and the Post Resurfacing Study, the test section of Slodusty Road was resurfaced. In addition Garden View Court, Garden View Road, and approximately 100 feet of Bayleaf Drive were resurfaced using an asphalt chip seal. These roads are adjacent to Golden Sierra High School and were sealed to prevent the release of airborne asbestos from traffic that could impact the school. A total of 8,775 linear feet (approximately 1.7 miles) of road were sealed during this study. The purpose of sealing the roads was to provide an effective barrier between the serpentine gravel and vehicle traffic. Figure 10 shows the location of the roads that were resurfaced.

This sealing process involves wetting and compacting the existing serpentine gravel road then wetting and compacting (to 95% of maximum compaction) 4-inches of class 2 limestone aggregate base (AB). Asphalt tack coat was then sprayed on the AB. Finally limestone pea gravel was spread over the tack coat layer. The limestone pea gravel was then compacted.

9.0 RISK ASSESSMENT:

Using the emissions data collected, the Cal EPA, Office of Environmental Health Hazard Assessment (OEHHA) prepared a report describing the potential health risk from exposure to NOA concentrations measured in the emission studies. The OEHHA report is included as Appendix D to this report and summarized below.

Potential cancer risk estimates were calculated using OEHHA protocols with conservative assumptions for chronic exposure. These protocols include using all the NOA structures counted regardless of their size. Because the cancer slope factors are based on studies where PCM technology was used, OEHHA uses a conversion factor of 320 to equate TEM structure counts to approximate the number of PCM structures in the sample. The TEM concentration in s/cc is converted to s/m^3 by multiplying by 10^6. The result is then divided by 320 to obtain the equivalent PCM concentration. Potential risk is estimated by multiplying the calculated PCM concentration of NOA by the unit risk factor which is 1.9/100 PCM s/m^3.

Several exposure scenarios were evaluated for potential airborne NOA exposures. Risk calculations were performed for each sampling station for each of the traffic patterns with the different exposure scenarios.

The first scenario is the most conservative and assumes a person spends every hour of every day for a 70 year lifetime at the same distance from the road where the NOA concentration was measured. It also assumes that the NOA concentrations measured at the respective distance from the road remain in the air at that concentration for the entire 70 years. This scenario is unlikely to occur.

The second set of scenarios adjusts the exposure factors for fewer hours per day, days per year, and years of potential exposure. In the second scenario the number of hours per day of exposure is reduced to 16 hours. Traffic is reasonably expected to use the road from approximately 5 AM – 9 PM. This scenario still assumes that the measured NOA concentrations remain constant at the levels measured for respective distances from the road for the entire 16 hours. In addition, the number of days per year that exposure occurs was reduced to 306 days to account for 59 rain days per year. This is the average number of rain days in the Sacramento area as recorded by the US National Weather Service. It is expected that NOA emissions to the air would be minimal on rain days. Risk calculations were made for three different exposure durations including 70 years (lifetime), 30 years and 9 years. As was done for the first scenario, estimated risks were calculated for each distance from the road where data was collected.

Table 6 shows the range of estimated potential risk for each of these exposure durations for the Initial Study results. Table 7 shows the range of estimated potential risk for each of the exposure durations using Post-Resurfacing Study results. Tables showing the results of all risk calculations for each distance from the road, each traffic pattern, and each of the three exposure durations are in Appendix D.

For the Initial Study, calculated risks range from 4 x 10^{-6} or 4 potential excess cancers in a population of one million people to 3.x 10^{-2}, or 3 potential additional cancers in a population of 100 people. The lowest estimated risk is associated with NOA concentrations at the farthest distance from the road, the fewest vehicles, the lowest speeds, and a 9 year exposure duration. The highest calculated risk occurs closest to the road with 70 years of exposure, higher number of vehicles, and higher speeds. For a 70 year exposure to the "typical" 10 vph/10 mph traffic pattern, the time adjusted estimated risk decreased from 3 additional potential cancer occurrences in one thousand (3 X 10^{-3}) to 3 additional potential cancer occurrences in 100,000 (3 X 10^{-5}) as the distance from the road increased from 5 to 190 feet. For the 30 vph/25mph traffic pattern, the airborne asbestos concentrations and associated estimated risk was approximately 10 times higher. The risk estimates show that the potential risk decreases with increasing distance from the roadside. Also, that estimated risk is greater downwind of the road as compared with the upwind direction. Also, it is important to note that significant potential risk is estimated for the farthest distance where airborne NOA was measured, particularly for the 25 mph/30 vph traffic pattern.

For the Post-Resurfacing Study, calculated risks for the 10 mph/10 vph traffic pattern range from 5.3×10^{-6} to 1.5×10^{-4} and for the 25 mph/30 vph pattern range from 1.3×10^{-5} to 2.9×10^{-4}.

The estimated cancer risks associated with the post-resurfacing 10 mph/10 vph traffic pattern were approximately 10 to 100 times less than those of the corresponding Initial Study 10 vph/10 mph traffic pattern, depending on wind direction and sampling distance from the road. The estimated cancer risks associated with the Post-Resurfacing 25 mph/30 vph traffic pattern were approximately 10 to 1000 times less than those of the corresponding Initial Study 25 mph/30 vph traffic pattern, depending on wind direction and sampling distance from the road. Sample results at the farthest station from the road were comparable to the measured background NOA concentration.

There is substantial uncertainty in these risk estimates. Sources of uncertainty include:

- Short term data were applied to long term exposure assumptions
- The data collected may or may not represent typical conditions
- Measured wind speed and directions may or may not represent typical weather conditions
- The number of vehicles and their speed may or may not represent typical use of the road
- The time adjusted estimates also assume that the average number of rain days in Garden Valley is the same as Sacramento
- Residents may or may not live on Slodusty Road for 9, 30 or 70 years, and
- Residents may or may not spend 16 hours per day for 306 days per year at home.

10.0 GENERAL CONCLUSIONS:

- Slodusty Road serpentine road surfacing material had an average NOA concentration of 1.9 % by weight. NOA concentrations in bulk soil samples from this study were less than NOA concentrations identified in previous road emission studies.

- Vehicular traffic created significant NOA emissions to the air at these relatively low concentrations of NOA in the road surface.

- Results from this NOA emissions study demonstrated that resurfacing the serpentine aggregate road with a multi-layered chipseal surface resulted in a dramatic reduction in NOA emissions.

- Other potential sources of NOA releases around Slodusty Road were not evaluated or included in the risk assessment.

- This study shows that the air borne NOA concentration decreases with distance from a serpentine aggregate covered road. While distance from the road appears to reduce exposure to airborne NOA for this road, local conditions around other serpentine covered roads may show different results. Factors such as wind direction or velocity, NOA concentration in the road surfacing material, presence of trees and shrubs, moisture conditions, topography and presence of NOA in native soil or fill material among others may result in different emissions from a specific road or driveway.

- Driving slower reduced emissions. Emission results from the 10 mph/10 vph traffic pattern were 10-fold lower than 25 mph/30 vph traffic pattern results.

- NOA fibers were detected at greater distances than visible dust. When you cannot see dust, it does not mean that NOA is not present in the air.

- The risk assessment calculations demonstrate that risk was significantly reduced following the resurfacing of the road.

- The post resurfacing samples were collected within one week of resurfacing the road and no rain events occurred between the resurfacing and air sample collection. As a result, dust and NOA fibers that had previously been deposited on vegetation and soil adjacent to the road could have been re-suspended by wind and air disturbances from passing vehicles during the post-resurfacing traffic simulations. It is anticipated that air sample results would show lower NOA concentrations following rain events that would “clean” the adjacent vegetation.

- Because the NOA containing serpentine aggregate is covered and sealed by the new resurfacing materials, it is anticipated that NOA concentrations in the air adjacent to the road will continue to remain low.

11.0 GENERAL RECOMMENDATIONS:

- Roads that are presently surfaced with serpentine aggregate should be resurfaced to reduce NOA emissions. The goal of resurfacing is to reduce emissions by selecting resurfacing materials and techniques that fully cover or encapsulate the road bed. Consideration should also be given to how long the surfacing material effectively contains the NOA and the cost of installation and maintenance. For Slodusty Road, the chipseal was determined to be cost-effective and acceptable to residents and property owners responsible for road maintenance. Other road surfacing materials and techniques were not evaluated as part of this study. Other methods may be as effective or more effective in reducing NOA emissions.

- Until serpentine aggregate surface roads can be resurfaced, users should drive slowly to minimize dust generation.

- Results from this study and other studies conducted on serpentine aggregate roads show that significant concentrations of NOA can be released to the air from vehicle traffic and that resurfacing roads with non-NOA-containing materials can significantly reduce air concentrations and lower risk to residents and users of these roads. In Garden Valley, serpentine roads are primarily privately owned. However, local, state and federal agencies responsible for maintaining public roads should also prioritize and resurface existing serpentine roads where significant public exposure occurs.

- Other activities, particularly if they occur on or near roads, driveways or walkways that are surfaced with materials that contain NOA, may result in release of NOA to air. Rototilling, lawn mowing, clearing vegetation, digging and recreational activities in areas that contain NOA or are secondarily impacted by NOA emissions may result in release of NOA fibers and potential increased exposure over ambient conditions. When engaging in these activities, residents and workers should take precautions to minimize emissions.

- Consult ARB website for measures to reduce exposure from other sources of NOA such as dust in homes, vehicles, walkways and driveways.

12.0 RECOMMENDATIONS FOR TECHINCAL EVALUATIONS IF FUTURE STUDIES ARE CONDUCTED:

Considering the findings from these studies, if future investigative activities related to NOA emissions along serpentine roadways are conducted, DTSC has that following technical recommendations.

- **Operational Improvements:** Potential operational improvements were identified during the Initial Study. These improvements were incorporated into the Post-Resurfacing Study sampling activities. In addition to those already incorporated, future air emission sampling events should consider the following:

  1. Collecting replicate (co-located) stationary samples at a frequency of 10% to increase quality control and quality assurance of the data collected.
  2. Collecting specific activity based samples for the personnel conducting the studies using personal air monitors as well as sampling for the duration of the complete study, in order to obtain a better understanding of potential exposure from the activities.
  3. Collecting additional "background" samples, in order to obtain a better representation of actual background levels for the area
  4. Collecting additional stationary samples at further distances from the roadside (i.e. greater than 300 feet, if possible) to evaluate the distance NOA fibers can travel under study conditions and
  5. If possible, selecting a test area with no vegetative or physical barriers, on either side of the road, that may alter meteorological conditions or limit stationary sample locations.

- **Follow-up Monitoring Along Slodusty Road:** Based on a comparison of the Initial Study and Post-Resurfacing Study results, it appears that the resurfacing activities reduced airborne NOA concentrations by 93% to 98%, near Slodusty Road. However, the long-term effectiveness of the resurfacing approach is unknown. The Post-Resurfacing Study sampling activities should be repeated along Slodusty Road in the future to verify vehicular traffic has not over time broken down the chipseal barrier to release the NOA fibers present within the original roadbed.

- **Monitoring of Airborne NOA Near Additional Unpaved Serpentine Roads:** The Post-Resurfacing Study sampling activities could be repeated along other similar unpaved roadways that have been sampled and identified to contain levels of NOA within the roadbed that are less than those found in Garden Valley, including an unpaved serpentine roadway where bulk samples were collected and found not to contain NOA within the roadbed. Sampling along a roadway where NOA is identified to be non-detect is important due to known limitations associated with analyzing for NOA within environmental media, such as a soil or gravel matrix.

The results from these sampling events could supplement the data from the Initial Study to create a data matrix for assessing potential NOA emissions at other unpaved serpentine roadways based on the level of NOA identified to be within the roadbed. A “screening” matrix of this type would enable decision makers to make initial conclusions based on bulk sampling of roadways which is a more economical and efficient approach than conducting air sampling along each of an area’s unpaved serpentine roadways. A screening matrix will also enable decision makers to prioritize among roadways determined to require further investigative and/or resurfacing activities.

- **Investigations for Other Sources of NOA Emissions:** The resurfacing activities have significantly reduced airborne NOA concentrations associated with vehicular traffic along Slodusty Road. The Initial Study results have indicated that NOA fibers have been transported from the roadway and potentially at distances greater than 300 feet. NOA fibers are environmentally persistent and as such, may still be present and a potential concern. Other sources and exposure routes should be investigated. Potential other sources include, but are not limited to dust inside residences, dust in vehicles driven or stored in the area, and soil adjacent to the roadway. Past studies have indicated that due to the persistent and physical characteristics of NOA fibers they have the potential to accumulate over time within residences and vehicles.

13.0 REFERENCES

40 Code of Federal Regulations – Chapter I – Part 763 –Appendix A to Subpart E: "Asbestos Hazard Emergency Response Act".

California Air Resources Board: "Development of a Technique to Estimate Ambient Asbestos Downwind from Serpentine Covered Roadways", Prepared by Valley Research Corporation, August 1992

California Air Resources Board: Method 435 "Determination of Asbestos Content of Serpentine Aggregate"; adopted June 6, 1991

California Code of Regulations: Title 8, Section 5208; "Asbestos"; Subchapter 7. "General Industry Safety Orders"; Group 16. "Control of Hazardous Substances"; Article 110. "Regulated Carcinogens"

Department of Toxic Substances Control: "Report on Surface Soil Sampling for Naturally Occurring Asbestos, Garden Valley, California", October 2002**.**

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U. S. BLM: "Knoxville Asbestos Survey", Lake County Air Quality Management District, April 15, 1988.

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U. S. EPA; "Garden Valley Ranch Estates Community Services District Asbestos Site", Garden Valley, CA; prepared by Roy F. Weston, Inc et al October 10, 1986

U. S. EPA "Superfund Method for Determination of Releasable Asbestos in Soils and Bulk Material; EPA 540R-97-028"; 1997

U. S. EPA draft “Modified Elutriator Method for the Determination of Asbestos in Soils and Bulk Material,” D. Berman & A. Kolk, May 23, 2000.

14.0 LIST OF ACRONYMS

AHERA	Asbestos Hazard Emergency Response Act
ATSDR:	Agency for Toxic Substances and Disease Registry
CARB	California Air Resources Board
DTSC	Department of Toxic Substances Control
EDDs	Electronic Data Deliverables
GVSDA	Garden Valley Study Area
MG/M^3	Milligrams per cubic meter
MPH	Miles per hour
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NOA	Naturally Occurring Asbestos
NVLAP	National Voluntary Laboratory Accreditation Program
OSHA	Occupational Safety and Health Administration
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscopy Equivalent
PEL	Permissible Exposure Level
PLM	Polarized Light Microscopy
S/CC	Structures per cubic centimeter
TAMS	Transportable Automated MET Station
TEM	Transmission Electron Microscopy
TWA	Time Weighted Average
USBLM	United States Bureau of Land Management
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VPH	Vehicles per hour

TABLE 1
NOA Bulk Data Results

	Bulk Method				Elutriator Method			
Sample ID	Asbestos Concentration <200 Mesh (% by weight)	Asbestos Concentration >200 Mesh (% by weight)	Transect Average % NOA <200 Mesh (% by weight)	Transect Average % NOA >200 Mesh (% by weight)	Protocol Structures/ gram PM10	Total Structures/ gram PM10	Protocol Structures/ gram Solid	Total Structures/ gram Solid
C1	0.4	1.3						
C2	1.4	1.2						
C3	0.9	0.6						
C4	2	0.9						
C5	1	0.2	1.14	0.84	3.74E+09	2.89E+10	1.27E+03	9.79E+03
S6	1.3	0.5						
S7	3.2	1.2						
S8	3.1	1.1						
S9	2.8	1.4						
S10	2.6	2.3	2.6	1.3	<1.09E9	8.60E+10	3.33E+02	2.63E+04
SS11	1.7	1.5						
SS12	2	1.5						
SS13	1.8	0.9						
SS14	3.1	2.8						
SS15	1.8	2.9	2.08	1.92	4.05E+09	7.36E+10	2.13E+03	3.88E+04
N16	1.5	2.6						
N17	1.7	1						
N18	1.8	0.6						
N19	1.8	7.1						
N20	0.6	1.4	1.48	2.54	1.04E+09	3.57E+10	4.45E+02	1.54E+04
NN21	1	1.5						
NN22	3.1	0.9						
NN23	3.6	1.9						
NN24	1.5	2						
NN25	1	7.8	2.04	2.82	5.15E+09	7.34E+10	1.56E+03	2.22E+04

Table 2
Comparison of Average Airborne Asbestos Results 10 mph / 10 vph Average Traffic Pattern Airborne Asbestos Results

Distance From Road (feet)	Initial (S/cc)	Post (S/cc)	% Difference (Initial & Post)	No Traffic (S/cc)	Background (S/cc)
5	0.7550	0.0155	98%	0.0585	0.0047
10	0.2250	NA		NA	0.0047
30	0.3300	< 0.0139	96%	0.0069	0.0047
50	NM	NA		NA	0.0047
80	0.2115	0.0250	88%	0.0046	0.0047
130	0.0477	NA		NA	0.0047
160	NM	NA		NA	0.0047
190	NM	NA		NA	0.0047
300	NM	0.0360		0.0091	0.0047
Average Asbestos Reduction 94%					

Background samples were collected from sample locations approximately 500 feet west of Slodusty Road study area.
NA =Not Analyzed
NM =Not Measured

Table 3
Comparison of Average Airborne Asbestos Results
25 mph / 30 vph Traffic Pattern

Distance From Road (feet)	Initial Airborne Asbestos Concentration (S/cc)	Post Airborne Asbestos Concentration (S/cc)	% Diff (Initial & Post)	No Traffic Simulation Airborne Asbestos Concentration (S/cc)	Background Airborne Asbestos Concentration (S/cc)
5	6.3000	0.0654	99%	0.0585	0.0047
10	2.2750	NA		NA	0.0047
30	1.5350	0.0218	99%	0.0069	0.0047
50	0.9100	NA		NA	0.0047
80	0.7100	0.0076	99%	0.0046	0.0047
100	0.4265	0.0130	97%	NA	0.0047
130	0.5050	NA		NA	0.0047
160	0.3500	< 0.0046	99%	NA	0.0047
190	0.1870	0.0090	95%	NA	0.0047
300	nm	< 0.0043		0.0091	0.0047

AVERAGE PERCENT DIFFERENCE **98%**

Not Analyzed

Not Measured

Table 4
Summary of Initial Study Personal Sample Results

Index IDs	Date collected	Notes	Estimated Exposure Period (hr)	TEM TWA (s/cc)	LAB	PCM TWA (f/cc)	LAB
P0-00016	07/15/02	Sedan Driver (DTSC personnel)	3.0	0.0056	EMSL++	could not analyze, filter type is PC EMSL	
P0-00017	07/15/02	Traffic Controller	3.0	0.2325	EMSL++	could not analyze, filter type is PC EMSL	
P1-00060	07/16/02	In pick-up truck	6.5	0.2844	EMSL++	0.0130	EMSL
				0.2681	RESI		
P1-00061	07/16/02	Field Personnel	6.5	0.2275	EMSL++	0.0049	EMSL
P1-00062	07/16/02	Traffic Controller	6.5	0.0114	EMSL++	< 0.0033	EMSL
P2-00002	07/17/02	Field Personnel	6.5	0.2763	EMSL++	0.0049	EMSL
				0.3819	RESI		
P2-00003	07/17/02	Traffic Controller	6.5	0.0496	EMSL++	< 0.0033	EMSL
				0.0496	RESI		
P2-00004	07/17/02	Field Personnel	6.5	0.3331	EMSL++	< 0.0033	EMSL
				0.4469	RESI		
				0.2113	RESI QC-RPs		
P3-00002	07/18/02	Field Personnel	3.0	0.1538	RESI	< 0.0034	EMSL
				0.0788	EMSL++		
P3-00003	07/18/02	Field Personnel	3.0	1.6875	RESI	0.0045	EMSL
				0.0525	EMSL++		
P3-00004	07/18/02	Sedan Driver	3.0	0.0413	RESI	< 0.0034	EMSL
				0.0563	EMSL++		
11	**Total Personal Samples**	**AVERAGE**		**0.2552**		**< 0.0049**	

NOTE: "++" EMSL concentrations excluded structures that appeared as "scrolled lizardite", concentrations were determined by EMSL prior to reaching a consensus among laboratories that structures that appear as "scrolled lizardite"

Table 5
Comparison of Average Airborne Asbestos Results Post Resurfacing All Traffic Patterns

Distance From Road (feet)	Post 10mph/10vph Airborne Asbestos Concentration (S/cc)	Post 25mph/30vph Airborne Asbestos Concentration (S/cc)	No Traffic Simulation Airborne Asbestos Concentration (S/cc)	Background Airborne Asbestos Concentration (S/cc)
5	0.0155	0.0654	0.0585	0.0047
10	NA	NA	NA	0.0047
30	< 0.0139	0.0218	0.0069	0.0047
50	NA	NA	NA	0.0047
80	0.0250	0.0076	0.0046	0.0047
100	NA	0.0130	NA	0.0047
130	NA	NA	NA	0.0047
160	NA	< 0.0046	NA	0.0047
190	NA	0.0090	NA	0.0047
300	0.0360	< 0.0043	0.0091	0.0047

NA Not Analyzed

Table 6
Initial Study NOA Emission Risk Ranges

TIME ADJUSTED HEALTH BASED RISK	10 mph/10vph SCENARIO	25mph/30vph SCENARIO
Lifetime/70 year exposure	$3.1x10^{-5}$ to $3.3x10^{-3}$	$2.7x10^{-4}$ to $3.2x10^{-2}$
30 year exposure	$1.3x10^{-5}$ to $1.4x10^{-3}$	$1.1x10^{-4}$ to $1.4x10^{-2}$
9 year exposure	$4.0x10^{-6}$ to $4.2x10^{-4}$	$3.4x10^{-5}$ to $4.1x 10^{-3}$

Table 7
Post Resurfacing Study
NOA Emission Risk Ranges

TIME ADJUSTED HEALTH BASED RISK	10 mph/10vph SCENARIO	25mph/30vph SCENARIO
Lifetime/70 year exposure	$5.3x10^{-6}$ to $1.5x10^{-4}$	$1.3x10^{-5}$ to$2.9x10^{-4}$
30 year exposure	$2.3x10^{-6}$ to $6.4x10^{-5}$	$3.1x10^{-6}$ to $1.3x10^{-4}$
9 year exposure	$6.8x10^{-7}$ to $1.9x10^{-5}$	$9.4x10^{-7}$ to $3.8x10^{-5}$

Figure 1: Location of Garden Valley

Figure 2: Garden Valley Study (Slodusty Road)

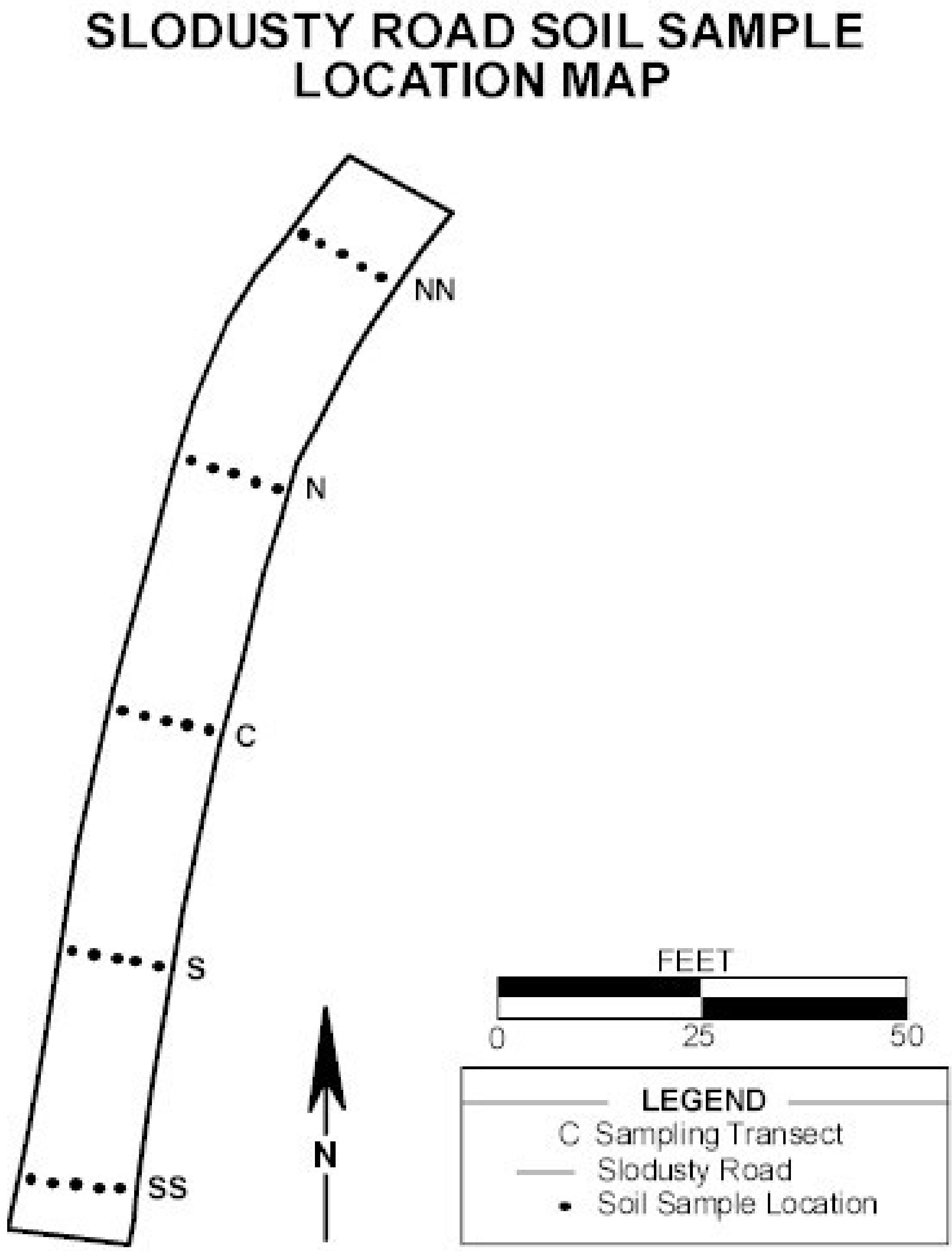


Figure 3

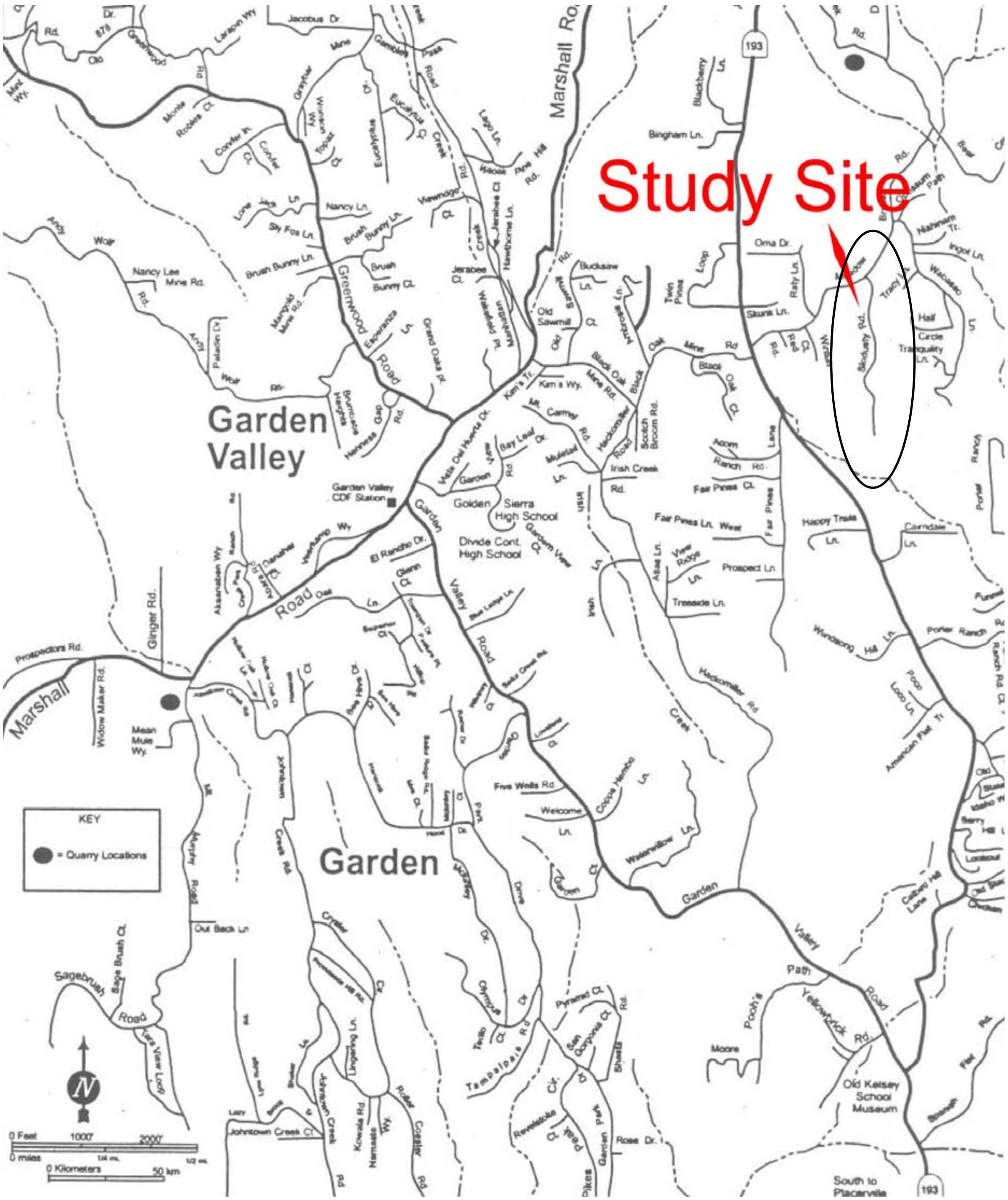

Study Site
Garden Valley
Garden
Marshall Road
Marshall
Greenwood Road
Garden Valley Road
Garden Valley CDF Station
Golden Sierra High School
Divide Cont. High School
Mean Mule Wy.
KEY
= Quarry Locations
Old Kelsey School Museum
South to Placerville
193
0 Feet 1000' 2000'
0 miles 1/4 mi. 1/2 mi.
0 Kilometers .50 km

Figure 4
Regression Plot Comparing Elutriator and Bulk Method Analysis

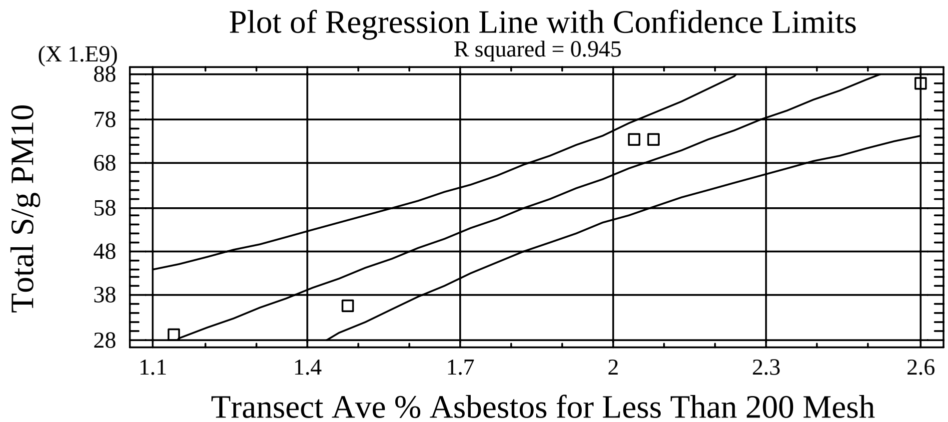
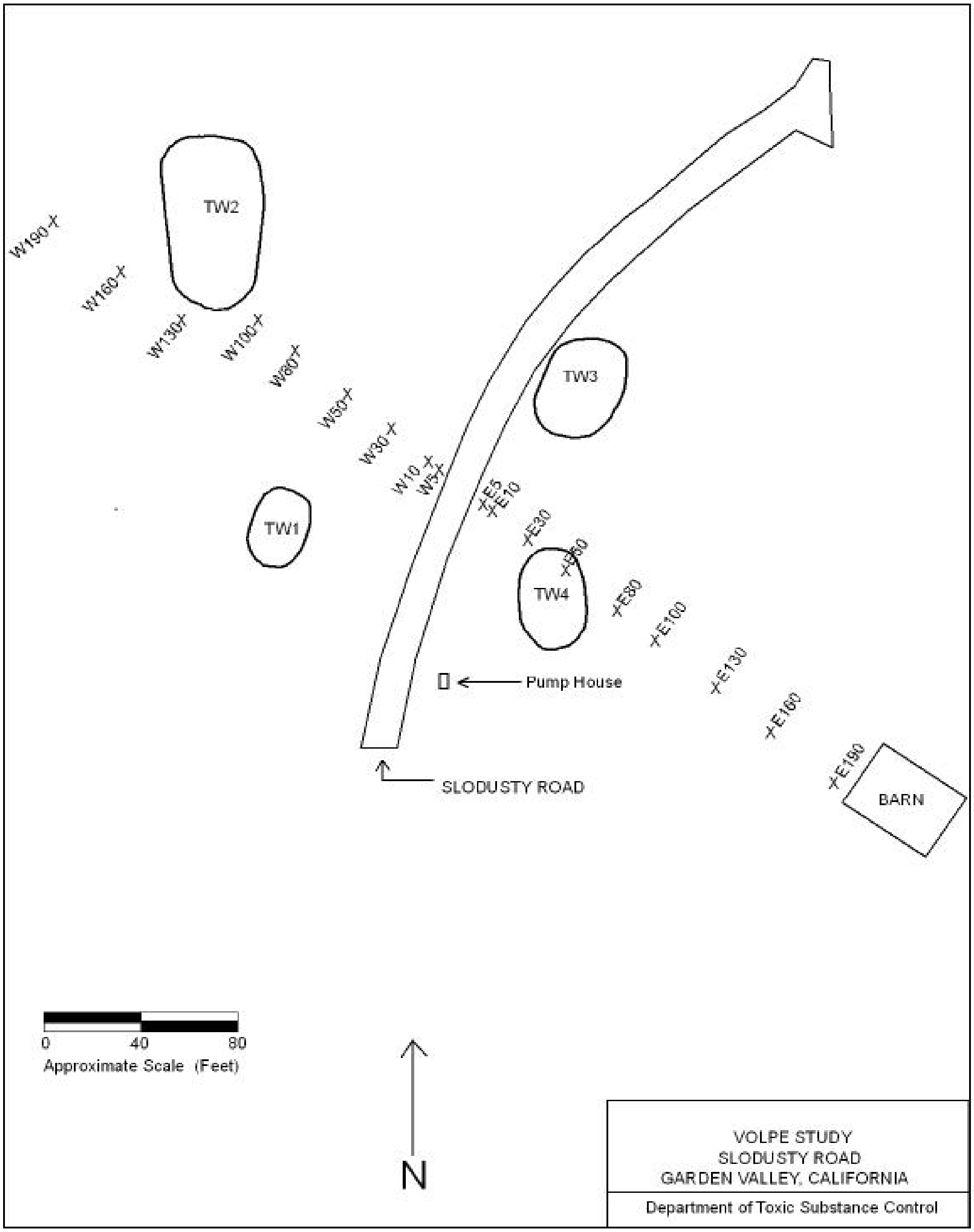


Figure 5
Location of Ambient Air Samplers



TW=tree, X=air sampler (E or W of road and distance (feet) away from road sampler was located)

Figure 6
Comparison of Average Airborne Asbestos Results 10 mph / 10 vph Traffic Pattern

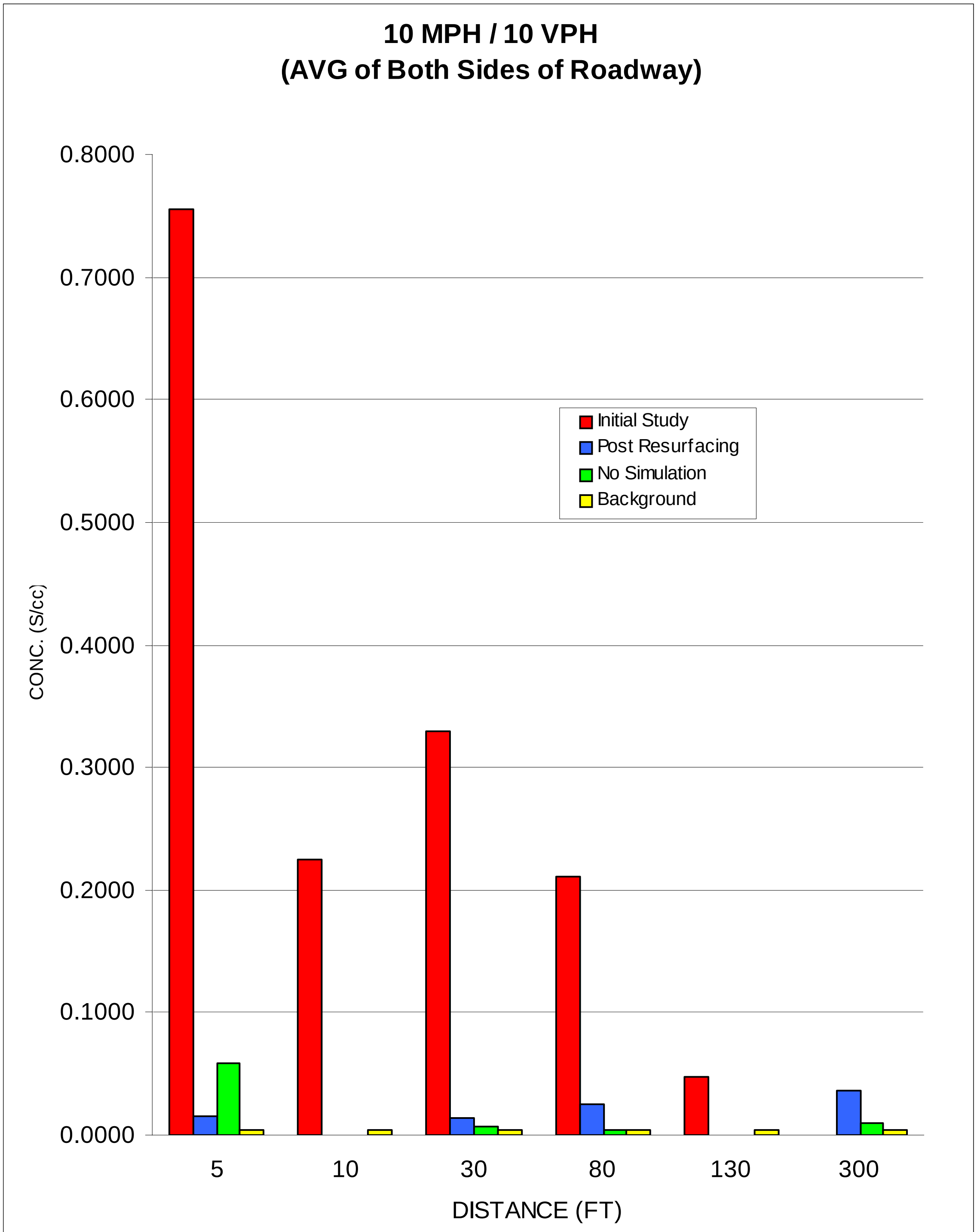


Figure 7
Comparison of Average Airborne Asbestos Results
25 mph / 30 vph Traffic Pattern

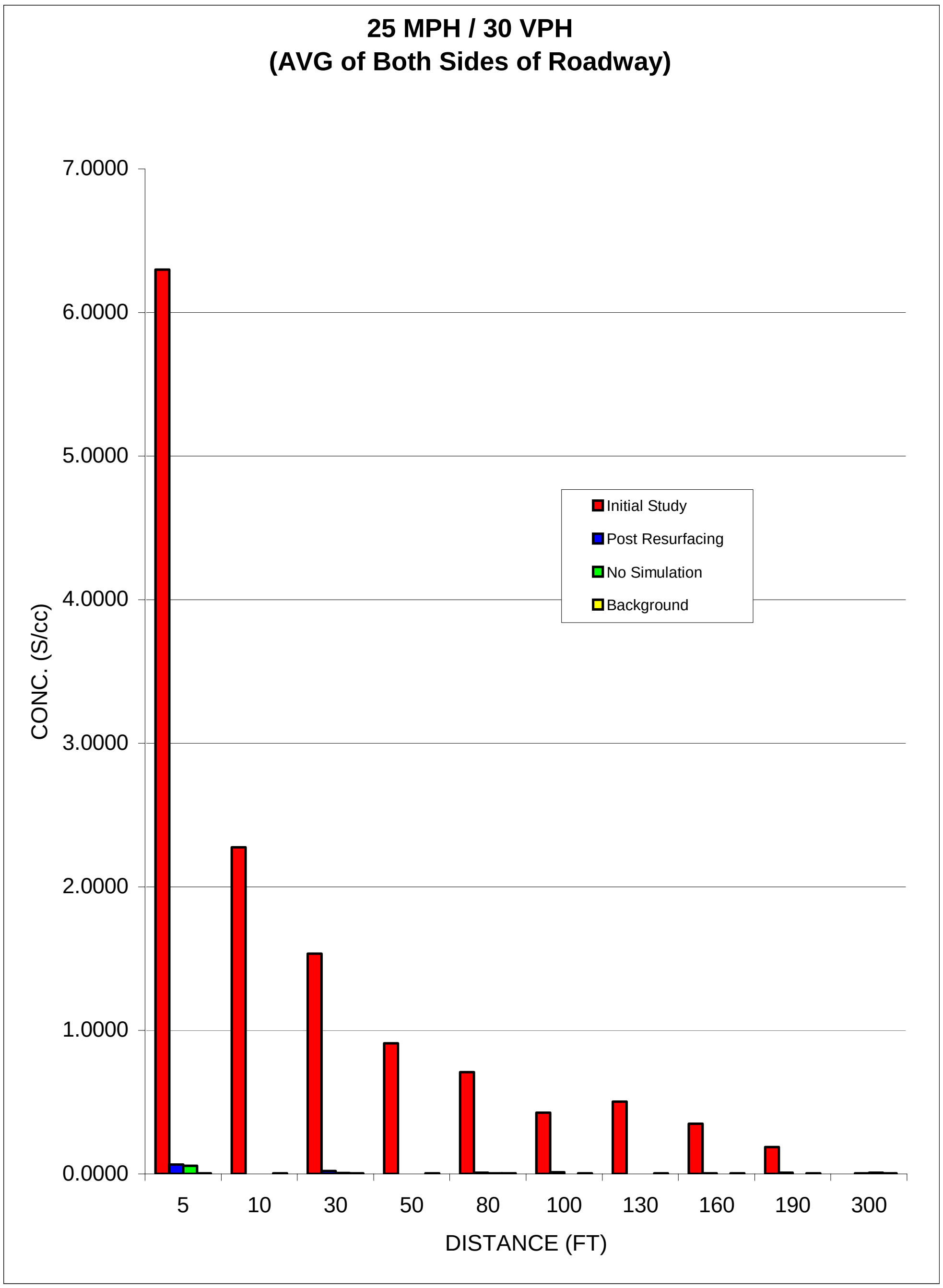


Figure 8
Comparison of Average Airborne Asbestos Results
25 mph / 30 vph Traffic Pattern (Magnified Scale)

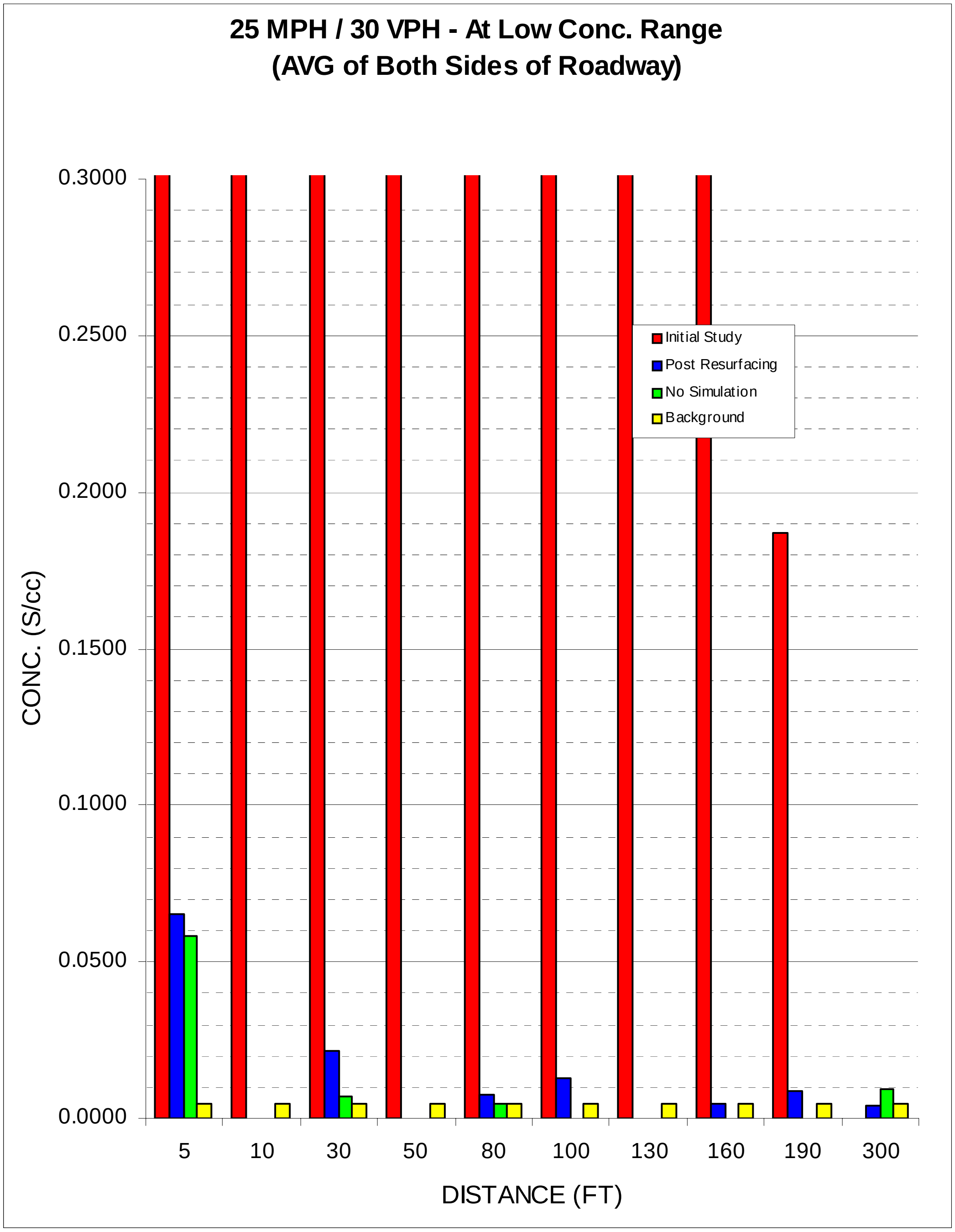


Figure 9
Comparison of Average Airborne Asbestos Results
Post Resurfacing All Traffic Patterns

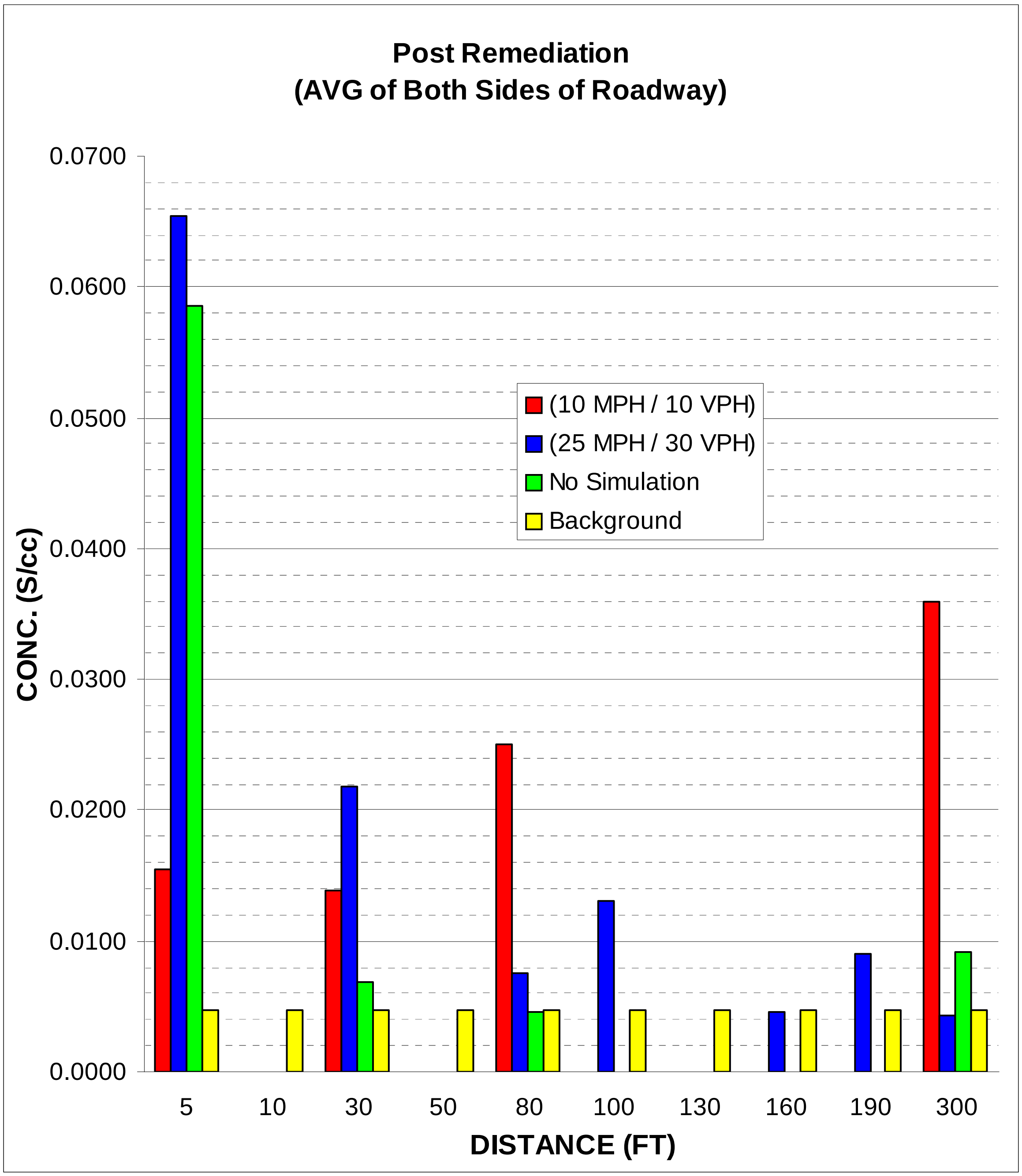


Figure 10
Location of Resurfaced Roads